The Republic of Moçambique
Electricidade de Moçambique (EDM)

Integrated Master Plan
Mozambique Power System Development
Final Report

February 2018

Japan International Cooperation Agency (JICA)
JERA Co., Inc.

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Summary

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1. Outline of the Study

1.1 Objective of the Study

1) To formulate a comprehensive "National power system development master plan" for 25 years including power generation, transmission and distribution planning

2) To familiarize the formulated master plan to relevant government agencies and conduct technical transfer concerning the planning

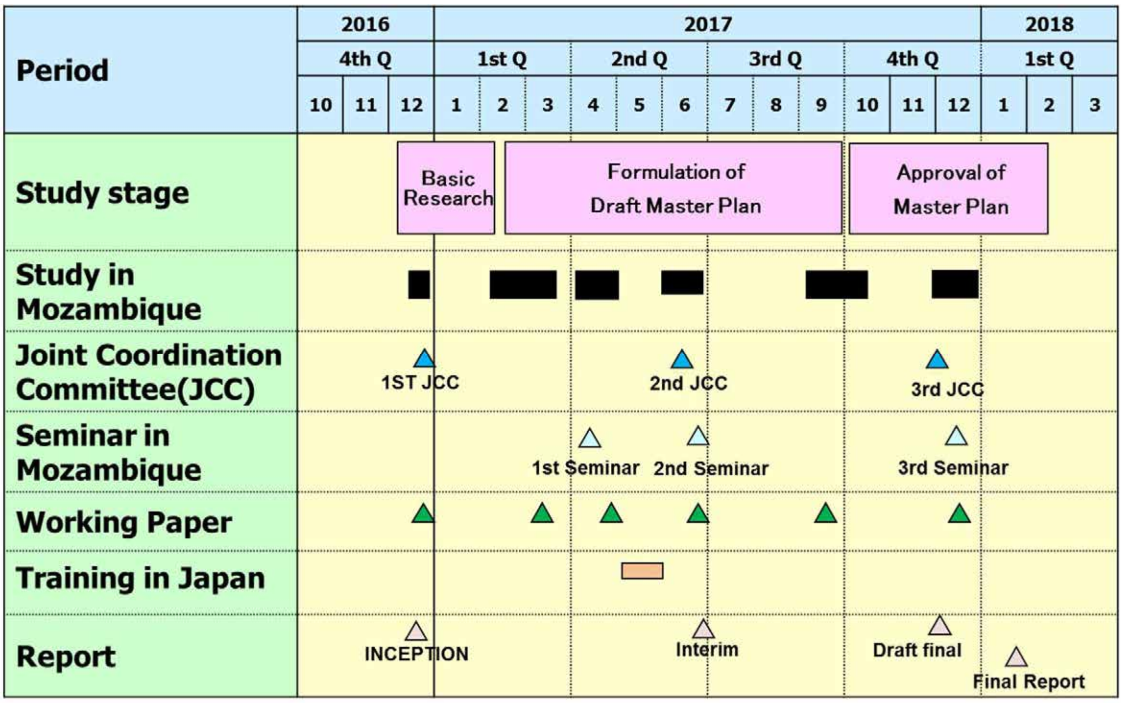
1.2 Counterparts

Main counterpart

- Electricidade de Moçambique (EDM)

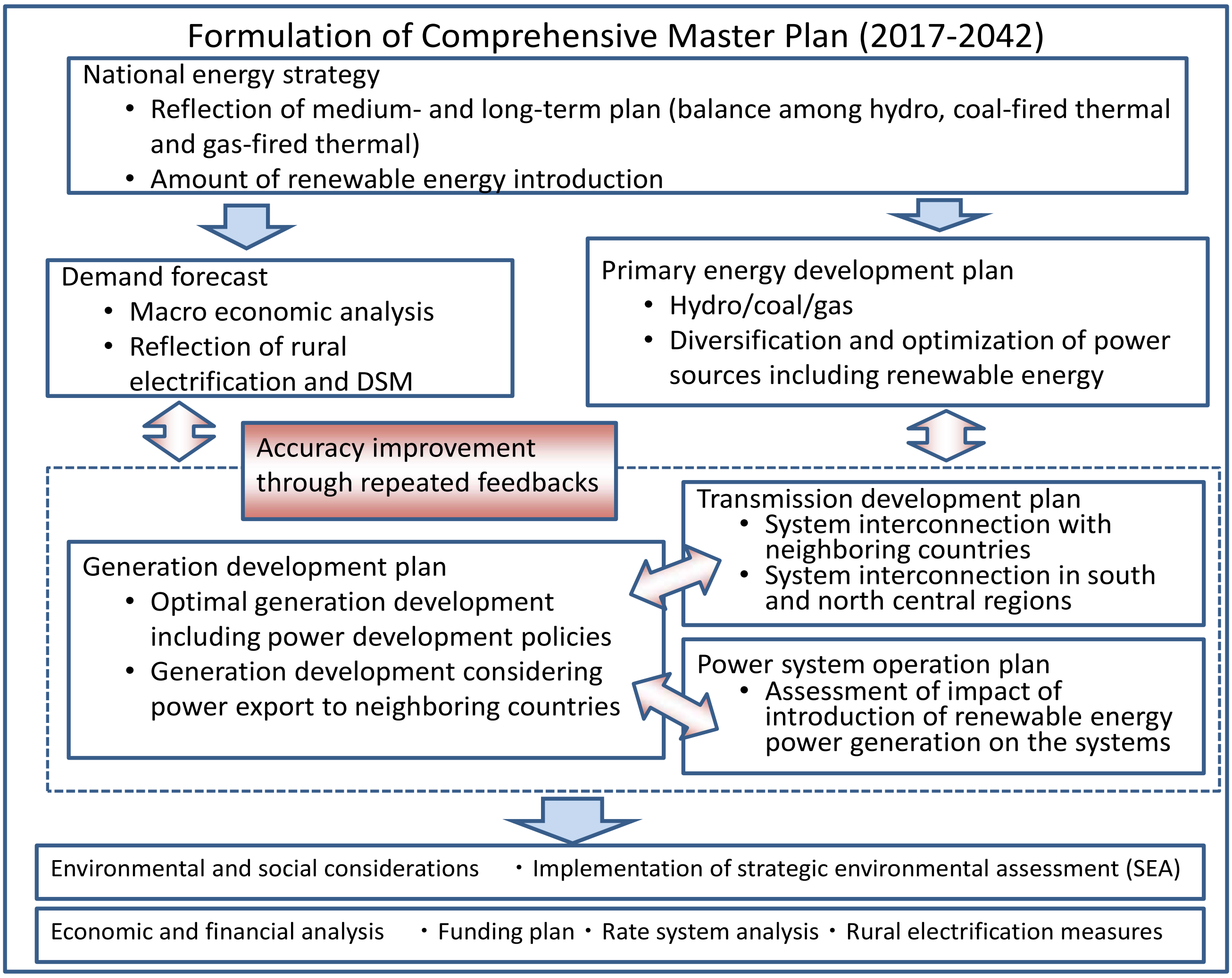
Related Organizations

- Ministry of Mineral Resource and Energy (MIREME)
- Hidroeléctrica de Cahora Bassa (HCB)
- National Council of Electricity - Regulator (CNELEC)
- Ministry of Land, Environment and Rural Development (MITADER)
- Fundo Nacional de Energia (FUNAE)
- Empresa Moçambicana de Exploraçao Mineira (EMEM)
- Empresa Nacional de Hidrocarbonetos de Moçambique (ENH)
- Instituto Nacional de Petroleo (INP)



Source: JICA Study Team

Figure 1.1 Schedule for the Study



Source: JICA Study Team

Figure 1.2 Formulation of Comprehensive Master Plan

2. Demand Forecast

Demand is divided into 3 categories. Firstly "General Customer" which is households and small customers supplied by LV (Low Voltage). Secondly "Medium-Large (M-L) Customer" which is big customers supplied by LV and MV (Medium Voltage) customers and HV (High Voltage) customers. Finally "Special Customer", which is customers whose contract is 1MW and more and supplied by 66kV and more.

Macro analysis is applied to "General Customer" and "M-L Customer". In view of the condition difference between the "General Customer", which is mainly household demand, and "M-L Customer", which is business demand, the demand analyzed by macro analysis was divided into 2 to improve the accuracy. Population, real GDP, electrification ratio and electricity tariff were considered as prospective indicators then evaluated, finally GDP/Capita was employed. Micro analysis was applied to the "Special Customer" because company condition can be considered individually.

The demand was forecasted at three levels, which are at customer side, at transmission substation and at power station taking transmission and distribution loss into account.

With respect to the national demand forecast at the receiving end (at customer side) is shown in the Table 2.1. AAGR of energy consumption is 8.58%.

Table 1.1 National Demand Forecast (Energy Consumption, Maximum Power)

	2015	2042
Energy Consumption	3,908GWh	35,444GWh
Maximum Power	655MW	5,950MW

Source: JICA Study Team

In the same way, demand forecast is conducted for 11 provinces. GDP/Capita of each province was employed and coincidence factor for 11 provinces consolidation was considered to forecast the maximum demand. Table 2.2 and Table 2.3 show the provincial demand forecast. Demand increase of northern provinces such as Cabo Delgado, Niassa, Nampula and Zambezia and Sofala in central region is larger than other provinces.

Table 2.2 Provincial Demand Forecast (Energy Consumption)

(GWh)

	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	Total
2015	99.3	55.7	476.6	148.6	147.1	351.5	375.3	117.0	267.2	855.3	1,049.1	3,942.7
2042	2,110.9	703.1	4,978.7	1,864.6	1,251.0	2,019.8	4,619.8	1,049.8	1,718.0	7,458.1	7,670.2	35,444.0
AAGR	12.58%	10.11%	9.33%	10.07%	8.31%	6.70%	10.41%	8.49%	7.18%	8.52%	7.67%	

Source: JICA Study Team

Table 2.3 Provincial Demand Forecast (Maximum Power)

(MW)

	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	Total
2015	21.4	12.5	94.3	33.9	26.6	73.0	73.9	18.0	43.3	160.1	164.1	721.0
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	6,651.0
AAGR	11.88%	10.00%	9.08%	9.35%	8.60%	6.62%	10.21%	8.95%	8.33%	8.41%	8.27%	

Source: JICA Study Team

3. Generation Development Plan

As power system in Mozambique as of 2017 is divieded into two systems of southern system and central & northern system. And generation development plan near the future should bestudied in each system. However, STE Back Bone project and Mphand Nkuwa hydropower project set to be operated in 2024, and after the operation of each project divide 2 systems will be integrated. Therefore, generation decelopment plan made in 2 stages; stage 1 is two systems of Southern and Central & Northern, stage 2 is one integrated system. The generation development plan in stage 1 is to meet domestic demand, and in stage 2 is same as stage 1 and also to export 20 % of domestic peak demand and PV and Wind power will be installed at most 10 % of domestic peak demand. Result of generation development plan is shown in Table 3.1 - Table 3.3.

Table 3.1 Generation Development Plan (southern system. 2018-2023)

Southern System										
Year	Peak Demand [MW]	Total Installed Capacity(1) [MW]	Hydro [MW]	Diesel [MW]	Gas [MW]	Coal [MW]	Required Additional Capacity [MW]	Solar [MW]	Wind [MW]	Retire [MW]
2017	622	661			40		80			-40
2018	680	727			106		50			-90
2019	800	867					140			
2020	872	937					70			
2021	951	1,017					80			
2022	1,031	1,117			400		-300			
2023	1,115	1,233			206		-120		30	
Developed Capacity(MW)			0	0	752	0	0	0	30	-130
			652							

(1) As of end of each fiscal year

Each mumber shows assumed project and WASP proposed project

Year	Operation Start	Retire
2017	Kuvaninga (40MW)	Aggreko Beluluane (40MW)
2018	JICA CTM (106MW)	Aggreko Ressano (90MW)
2019		
2020		
2021		
2022	Temane (MGTP) (400MW)	Additional Capacity (300MW)
2023	Temane (CCGT) (100MW) CTM Phase2 (106MW) Tofo (wind) (30MW)	Additional Capacity (120MW)

Source: JICA Study Team

Table 3.2 Generation Development Plan (central & northern system. 2018-2023)

Central & Northern System										
Year	Peak Demand [MW]	Total Installed Capacity(1) [MW]	Hydro [MW]	Diesel [MW]	Gas [MW]	Coal [MW]	Required Additional Capacity [MW]	Solar [MW]	Wind [MW]	Retire [MW]
2017	498	513								
2018	725	773					260	40		-40
2019	823	913					100	40		
2020	878	963					50			
2021	981	1,073					110			
2022	1,087	1,183					110			
2023	1,194	1,313				650	-520			
Developed Capacity(MW)			0	0	0	650	110	80	0	-40
			800							

(1) As of end of each fiscal year

Each mumber shows assumed project and WASP proposed project

Year	Operation Start	Retire
2017		
2018	Mocuba (solar) (40MW)	Nacala Barcassa (40MW) for Mozambique
2019	Metoro (solar) (40MW)	
2020		
2021		
2022		
2023	Jindal (150MW) Nacala Coal (200MW) Tete Coal (1unit) (300MW)	Additional Capacity (520MW)

Source: JICA Study Team

Table 3.3 Generation Development Plan (integrated system. 2024-2042)

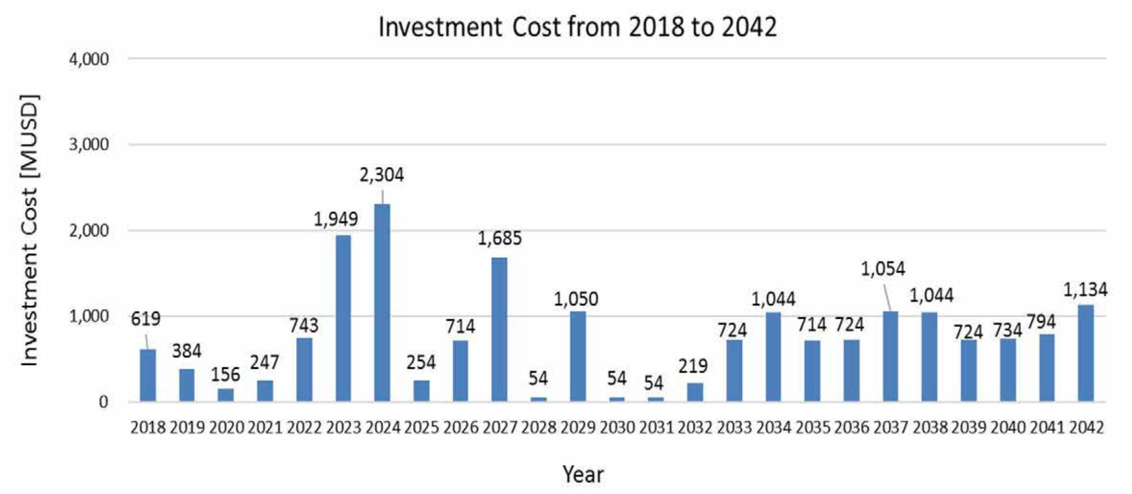
Each number shows assumed project and WASP proposed project

Year	Peak Demand (Total)	Peak Demand (Domestic)	Peak Demand (Additional Export)	Total Installed Capacity(1)	Integrated System: Mphanda Nkuwa	Cahora Bassa North	Lupata, Boroma	Tete	Hydro	CCGT	Coal	Solar Power	Wind Power
					Hydro	Hydro	Hydro	Coal	Hydro	Gas	Coal	Solar	Wind
	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]
2024	2,777	2,314	463	3,966	1,500							30	
2025	2,994	2,495	499	4,046					50			30	
2026	3,217	2,681	536	4,376				300				30	
2027	3,449	2,875	575	5,136			650			80			30
2028	3,691	3,076	615	5,166								30	
2029	3,941	3,284	657	6,441		1,245						30	
2030	4,201	3,500	700	6,471								30	
2031	4,469	3,724	745	6,501									30
2032	4,746	3,955	791	6,581					50			30	
2033	5,032	4,194	839	6,911					100	200		30	
2034	5,329	4,441	888	7,341				300	100			30	
2035	5,636	4,697	939	7,571					200				30
2036	5,955	4,962	992	7,901					100	200		30	
2037	6,286	5,238	1,048	8,331					200	200		30	
2038	6,629	5,525	1,105	8,761				300	100			30	
2039	6,987	5,823	1,165	9,091					100	200			30
2040	7,359	6,133	1,227	9,521						400		30	
2041	7,732	6,443	1,289	9,951						200	200	30	
2042	8,126	6,772	1,354	10,581						400	200	30	
Developed Capacity [MW]					1,500	1,245	650	900	1,000	1,880	400	450	120
					8,145								

(1) As of end of each fiscal year

Source: JICA Study Team

The investment cost of generaton development plan from 2018 to 2042 is in Figure 3.1. Total investment cost in 25 years is 18,786 MUSD.



Source: JICA Study Team

Figure 3.1 Investment Cost from 2018 to 2042

4. Transmission Development Plan

Transmission development plan is calculated using each substation demand and recommended generation development scenario (Export power is 20% of peak demand and solar & wind power is 10% of peak demand).

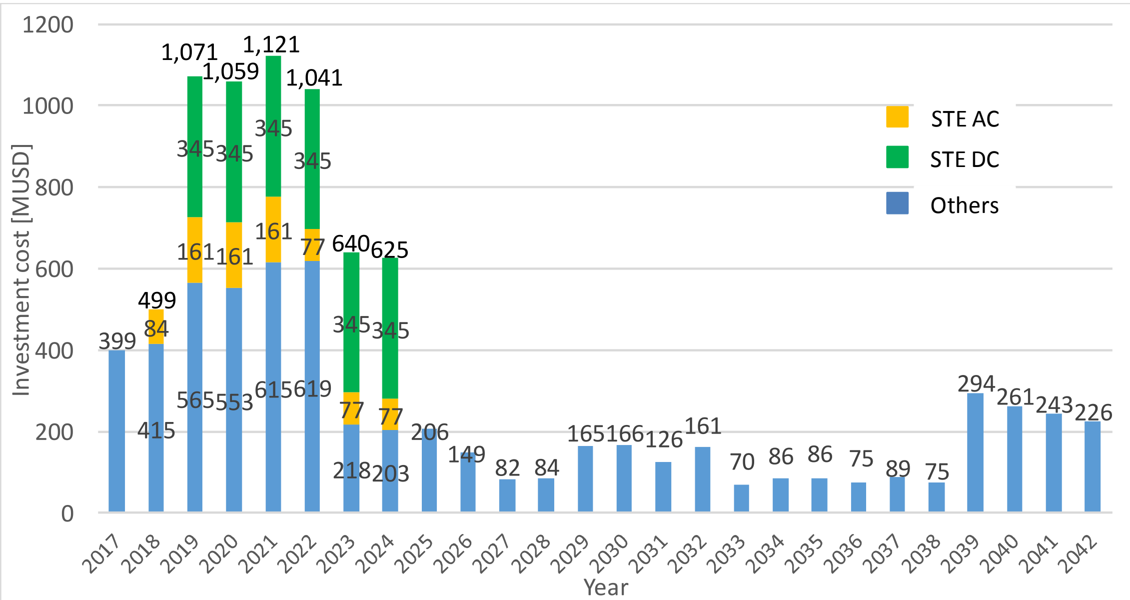
・Power system are formulated considering the introduction of major transmission project is in Table 4.1 and to meet demand growth and N-1 criteria. And expected power system in 2042 is shown in Figure 4.2.

Table 4.1 Major transmission project

Project	Commissioned year
400kV STE Phase 1-1 HVAC (Vilanculos-Maputo)	2022
400kV Malawi interconnector	2021
400kV Zambia interconnector	2022
400kV Caia-Nacala	2022
400kV STE Phase 1-2 HVAC (Songo-Vilancuos)	2024
500kV STE Phase 1&2 HVDC (Cataxa-Maputo)	2024
400kV MoZiSa Project	2025
400kV Tanzania interconnector	2026
400kV Palma-Metoro	2026

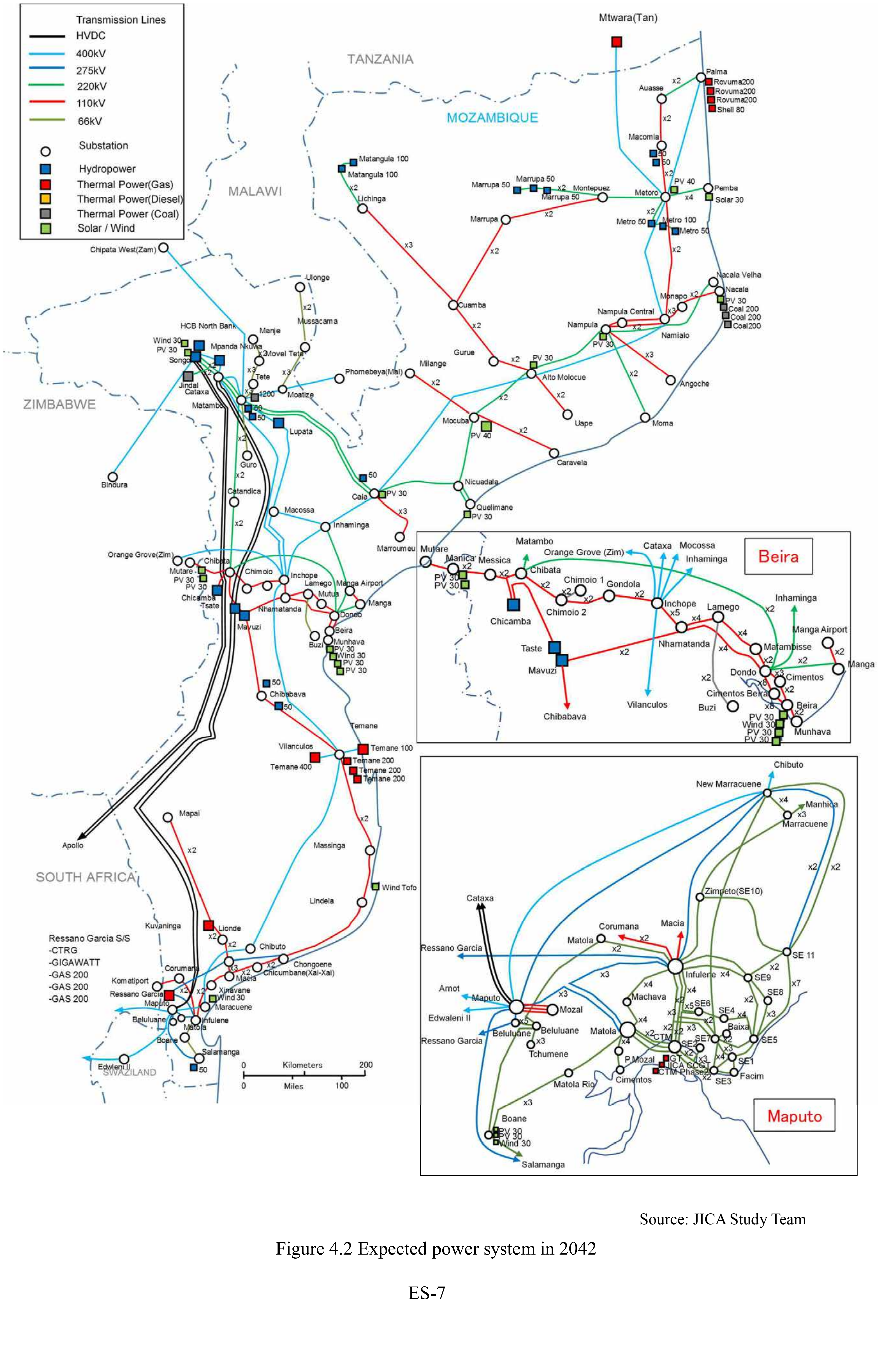
Source: JICA Study Team

・Total investment cost is estimated at 9,100MUSD for 25 years and shown in Figure 4.1. And the investment cost by 2024 become 6,500MUSD, which account for about 70% of the total investment cost by 2042.



Source: JICA Study Team

Figure 4.1 Investment cost for power system



Source: JICA Study Team

Figure 4.2 Expected power system in 2042

5. System Operation

Currently in Mozambique, Southern system, linking with RSA and the other systems, central, central-north and northern systems are separated. To meet system integration, especially interconnection among all scattered systems aforementioned, modernized system controlling and dispatching functionalities should be established. To establish this, current issues should be resolved with reasonable manner which is compatible with basic design (concept) for system operation.

Current issues are following. The Study proposes their solutions.

Table 5.1 Short-Term Challenges related to System Operation

1	No capacity of NCC SCADA maintenance
2	No approved system operation guidelines
3	Unclear HR development program related to system operation

Source: JICA Study Team

Basic concept to be determined are also proposed as the approaches against Mid - to Long-Term challenges to be tackled on the table below.

Table 5.2 Mid- to Long-Term Challenges related to System Operation

Mid- to Long-Term Challenge		Direct Approach related to Solution
A	Establishment of system operation guidelines in accord with facility operation	・ Selection of automatic control device and sophistication of facility operation method ・ Introduction of facility on site that reduces operation load
B	Familiarity with supply and demand control in line with system enhancement	・ Formulation of setup method of automatic generation control (AGC) ・ Finalization of control area ・ Careful examination of EDM's internal business process ・ Formulation of HD development program
C	Introduction of supply and demand control function and SCADA system that reduces load on system operator	・ Decision of NCC and backup control center ・ Construction of communication network
D	Development of key business management system incorporating system operation information	・ Formulation of business model ・ Provision of new services

Source: JICA Study Team

6. Distribution Development Plan

Distribution development plan is studied for Maputo city, Maputo province and Nampula province.

1) Distribution investment cost

EDM has internal budget allocated by EDM and external budget supported by donors. Internal budget has been decreased from 2012 to 2016. However, EDM should secure enough budget since expanded and rehabilitated facilities will increase. Table 6.1 shows total amount of distribution investment cost from 2018 to 2042. The total cost is 6,587 MUSD (263 MUSD per year).

Table 6.1 Distribution investment cost from 2018 to 2042

[million USD]

Rehabilitation	EDM	176
	Donors	1,461
Electrification (EDM, government, donors)		4,950
Total		6,587

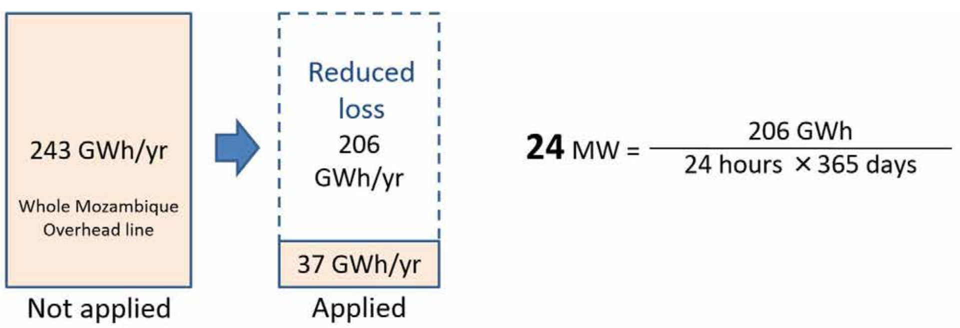
Source: JICA Study Team

2) Loss reduction

Distribution loss in 2015 is 18% and it should be reduced Distribution loss reduction will have the same effect as increasing supply capability through construction of new power stations. In other words, distribution loss reduction projects will reduce construction cost and operation cost (including fuel cost) of power stations.

Long length low voltage line has been constructed. It is expected that technical loss is large due to long length low voltage line and it should be reduced. Therefore, we propose the introduction of multi transformer system. Distribution loss can be reduced drastically by introducing multi transformer system.

It is expected that the distribution loss will be reduced by 206GWh per year. The reduced loss of 206 GWh/year is worth of the power plant which capacity is 24MW.



Source: JICA Study Team

Figure 6.1 The amount of distribution loss reduction before and after the introduction of multi transformer system to overhead line in nationwide Mozambique

The effect of loss reduction by multi transformer system would be equivalent to the aforementioned power plant, which would cost about 461 million USD for 25 years as shown in Table 2. Meanwhile, the project cost for introduction of multi transformer system is 317 million USD. Multi transformer system can reduce construction cost and operation cost (including fuel cost) of power stations.

Table 6.2 Total cost of 24MW power plant for 25 years

[million USD]

Initial cost for CCGT plant	41
Fuel cost and O&M cost for 25 years	420
Total	461

Source: JICA Study Team

7. Electrification Plan

The official target is to achieve universal access by 2030. On the other hand, national electrification ratio in 2015 is still 26%. Precisely electrification ratio in Maputo city reaches 91.9%, but that in Cabo Delgado, Niassa and Zambezia province, is definitely low. Especially, disparity between large city and rural areas is getting wider.

Generally, it is easy and effective to increase national electrification ratio is to uplift connections in electrified village. But it is meaningful to electrify the non-electrified village to spread electrification nationwide. Therefore, government should make decision the balance of them to uprate the electrification ratio.

In the on-grid electrification project, if priority is given to the improvement of electrification ratio with low cost, the improvement of electrification ratio in the already electrified villages is more cost-effectiveness. On the other hand, if priority is given to the improvement of the number of electrified villages, electrification cost will increase due to extension of the distribution line to isolated villages. Prioritization depends on electrification policy.

Table 7.1 shows the conditions for assumption for on-grid electrification cost. Table 7.2 shows the electrification cost by 2042. Total amount of electrification cost is 4,950 MUSD (198 MUSD per year). To achieve universal access, support by government and donors for on-grid electrification project, and cooperation with off-grid electrification project, is important.

Table 7.1 Conditions for estimation of on-grid electrification cost

The target of electrification ratio	95% by 2030 will be achieved and will be continued thereafter
Population (as of 2016)	27,000,000
Person in household (as of 2016)	5
The number of households (as of 2016)	5,400,000
Population growth	2%
The number of electrified households per year by EDM on-grid system	110,000
Ratio of the household number (as of 2017)	On-grid: 80% Off-grid: 20%
On-grid electrification cost per connected household	1,500USD[1]
Shift from off-grid system to EDM on-grid system	20% off-grid customers

Source: JICA Study Team

[1] Development of NES & Plan to Accelerate Universal Access to Energy in Mozambique by 2030, World Bank

Table 7.2 On-grid electrification cost

Year	2017	2042
The number of electrified households [million households]	1.3	4.6
On-grid electrification cost [MUSD]		4,950

Source: JICA Study Team

In terms of off-grid electrification, MIREME proceeds off-grid electrification utilizing FUNAE as execution institute in cooperation with grid expansion by EDM.

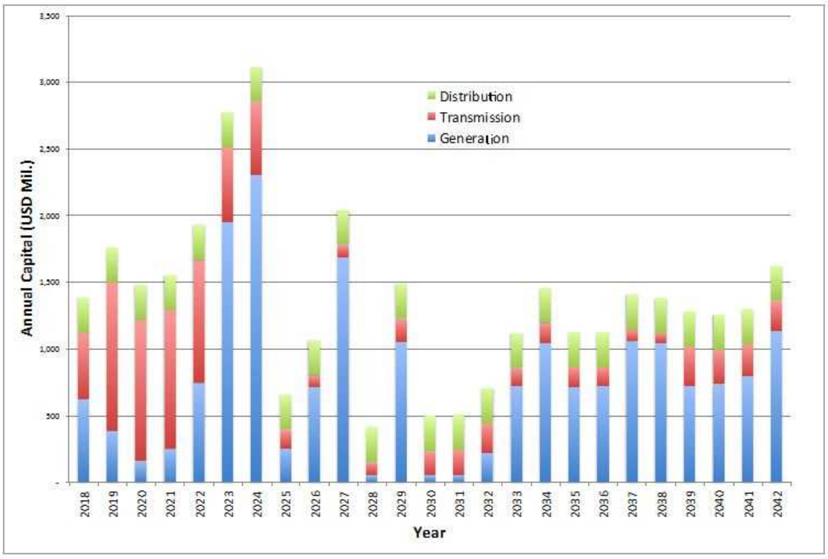
FUNAE launched a portfolio of renewable energy projects[2], budgeted at 500 MUSD, on September, 2017. It aims to invite the investment from not only government but also private financing. To create project list, FUNAE has checked ①Population density and its dispersion, ②Availability of energy resources, ③Economic and social activities, ④Existing infrastructures and ⑤Exiting projects. FUNAE is tackling to investigate and survey the project sites in detail and project list will be updated.

2 Renewable energy projects portfolio hydro and solar resources, FUNAE, September 2017

8. Economic and Financial Analysis

1) Investment Plan

The total investment needs in the Master Plan is approximately USD 34 billion for 25 years from 2018 to 2042. The annual investment amounts by generation, transmission and distribution are shown in Table 8.1. In 2024, since it is expected to have projects of large hydro and STE transmission line, the annual amounts would be more than USD 3 billion.

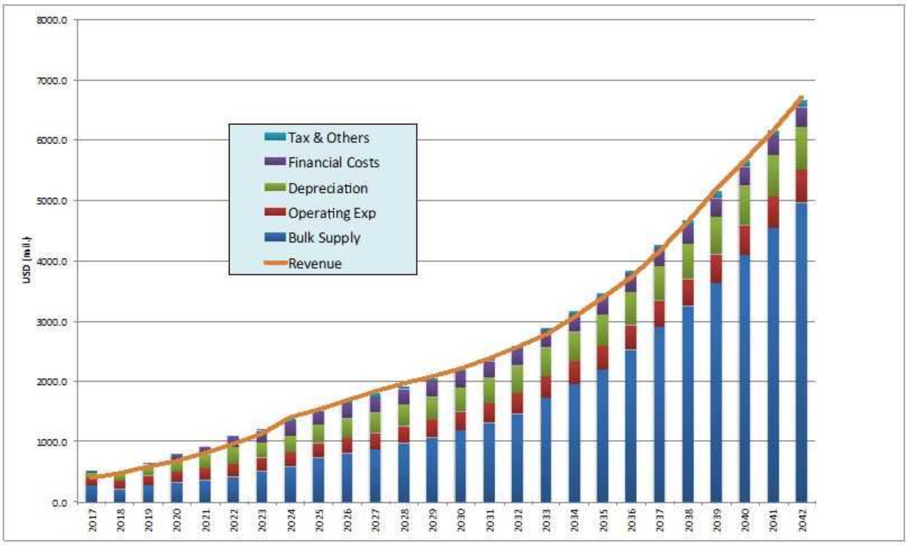


Source: JICA Study Team

Figure 8.1 Future Funding Requirement

2) Financial Analysis

The financial analysis conducted two cases of (i) base case (power import from South Africa from 2018 to 2022) and (ii) comparison case (additional power purchase from HCB from 2018 to 2022). The result of the analysis of base case is following. The power tariffs assume full cost recovery from power sales revenue in each year.

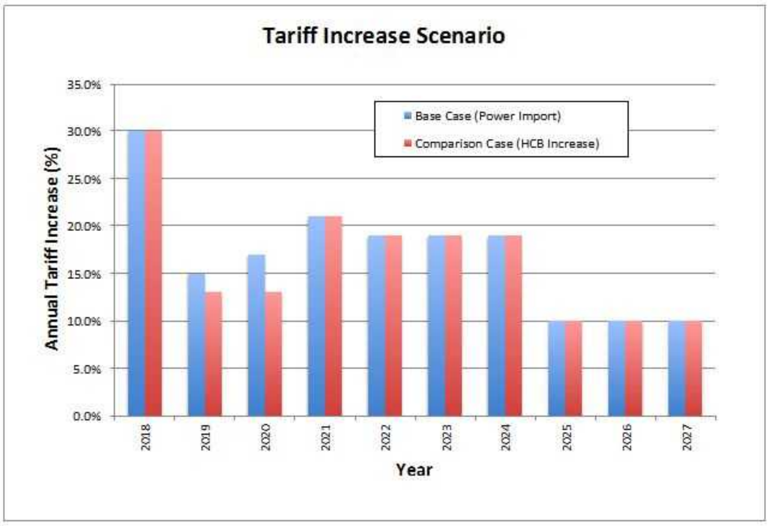


Source: JICA Study Team

Figure 8.1　Revenue and Expenses of EDM

3) Requirements for Power Tariff Adjustments

The power sales revenue is expected to recover all the costs for investment, operation and maintenance of power facilities.　The expected power tariff adjustment schedule is as shown below. The increases would be expected approximately 30% and 15% for year 2018 and 2019, respectively.



Source: JICA Study Team

Figure 1-1　Base case

4) Recommendations

The recommendations for financial management of power sector development are summarized as follows.

Table 8.1 Recommendations for financial management

Org.	Category	Timing		
		Short-term (2018-2022)	Mid-term (2023-2030)	Long-term (2031-2042)
EDM	Power Tariff	• To process the tariff adjustments for 2018 and 2019. 30% increase in 2018 is particularly critical for future development.	• To monitor the financial positions periodically and reflect in the tariff adjustments since this period concentrates the investment needs and hence the power tariff requirements.	• To pay close attentions to the revenue and cost data to review the tariff levels.
EDM	Implementation of Development Plan	• To establish the development strategies for sub-projects of generation, transmission and distribution. In particular on the mobilization of funds and financial strategy.	• To implement the EDM projects such as important strategic projects.	• To exchange views and information on sub-projects with the concerned organizations and companies, and to formulate the implementation plans.
EDM	Coordination with Related Organizations	• To decide the implementation framework for private investments and joint projects with HCB/Motraco. In particular the power purchase agreement and legal framework for joint implementation.	• To monitor the progress of private projects and HCB/MOTRAC joint projects with HCB/Motraco. To provide advise and assistance.	• To forecast the future financial positions for power sector.
MIREME/ MEF	Power Tariff	• To discuss at the cabinet the power adjustments for 2018 and 2019.	• To strengthen the function and capacity of the regulatory agency of power sector. This includes the power tariff, private investment and other sector regulatory issues.	• To examine the policy and implementation to export power to other countries.
MIREME/ MEF	Sector Regulation	• To study the measures to facilitate the private sector participation, and to improve/create the legislations. In particular the power purchase agreements and legal and financial matters.	• To follow up on the impact of the investment projects on the macro-economic situations.	• To study strengthening the power development policy with the primary energy development, and its synergy.
HCB	Implementation of Development Plan	• To establish the development strategy for large hydropower projects by establishing and strengthening the project teams for projects that will be commenced within 5 or 6 years.	• To implement large hydropower projects. To continuously exchange and provide information on the progress and situations of the project.	• To review the business development strategy for power projects, and study further collaborations with EDM.
Motraco	Implementation of Development Plan	• To study the implementation plans for large-scale transmission line projects with EDM. To establish and strengthen the project teams for projects that will be commenced within 5 or 6 years.	• To implement large-scale transmission line projects. To continuously exchange and provide information on the progress and situations of the project.	• To study further collaborations with EDM.

Source: JICA Study Team

9. Environmental and Social Consideration

1) Environmental Impact Assessment

The Environmental Impact Assessment (EIA) process and procedure are regulated in "Regulations for Environmental Impact Assessment (Decree No.54/2015)". Proponents of all development projects need the environmental licenses from the Ministry of Land, Environment and Rural Development (MITADER) as governing agency of EIA for the implementation. The EIA Regulations classify development projects into the following four categories.

Category A+: Projects have complex and irreversible impacts on the environment. Projects such as nuclear power mineral development, and natural gas development are listed in this category. The EIA is required for this category.

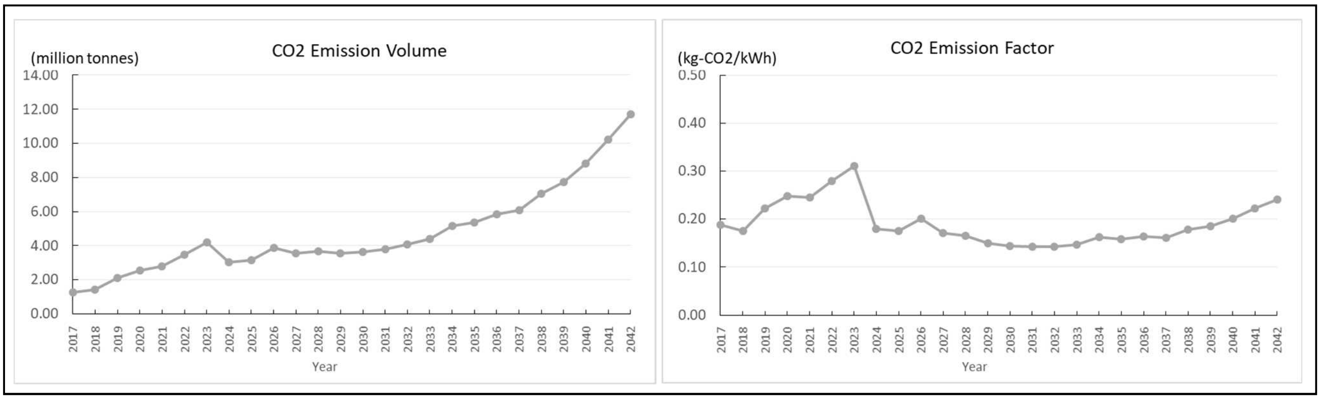
Category A: Projects have significant impacts on the environment. Electric generation projects such as hydropower plant, thermal power plants, geo-thermal power plant and solar photovoltaic power, and construction of transmission line over 66kV listed in this category. The EIA is required for this category.

Category B: Projects have potential impacts less adverse than those of Category A projects on the environment. Construction of transmission line less than 66kV in electric sector is listed in this category. Construction of transformer station is classified in this category in general. The Simplified Environmental Assessment (EAS) is required for this category.

Category C: Projects have minimal or little adverse impacts on the environment. Construction of 33kV transmission line in electric sector is listed in this category. The category C does not required the EIA or SEA.

2) CO2 Emissions of Selected Development Scenario

The CO2 emission volume from 2018 to 2023 is gradually increased due to the introduction of several thermal plants. The volume after 2024 is decreased and not increased so much because of the operation of large scale hydropower units. Average CO2 emission factor from 2018 to 2023 is gradually increased. After 2024, the factor is decreased. The low level will continue in the future.



Source: JICA Study Team

Figure 9.1 Transition of CO2 Emission Volume and Emission Factor

3) Provisional Environmental Scoping

The provisional environmental scoping of typical sub-projects proposed in the master plan was conducted. Because the Master plan does not refer to specific projects, general potential impacts of each sub-project type are considered on the basis of general conditions.

1. Hydro Power Generation

Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Impact Item	Pre-Construction Phase Construction Phase	Operation Phase
Pollution			15. Ethnic minorities and indigenous peoples	B-	D
1. Air pollution	B-	D	16. Local economies, such as employment, livelihood, etc.	B±	B+
2. Water pollution	B-	B-	17. Land use and utilization of local resources	B-	B-
3. Waste	B-	B-	18. Water usage	B-	B-
4. Soil pollution	D	D	19. Existing social infrastructures and services	B-	B-
5. Noise and vibration	B-	D	20. Social institutions such as social infrastructure and local decision-making institutions	B-	D
6. Ground subsidence	D	C~D	21. Misdistribution of benefits and damages	B-	D
7. Offensive odors	D	D	22. Local conflicts of interest	D	D
8. Bottom sediment	D	B-	23. Cultural heritage	B-	D
Natural Environment			24. Landscape	A-	A-
9. Protected areas	B~C	B~C	25. Gender	D	D
10. Ecosystem	A-	A-	26. Children's rights	D	D
11. Hydrology	A-	A-	27. Infectious diseases such as HIV/AIDS	B-	B-
12. Geographical features	A-	D	28. Working conditions (including occupational safety)	B-	B-
Social Environment			Other		
13. Resettlement/ Land Acquisition	A-	D	29. Accidents	B-	B-
14. Poor people	B-	D	30. Trans-boundary impacts or climate change	B-	D

2. Gas Thermal Power Generation

Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Impact Item	Pre-Construction Phase Construction Phase	Operation Phase
Pollution			15. Ethnic minorities and indigenous peoples	C~D	D
1. Air pollution	B-	B-	16. Local economies, such as employment, livelihood, etc.	B±	B+
2. Water pollution	B-	B-	17. Land use and utilization of local resources	B-	B+
3. Waste	B-	D	18. Water usage	D	D
4. Soil pollution	D	D	19. Existing social infrastructures and services	B-	D
5. Noise and vibration	B-	B-	20. Social institutions such as social infrastructure and local decision-making institutions	D	D
6. Ground subsidence	D	C~D	21. Misdistribution of benefits and damages	D	D
7. Offensive odors	D	D	22. Local conflicts of interest	D	D
8. Bottom sediment	D	D	23. Cultural heritage	D	D
Natural Environment			24. Landscape	D	D
9. Protected areas	C~D	C~D	25. Gender	D	D
10. Ecosystem	C~D	C~D	26. Children's rights	D	D
11. Hydrology	D	D	27. Infectious diseases such as HIV/AIDS	B-	D
12. Geographical features	D	D	28. Working conditions (including occupational safety)	B-	B-
Social Environment			Other		
13. Resettlement/ Land Acquisition	C~D	D	29. Accidents	B-	B-
14. Poor people	C~D	D	30. Trans-boundary impacts or climate change	B-	B-

3. Coal Thermal Power Generation

Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Impact Item	Pre-Construction Phase Construction Phase	Operation Phase
Pollution			15. Ethnic minorities and indigenous peoples	C~D	D
1. Air pollution	B-	A~B-	16. Local economies, such as employment, livelihood, etc.	B±	B+
2. Water pollution	B-	B-	17. Land use and utilization of local resources	B-	B+
3. Waste	B-	A~B-	18. Water usage	D	D
4. Soil pollution	D	C~D	19. Existing social infrastructures and services	B-	D
5. Noise and vibration	B-	B-	20. Social institutions such as social infrastructure and local decision-making institutions	D	D
6. Ground subsidence	D	C~D	21. Misdistribution of benefits and damages	D	D
7. Offensive odors	D	C~D	22. Local conflicts of interest	D	D
8. Bottom sediment	D	D	23. Cultural heritage	D	D
Natural Environment			24. Landscape	D	D
9. Protected areas	C~D	C~D	25. Gender	D	D
10. Ecosystem	C~D	C~D	26. Children's rights	D	D
11. Hydrology	D	D	27. Infectious diseases such as HIV/AIDS	B-	D
12. Geographical features	C~D	D	28. Working conditions (including occupational safety)	B-	B-
Social Environment			Other		
13. Resettlement/ Land Acquisition	C~D	D	29. Accidents	B-	B-
14. Poor people	C~D	D	30. Trans-boundary impacts or climate change	B-	B-

4. Solar Power Generation

Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Impact Item	Pre-Construction Phase Construction Phase	Operation Phase
Pollution			15. Ethnic minorities and indigenous peoples	C~D	D
1. Air pollution	B-	D	16. Local economies, such as employment, livelihood, etc.	B±	B+
2. Water pollution	B-	D	17. Land use and utilization of local resources	B-	D
3. Waste	B-	B-	18. Water usage	D	D
4. Soil pollution	D	D	19. Existing social infrastructures and services	B-	D
5. Noise and vibration	B-	D	20. Social institutions such as social infrastructure and local decision-making institutions	D	D
6. Ground subsidence	D	D	21. Misdistribution of benefits and damages	D	D
7. Offensive odors	D	D	22. Local conflicts of interest	D	D
8. Bottom sediment	D	D	23. Cultural heritage	C~D	D
Natural Environment			24. Landscape	D	B-
9. Protected areas	C~D	C~D	25. Gender	D	D
10. Ecosystem	C~D	C~D	26. Children's rights	D	D
11. Hydrology	D	D	27. Infectious diseases such as HIV/AIDS	B-	D
12. Geographical features	D	D	28. Working conditions (including occupational safety)	B-	D
Social Environment			Other		
13. Resettlement/ Land Acquisition	C~D	D	29. Accidents	B-	D
14. Poor people	C~D	D	30. Trans-boundary impacts or climate change	B-	D

5. Wind Power Generation

Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Impact Item	Pre-Construction Phase Construction Phase	Operation Phase
Pollution			15. Ethnic minorities and indigenous peoples	C~D	D
1. Air pollution	B-	D	16. Local economies, such as employment, livelihood, etc.	B±	B+
2. Water pollution	B-	D	17. Land use and utilization of local resources	B-	D
3. Waste	B-	D	18. Water usage	D	D
4. Soil pollution	D	D	19. Existing social infrastructures and services	B-	D
5. Noise and vibration	B-	B-	20. Social institutions such as social infrastructure and local decision-making institutions	D	D
6. Ground subsidence	D	D	21. Misdistribution of benefits and damages	D	D
7. Offensive odors	D	D	22. Local conflicts of interest	D	D
8. Bottom sediment	D	D	23. Cultural heritage	C~D	D
Natural Environment			24. Landscape	D	B-
9. Protected areas	C~D	C~D	25. Gender	D	D
10. Ecosystem	C~D	B~C	26. Children's rights	D	D
11. Hydrology	D	D	27. Infectious diseases such as HIV/AIDS	B-	D
12. Geographical features	D	D	28. Working conditions (including occupational safety)	B-	D
Social Environment			Other		
13. Resettlement/ Land Acquisition	C~D	D	29. Accidents	B-	B-
14. Poor people	C~D	D	30. Trans-boundary impacts or climate change	B-	D

6. Transmission Line

Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Impact Item	Pre-Construction Phase Construction Phase	Operation Phase
Pollution			15. Ethnic minorities and indigenous peoples	C~D	D
1. Air pollution	B-	D	16. Local economies, such as employment, livelihood, etc.	B±	B+
2. Water pollution	B-	D	17. Land use and utilization of local resources	B-	D
3. Waste	B-	D	18. Water usage	D	D
4. Soil pollution	D	D	19. Existing social infrastructures and services	B-	D
5. Noise and vibration	B-	D	20. Social institutions such as social infrastructure and local decision-making institutions	D	D
6. Ground subsidence	D	D	21. Misdistribution of benefits and damages	D	D
7. Offensive odors	D	D	22. Local conflicts of interest	D	D
8. Bottom sediment	D	D	23. Cultural heritage	D	D
Natural Environment			24. Landscape	D	B-
9. Protected areas	C~D	C~D	25. Gender	D	D
10. Ecosystem	C~D	B~C	26. Children's rights	D	D
11. Hydrology	D	D	27. Infectious diseases such as HIV/AIDS	B-	D
12. Geographical features	B-	D	28. Working conditions (including occupational safety)	B-	B-
Social Environment			Other		
13. Resettlement/ Land Acquisition	B~C	D	29. Accidents	B-	B-
14. Poor people	C~D	D	30. Trans-boundary impacts or climate change	B-	D

7. Power Distribution

Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Impact Item	Pre-Construction Phase Construction Phase	Operation Phase
Pollution			15. Ethnic minorities and indigenous peoples	D	D
1. Air pollution	B-	D	16. Local economies, such as employment, livelihood, etc.	D	B+
2. Water pollution	B-	D	17. Land use and utilization of local resources	D	D
3. Waste	B-	B-	18. Water usage	D	D
4. Soil pollution	D	D	19. Existing social infrastructures and services	D	D
5. Noise and vibration	B-	B-	20. Social institutions such as social infrastructure and local decision-making institutions	D	D
6. Ground subsidence	D	D	21. Misdistribution of benefits and damages	D	D
7. Offensive odors	D	D	22. Local conflicts of interest	D	D
8. Bottom sediment	D	D	23. Cultural heritage	D	D
Natural Environment			24. Landscape	D	D
9. Protected areas	D	D	25. Gender	D	D
10. Ecosystem	D	D	26. Children's rights	D	D
11. Hydrology	D	D	27. Infectious diseases such as HIV/AIDS	D	D
12. Geographical features	D	D	28. Working conditions (including occupational safety)	B-	B-
Social Environment			Other		
13. Resettlement/ Land Acquisition	D	D	29. Accidents	B-	B-
14. Poor people	D	D	30. Trans-boundary impacts or climate change	B-	D

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected

* Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"

Source: JICA Study Team

Figure 9.2 Result of Provisional Environmental Scoping

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Abbreviations

AAGR	Annual Average Growth Rate
ADB	Asian Development Bank
AFD	Agence Française de Developpement
AfDB	African Development Bank
AGC	Automatic generation control
AMS	Asset Management System
ARENE	Energy Regulatory Authority
ASC	Área de Serviço ao Cliente
ASCANG	Área de Serviço ao Cliente de Angoche
ASCCM	Área de Serviço ao Cliente da Cidade de Maputo
ASCNCL	Área de Serviço ao Cliente de Nacala
ASCNPL	Área de Serviço ao Cliente de Nampula
ASCPM	Área de Serviço ao Cliente da Provincia de Maputo
BEMS	Building Energy Management System
BoSa	Botswana - South Africa
BPC	Botswana Power Corporation
CCGT	Combined Cycle Gas Turbine
CEPCO	Chubu Electric Power Co., Inc.
CFL	Compact Fluorescent Lamp
CNELEC	National Council of Electricity – Regulator
CPI	Centro de Promoção de Investimentos
DPS	Direcção da Planeamento of Systemas (System Planning)
DR	Demand Response
DRT	Direcção da rede de transporte (Directorate of Transport network)
DSM	Demand Side Management
EAPP	Eastern African Power Pool
EBRD	European Bank for Reconstruction and Development
EDM	Electricidade de Moçambique
EED	Energy Efficiency Directorate
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EMEM	Empresa Moçambicana de Exploração Mineira
ENH	Empresa Nacional de Hidrocarbonectos de Moçambique
ESCO	Energy Service Company
ESCOM	Electricity Supply Corporation of Malawi
ESKOM	South African Electric Utility Supplier
FDI	Foreign Direct Investment
FIT	Feed-in Tariff
FS	Feasibility Study
FUNAE	Fundo de Energia
GDP	Gross Domestic Product

GHG	Greenhouse Gas
GIS	Geographic Information System
GoM	Government of Mozambique
HCB	Hidroeléctrica de Cahora Bassa
HEMS	Home Energy Management System
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
ICCP	Inter-Control Center Communications Protocol
IDA	International Development Association
IEE	Initial Environmental Examination
IGMoU	Inter Governmental Memorandum of Understanding
IMF	International Monetary Fund
INE	Instituto Nacional de Estatística
INP	Instituto Nacional de Petroreo
IPP	Independent Power Producer
IUMoU	Inter Utility Memorandum of Understanding
JCC	Joint Coordinating Committee
JICA	Japan International Cooperation Agency
JST	Joint Study Team
KfW	Kreditanstalt für Wiederaufbau
LDC	Load Duration Curve
LF	Load Factor
LFC	Load Frequency Control
LNG	Liquefied Natural Gas
LOLP	Loss of Load Probability
LV	Low voltage
MD	Maximum Demand
METI	Ministry of Economy, Trade and Industry
MEF	Ministério da Economia e Finanças
MICOA	Ministry of Coordination of Environmental Affair
MIREME	Ministry of Mineral Resource and Energy
MITADER	Ministry of Land, Environment and Rural Development
M/M	Minutes of Meeting
MOTRACO	Mozambique Transmission Company
MOZAL	Aluminum smelter outside Maputo
MoZiSa	Mozambique – Zimbabwe - South Africa
MV	Medium voltage
MZ	Mozambique
NCC	National Control Center
NEPAD	New Partnership for Africa's Development
NEPAD IPPF	NEPAD Infrastructure Project Preparation Facility
NGO	Non-Governmental Organization
O&M	Operation & Maintenance
PPA	Power Purchase Agreement

PPP	Public–Private Partnership
PS	Posto de seccionamento
P/S	Power Station
PSS/E	Power system simulator for engineering
R/D	Record of Discussion
REFIT	Regulamento que Estabelece o Regime Tarifario para as Energias Novas e Renovaveis
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SAPP-PAU	Southern African Development Community
SC	Static Condenser
SCADA	Supervisory Control and Data Acquisition
SE	Substation (Subestação)
SEA	Strategic Environmental Assessment
SEC	Swaziland Electricity Company
SEZ	Special Economic Zone
ShR	Shunt Reactor
SIDA	Swedish International Development Cooperation Agency
SPV	Special Purpose Vehicle
S/S	Substation
STE	Sistema Nacional de Transporte de Energia (Mozambique Regional Transmission Backbone Project), Mozambique
SVC	Static VAR Compensator
Tanesco	Tanzania Electric Supply Company Limited
T&D	Transmission and Distribution
TEPCO	Tokyo Electric Power Co., Inc.
TOU	Time of Use
VAT	Value Added Tax
WASP	Wien Automatic System Planning
WB	World Bank
WFM	Work Force Management
ZESA	Zimbabwe Electricity Supply Authority
ZESCO	Zambia Electricity Supply Corporation

Chapter 1 Preface

1.1 Background

The Republic of Mozambique (population about 27.22 million, GNI per capita 620 USD, 2014; hereinafter referred to as "Mozambique") is in Southeast Africa and has been maintaining a high GDP growth rate of an average of over 7% for the last 10 years. With abundant natural resources and active FDI (foreign direct investment), the country is expected to have further GDP growth by about 7.5% to 8% in the medium- and long-term through expansion and concretization of coal and natural gas mega projects.

Maximum power demand was 831 MW and power consumption was only 4,962 GWh/year in 2014. However, with recent steady economic growth and increase in electrification ratio, power demand has been significantly increasing and maximum power demand is expected to reach 1,684 MW in 2018.

The largest power source in the country is Cahora Bassa Hydro Power Station (output: 2,075 MW), which supplies 88% of all the power consumed in the country (2014). However, the power station is managed by Hidroelectrica de Cahora Bassa (hereinafter referred to as "HCB"), an independent power producer, and most of the generated power is transmitted to South Africa. The national power generation company conducting power generation and transmission is Electricidade de Moçambique (Main counterpart, hereinafter referred to as "EDM"), which generates only 6% of the power consumption and cannot cover the whole domestic demand.

As the southern system and the central and northern system are not connected, power transmission from the Cahora Bassa Hydro Power Plant to the south, where there is power demand, is carried out through South Africa. In addition to this issue of separate power systems, there are other issues with insufficient capacity, aging, etc. of power transmission facilities.

Under these circumstances, a master plan based on appropriate demand forecast and energy supply planning is necessary. However, the current master plan (formulated in 2014; hereinafter referred to as the "existing master plan") especially lacks medium- and long-term optimum generation development planning. In this situation, technical cooperation was requested for formulating a comprehensive national power system development master plan (for 25 years) through review of the existing master plan and update of necessary specifications (available technologies, cost, etc.) in light of the latest technological information and various circumstances surrounding Mozambique (energy resource development plan, etc.).

1.2 Objectives of the Study

- To formulate a comprehensive national power system development master plan for 25 years including power generation, transmission and distribution planning
- To familiarize the formulated master plan to relevant government agencies and conduct technical transfer concerning the planning

1.3 Counterparts

(a) Main counterparts

・Electricidade de Moçambique (EDM)

(b) Other related organizations

・Ministry of Mineral Resource and Energy (MIREME)
・Hidroeléctrica de Cahora Bassa (HCB)
・Energy Regulatory Authority (ARENE)
・Ministry of Land, Environment and Rural Development (MITADER)
・Fundo de Energia (FUNAE)
・Empresa Moçabicana de Explorazao Mineira (EMEM)
・Empresa Nacional de Hidrocarbonectos de Moçambique (ENH)
・Instituto Nacional de Petroreo (INP)
・Moçambique Transmission Company (MOTRACO)

1.4 JICA Study Team Members

Table 1.4-1 shows JICA Study Team members.

Table 1.4-1 JICA Study Team members

No	Name	Assignment
1	Mr. Yoshitaka SAITO	Team Leader/Power Development Planning
2	Mr. Yoshihide TAKEYAMA	Power System Operation
3	Mr. Mitsuhiro WATANABE	Primary Energy Analysis
4	Mr. Akira HIRANO	Demand Forecast
5	Mr. Tomohiro KATO	Generation Development Plan (1)
6	Mr. Takahiro KOBAYASHI	Generation Development Plan (2)
7	Mr. Toshitaka YOSHIDA	Transmission Development Plan
8	Mr. Shinichi MITSUI	Distribution Development Plan
9	Dr. Takeshi KIKUKAWA	Economic and Financial Analysis
10	Mr. Kanji WATANABE	Environmental and Social Considerations

1.5 Study Schedule

The entire schedule for the study and the overall flow of the study are shown in Table 1.5-1.

Table 1.5-1 Entire schedule and overall flow of the study

Study flow

Basic Survey Stage
- Schedule coordination and consensus building with EDM
- Basic information collection
- Study of plan formulation methods

Input from SAPP study

Master Plan Formulation Stage 1
- **Development of power demand forecast** → **Formulation of generation development plan**
- Study of power sources, transmission and distribution, finance, etc. SEA baseline survey

Master Plan Formulation Stage 2
- **Formulation of transmission/distribution development plan**
- **Formulation of long-term investment plan**
- **Implementation of SEA**

Master Plan Approval Stage
- **Formulation of Master Plan**
- Support for obtaining approval in Mozambique and publication to the public

Item for work In Japan / Item for Activities in Mozambique

Basic Survey Stage

Preparation Work in Japan
1) Review of existing information and formation of the study plan
2) Development and submission of Inception Report

1st Activities in Mozambique (1)
1) Explanation and discussion of Inception Report
2) Support for holding the 1st Joint Coordinating Committee (JCC)
3) Organization of JST
4) Periodic study report and information provision to EDM management
5) Collection of relevant information

1st Activities in Mozambique (2)
1) Support for holding the 1st seminar
2) Development of power demand assumptions
3) Formulation of primary energy utilization plan
4) Study concerning optimal generation development plan
5) Study of transmission development planning consistent with generation development plan
6) Survey of actual condition of system operation
7) Data analysis contributing to the formulation of distribution development plan
8) Study of rural electrification policy
9) Review of EDM financial status
10) Baseline survey for strategic environmental assessment

Master plan Formulation Stage 1

1st Work in Japan
- Study in each study area

2nd Activities in Mozambique
1) Formulation of optimal power development plan
2) Study concerning transmission development plan
3) Study and proposals concerning system operation improvement
4) Study concerning distribution development plan
5) EDM's financial analysis

Master Plan Formulation Stage 2

2nd Work in Japan
1) Training in Japan
2) Development of Interim Report

3rd Activities in Mozambique
1) Formulation of transmission development plan
2) Formulation of distribution development plan
3) Formulation of rural electrification plan
4) Formulation of long-term investment plan
5) Proposal of financial strategies
6) Strategic environmental assessment
7) Explanation and discussion of Interim Report
8) Support for holding the 2nd Joint Coordinating Committee (JCC)
9) Support for holding the 2nd seminar

3rd Work in Japan
1) Development of Draft Final Report
2) Development of Action Plan
3) Suggestion concerning JICA electric power sector cooperation

Master Plan Approval Stage

4th Work in Japan
- Development of Final Report and submission

4th Activities in Mozambique
1) Formulation of Master Plan
2) Proposal of policies
3) Support for holding the 3rd Joint Coordinating Committee (JCC)
4) Support for holding the 3rd seminar
5) Support for approval of internal support and publication of Master Plan

Schedule

Year	2016						2017									2018	
Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Study stage Activities in Mozambique		1st Activities in Mozambique (1)	1st Activities in Mozambique (1)	1st Activities in Mozambique (2)	1st Activities in Mozambique (2)	1st Activities in Mozambique (2)	2nd Activities in Mozambique	2nd Activities in Mozambique	3rd Activities in Mozambique (1)			3rd Activities in Mozambique (2)	3rd Activities in Mozambique (2)	4th Activities in Mozambique	4th Activities in Mozambique		
Work in Japan		Preparation Work in Japan				1st Work in Japan		2nd Work in Japan					3rd Work in Japan		4th Work in Japan		
Month	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Seminar							△1st Seminar		△2nd Seminar						△3rd Seminar		
JCC			△1st JCC						△2nd JCC						△3rd JCC		
Working paper				△		△		△		△			△		△		
Training in Japan								▭									
Report		△ Inception		△ Revised Inception					△ Interim						△ Draft final	△ Final	

Source: JICA Study Team

1.6 Support for Establishment of Joint Coordination Committee (JCC) and Joint Study Team (JST)

For a realization of the master plan, EDM established JCC and JST. JICA Study Team provided support to the teams.

JCC managed the formulation of the national power system development master plan and reflect it in the power development policy. Periodic sharing of study progress, step-by-step consensus building and promotion of understanding of the study contents has been proceeded in the JCC.

JST was responsible for practical affairs as a subordinate organization of JCC. For smooth implementation of the study and technical transfer through OJT, JST was organized for each study field.

1.6.1 Project Organization

Table 1.6-1 and Table 1.6-2 show JCC members and JST members, respectively.

Table 1.6-1 JCC members

Name	Organization	
Dr. Mateus Magala	Chairman & CEO of EDM	Chairman of the JCC
Mr. Aly Sicola Impija	Executive Director of Planning and Business	Member
Mr. Carlos Yum	Executive Director of Operation	Member
Mr. Antonio Gimo	Director of System Planning	Project Manager
Mr. Narendra Gulab	Director of Generation	Member
Mr. Feliciano Massingue	Director of Transmission/Distribution	Member
Mr. Luis Amado	Director of Distribution	Member
Mr. Augusto Sanjane	Director of Human Resource Development	Member
Mr. Casmiro Francisco	Representatives designated by EMEM	Member
Mr. Omar Mitha	Representatives designated by ENH	Member
Mr. Carlos Zacarias	Representatives designated by INP	Member
Mr. Pascoal Bacela	Representatives designated by MIREME	Member
Mr. Adriano Jonas Mr. Moises Machava	Representatives designated by HCB	Member
Mr. Erasmo Biosse	Representatives designated by CNELEC	Member
Mr. Olegario Banze	Representatives designated by MITADER	Member
Mr. Antonio Saide	Representatives designated by FUNAE	Member
Mr. Hiroaki Endo	Chief Rep. of JICA Mozambique Office	Member
Mr. Yoshitaka Saito	Team Leader of JICA Study Team	Member

Source: JICA Study Team

Table 1.6-2 JST members

JST	Counterparts	JICA Study Team
Demand Forecast	Mr. Iazalde Jose (MIREME): Leader Mr. Isaias Matsinhe (EDM) Mr. Julio Guivala (EDM) Mr. Faustino Mauaua (EDM) Mr. Rivas Sitoe (EDM) Mr Arlindo Sitoe (MIREME) Mr. Suleimane Combo (HCB)	Mr. Akira Hirano: Leader Mr. Shinichi Mitsui
Primary Energy Analysis Generation Development Plan	Ms. Olga Utchavo Madeira (EDM): Leader Mr. Guilherme Tenjua (EDM) Mr. Mario Jonas (EDM) Mr. Gilberto Muchanga (EDM) Mr. Tauancha Vaquina (EDM) Mr. Inocêncio Gujamo (MIREME) Mr. Antonio Chicachama (MIREME) Mr. David Gune (HCB) Mr. Júlio Chipuazo (HCB)	Mr. Yoshitaka Saito: Leader Mr. Tomohiro Kato Mr. Takahiro Kobayashi Mr. Mitsuhiro Watanabe
Transmission Development Plan Power system Operation	Ms. Olga Utchavo Madeira (EDM): Leader Ms. Yara Cabra (EDM) Mr. Sebastiao Ngungulo (EDM) Mr. Edgar Mabui (EDM) Mr. Prosperino Saidane (EDM) Mr. Francisco Mahangue (MIREME) Mr. Lucas Gune (HCB) Mr. Maxcêncio Tamele (HCB)	Mr. Yoshihide Takeyama: Leader Mr. Toshitaka Yoshida
Distribution Development Plan Rural Electrification	Mr. Isaias Matsinhe (EDM): Leader Mr. Sergio Viegas (EDM) Mr. Gilberto Muchanga (EDM) Mr. Julio Guivala (EDM) Mr. Iazalde Jose (MIREME) Mr. Anisio Pinto (MIREME) Mr. Jonas Manuel (HCB)	Mr. Shinichi Mitsui: Leader Mr. Akira Hirano
Economic and Financial Analysis	Mr. Felix Bucuane (EDM): Leader Mr. Antonio Munguambe (EDM) Mr. Alexandre Monjane (EDM) Mr. Noa Inacio (MIREME) Ms. Jéssica Cumbe (MIREME)	Dr. Takeshi Kikukawa: Leader
Environmental and Social Consideration	Ms. Belarmina Mirasse (EDM): Leader Ms. Aissa Naimo (EDM)	Mr. Kanji Watanabe: Leader Mr. Yoshitaka Saito Mr. Tomohiro Kato Mr. Takahiro Kobayashi

Source: JICA Study Team

Chapter 2 Outline of Electricity Sector

2.1 Power Sector Overview

2.1.1 Development Policy and Legislation of Power Sector

The major laws, legislation, and policies in the power sector can be summarized in the following.

Laws

(1) Electricity Act No.21/97 of 1 October 1997

Rules and Regulations

(1) Decree No 8/2000 of 20 April 2000 - Regulations on the Powers and Procedures for the Award of Concessions, and the Import and Export of Energy.
(2) Decree No 42/2005 of 29 November 2005 - Regulations on the National Power Transmission Network ("NPTN").
(3) Decree No 43/2005 of 29 November 2005 entrusting the role of NPTN Electricidade de Moçambique.
(4) Decree No 45/98 of 25 September 1998 – Regulations on management of power facilities built or renovated with own funds in the districts that has not been assigned to a public company.
(5) Ministerial Diploma No 31/85 of 31 July 1985 - Regulations on technical skills for preparing, implementing and operating power facilities of particular service.
(6) Decree No 48/2007 of 22 October 2007 - Licensing regulations for electric facilities
(7) Decree No 25/2000 of 3 October 2000 – Electricity National Council (CNELEC) Statutes.
(8) Decree No 46847 - Regulation of safety of high voltage power lines and distribution networks of low voltage power.
(9) Decrees 29782, 30308 and 37823 - Regulation of safety of low voltage power facilities.

Legislation and Policies

(1) Municipal Legislation (1997)
(2) National Energy Strategy by MIREME (2014-2023)
(3) Energy Sector Five-Year Plan by MIREME
(4) Five-Year Strategy Plan by EDM (2015-2019)
(5) Electricity Master Plan by EDM (2014)

Source: JICA Study Team

Figure 2.1-1 Major laws, legislation, and policies in the power sector

The following mentions the major legislation and policy on the power sector.

(1) Electricity Law

The Electricity Law (No. 21/97) defines the general policy for the organization of the electrical energy sector and the administration of the supply of electrical energy. It also prescribes the general legal framework for electrical energy generation, transmission, distribution and sale within the country; and controls the exportation and importation of energy from outside of the national territory, and the granting of concessions for such activities.

The Electricity Law also allowed for private participation in the electricity industry under a concession system, as well as maintaining a special position and responsibility for EDM as the primary driver of the law. The law was supplemented with the Decree No. 8/2000, which further specifies procedures concerning concession for generation, transmission, distribution and sale of electricity.

The Energy Regulatory Authority (ARENE), which replaced the National Electricity Council (CNELEC), was also established by the law as a governmental consultative entity, which works a s regulatory instrument concerning generation, transmission and sale of electricity.

(2) Energy Policy (1998)

The Energy Policy (1998) is one of the main energy documents in the country that presents a clear statement on the importance of providing energy to the households and productive sectors. The Energy Policy approved March 3rd 1998 by the Council of Ministers under Resolution 5/98 established with the following objectives.

- Guarantee reliable supply of energy, at lowest possible cost, in order to meet present demand and future levels based on economic development trajectories,
- Increase the energy options available for household consumption,
- Secure better efficiency in energy utilization,
- Promote the development of environmentally friendly conversion technologies, namely hydro, solar, wind and biomass.

(3) National Energy Strategy

Mozambique's Energy Strategy was designed for a ten-year period (2014-2023) and it provides a vision and path to respond to the challenges and opportunities in the power sector. The main goals are to reinforce Mozambique's position as an important regional energy producer, to support social development and poverty alleviation, and to promote general economic growth.

The mission under this strategy is to further diversify the mix of energy forms used, and contribute to industrial and socio-economic development. Hence, under the strategy, the Government of Mozambique will continue building institutional capacity in the sector to ensure the efficient promotion and regulation of the sector, which is needed to complete current infrastructural projects and enhance Mozambique's role within the SADC region.

2.1.2 Organizational Setup in Power Sector

The organizational setup in the power sector in Mozambique can be stated as follows.

(1) Ministry of Energy and Mineral Resources (MIREME)

MIREME is responsible for national energy planning and policy formulation and for overseeing the operation and development of the energy sector. The technical matters on the energy are handled by the three main thematic directorates (Power Sector, Renewables and Liquid Fuels). The National Directorate for Electrical Energy (DNEE) is a central technical body within the MIREME, responsible for the analysis, preparation and elaboration of energy policies.

(2) Energy Regulatory Authority (ARENE)

ARENE replaced CNELEC in May 2017. Former regulator CNELEC was created in 2004 under the National Energy Council as a governmental consultative which works as a regulatory instrument concerning generation, transmission and sale of electricity. CNELEC was re-established as an independent advisory regulatory body for the electricity sector in early 2008 with support from the World Bank Energy Reform and Access Project (ERAP). CNELEC was instructed to give its highest priority to an evaluation of EDM 's performance under its Performance Contract with the GoM. This Performance Contract sets out the goals and indicators to be met annually by EDM and GoM. CNELEC was also instructed to conduct a review of the current methodology used by EDM in setting tariffs. In performing the review of EDM 's performance, the directive instructed CNELEC to conduct its review in an open and transparent manner with public hearings in several locations throughout the country.

(3) National Fund for Rural Electrification (FUNAE)

FUNAE was established in 1997, in charge of off-grid electrification, as a contributor to economic and social development in the country. Since its establishment FUNAE has implemented numerous projects using renewable energy technologies to electrify schools, clinics and communities.

(4) Electricidade de Moçambique (EDM)

EDM is a vertically-integrated, government-owned electric utility responsible for generation, transmission and distribution of electricity in the national grid. EDM buys most of its power supply (approx. 400 MW) from Hidroeléctrica de Cahora Bassa (HCB), owner and operator of the Cahora Bassa hydro power plant on the Zambeze river (2,075 MW). The GoM owns 82 percent of HCB which operates as an Independent Power Producer (IPP) The bulk of the electricity generated at HCB is exported to South Africa, with a small amount to Zimbabwe. EDM sells any excess electricity on the Southern Africa Short Term Energy Market. The Mozambique transmission grid is currently interconnected with South Africa, Zimbabwe and Swaziland.

(5) Mozambique Transmission Company (MOTRACO)

MOTRACO is owned by EDM, South Africa Electricity Supply Company (ESKOM) and Swaziland Electricity Company (SEC), 33.33% each, responsible to supply electricity to MOZAL aluminum smelter in Mozambique and wheeling of power to EDM in Mozambique and SEC in Swaziland. MOTRACO's activities are supported by an infrastructure made up of two 400 kV substations and transmission lines 132 and 400 kV, owned by MOTRACO.

2.1.3 Power Tariff

The current power tariff as of September 2017 can be presented in the Table 2.1-1. This is based on the three-time tariff revises from 2015 to 2017.

The power tariff has been established by the customer category and by the electricity consumption for the low-voltage customers. Regarding the high-voltage customers, the tariffs have been categorized by the voltage of the customers and the connection fee is also charged.

The customer categories for the low-voltage are social consideration tariff, domestic, agriculture and general commerce and fixed tariff. Regarding the large customers, the tariff is a two-part setup of the basic charge and metered charge depending on the voltage level.

Table 2.1-1 EDM Electricity Tariff

Electricity Tariff -Mozambique (2017.09)

Tariff categories: Social, Domestic, Agricultural and General (Low Voltage)

Registered Consumption (kWh)	Social Tariff (MZN / kWh)	Domestci Tariff (MZN / kWh)	Agriculture Tariff (MZN / kW)	General Rate (MZN / kW)	Flat Rate (MZN)
0 - 100	1.07				
0 - 300		5.46	3.40	8.24	205.70
301 - 500		7.73	4.84	11.77	205.70
More than 500		8.11	5.30	12.88	205.70
Prepayment	1.07	6.95	4.71	11.80	n/a

Note: For customers who fit the parameters for the social tariff (power 1.1 kVA and not consumption above 100 kWh / month), whose installations use the Prepayment type counter (CREDELEC), will set a current limit 5 Amperes.

Large consumers of low voltage, medium voltage, medium voltage agri., and High Voltage

Consumer Caterogy	(MZN / kWh)	(MZN / kW)	Flat Rate (MZN)
Large Consumer BT (GCBT)	4.70	361.19	602.28
Medium Voltage (MT)	4.06	422.63	2,826.99
Medium Voltage Agriculture (MTA)	2.51	288.59	2,826.99
High Voltage (AT)	3.99	510.27	2,826.99

Note: For Tariff Category "Average Agricultural Voltage" Power to the invoice must be equal to the power socket.

The High Voltage Rate is subject to negotiation on the terms and conditions of the applicable law, whenever the power to hire and technical conditions so warrant, to ensure in relation to EDM (i) reasonable compensation for the costs of operation, production, purchase and / or import of electricity (ii) a compatible return on capital invested in electricity infrastructure and (iii) the amortization, over time, incurred capital costs.

Connection Fee for BT Large Consumers

Amount to be collected (VAT - MZN)	VAT (MZN)	Amount to be collected (with VAT - MZN)
163.71	27.83	191.54

Connection fee for Big MT and AT Consumers

Amount to be collected (VAT - MZN)	VAT (MZN)	Amount to be collected (with VAT - MZN)
768.42	130.63	889.05

Source: EDM Data

The power tariffs are different by the customer category, contract energy amount, consumption. The typical charges by each customer can be calculated in Table 2.1-2.

Table 2.1-2 Sample Electricity Tariff (in USD)

Customer Category	Assumed Consumption (kWh/month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	8.81 (14.21MZN/kWh)
Small Commercial	1,000	20.77 (33.5MZN/kWh)
Large Commercial/Industry	10,000	13.61 (21.95MZN/kWh)

As of September 2017（1 USD=0.01613 MZN）

Source: JICA Study Team

These data have been calculated by dividing the payment charge be the energy amount under the assumptions for typical customers. The price per unit energy consumption may differ by the category and conditions of use. The price in US dollar would also differ by the US exchange rate.

2.1.4 Overview of Power Sector Issues

- Short-term response of the power supply needs to meet the demand linked to economic and social projects currently underway, with particular emphasis on the south and the special economic zone of Nacala in northern Mozambique.
- Mobilization of resources for the implementation of transmission line projects and power generation and other energy infrastructure to improve quality and efficiency in energy supply.
- Increase access to diverse forms of energy in a sustainable manner, contributing to the well-being of the population, industrialization and economic welfare.
- Combating and preventing loss of power resulting from dishonest attitudes such as vandalism, theft of materials and equipment from the national grid and theft of electricity through fraud and illegal connections.
- It is necessary to make the energy sector more attractive and dynamic for investment, thereby contributing to a more sustainable socio-economic growth for Mozambique.

It is envisaged that the fossil fuel can be converted to renewable energy as well as increasing the access rate of electricity.

2.2 Support by Donors

In a lot of businesses, such as generation, transmission, electrification, human development etc., donors are supporting for EDM and MILEME, which are main players in electric power industry, and other institutes like FUNAE and ARENE. Total No. of donors are 19, JICA, WB, USAID, AfDB and others. Concrete situations of cooperation are described in from the next section.

2.2.1 Support by WB

WB are conducting study on "Development of the National Electrification Strategy and Plan (NESP)" which started in October 2016. Draft final report was reported in April 2017. The main purposes of this study are following two points:

・To evaluate present electrification model

・To establish new business model to Universal Access

In addition to scenario of the universal access by 2030, scenario of the universal access by 2055 is studied. Furthermore, very important criteria to proceed electrification is evaluated from the viewpoints of distance from existing distribution lines, distribution capacity and population density. Electrification cost and operation method of electrification fund are also studied.

Further cooperation has been executing with IDA, for instance, "Energy Development and Access Project (EDAP APL-2)". This is the project to improve access ratio and supply reliability in rural area and area surrounding city.

With respect to power system, WB executed FS on STE Backbone project in 2012, and is supporting expansion and rehabilitation projects for substations and transmission lines in Maputo city.

WB disclosed the 150 Million USD grant in September 2017. This is the IDA (International Development Association) Project and the objective of this project are the increase of transmission capacity and the improvement of system operation of EDM. This project is expected to improve the system stability and some problems are expected to be solved such as deterioration of efficiency operation and the captive power possession for customers. This project consists of 3 components described in Table 2.2-1, Table 2.2-2, and Table 2.2-3.

(1) Power System Rehabilitation (US$117million)

Table 2.2-1 IDA Project Component 1

Objective	To improve the power system reliability in Matola, Maputo, Nacala, Pemba and Lichinga.
Contents	● Transformer installation: 1 x 40MVA (Lichinga) ● Transformer installation: 6 x 40MVA (Maputo) ● Middle voltage transmission lines installation: 66kV 70km (Maputo, Matola) ● Capacitor installation: 15MVR (Pemba substation) ● Replacement of control panels in substations and mini-SCADA development in northern system

Source: WB

(2) Enhancement of EDM Operational and Commercial Operations (US$29.5million)

The focus of this component is to enhance governance, efficiency, transparency, and accountability in operations in EDM's key business areas

Table 2.2-2 IDA Project Component 2

Subcomponent ①: Organizational Restructuring, Process Reengineering, and Capacity Building (US$3.7 million)	
Objective	To optimize efficiency, transparency in operations and enhance both internal and external governance.
Contents	● Defining and implementing a new organizational structure ● Reengineering processes and activities in all business areas ● Capacity building and technical assistance to improve the performance of key departments such as finance, human resources, technical and procurement
Subcomponent ②: Consolidation of SIGEM (US$11.1million)	
Objective	To ensure full permanent use of the functionalities provide by the information system (IS) supporting operations in all business areas incorporated under SIGEM.
Contents	● Training incorporation of additional system functionalities, including a geographic information system (GIS), an asset management system (AMS), and a new package to optimize management of purchases by prepaid customers.
Subcomponent ③: Revenue Protection (US$6.3million)	
Objective	To protect the revenues that EDM receives from sales to large-size and medium-size customers, ensuring that all users in that high-value segment are systematically billed and eliminate the non-technical loss
Contents	● Meters installation for 2000 large-size customers and 8000 medium-size customers to measure remotely
Subcomponent ④: Upgrade of Information Systems (US$8.4million)	
Objective	To have strong, reliable communication links with the data center where the IS are hosted, in all regions in the country, where EDM provides electricity services to its customers
Contents	● Upgrades and acquisition of IS (hardware and software).

Source: WB

(3) Capacity Building and Implementation Support (US$3.5million)

Table 2.2-3 IDA Project Component 3

Subcomponent ①: Capacity Building and Implementation Support for MIREME (US$2.0million)	
Objective	To conduct capacity building for MIREME and ARENE (Energy Regulatory Authority) which was newly developed
Contents	● Support of adequate planning and regulation of the power sector, in particular for the development of sound mechanism to implement the NESP (National Electrification Strategy and Plan) and the Master Plan (2017–2042) ● Capacity building for methodologies and procedures to calculate electricity tariffs reflective of recognized (or allowed) efficient costs, and mechanisms to promote access and public participation in government-related activities (like planning or tariff processes). ● Support project management related expenses
Subcomponent ②: Capacity Building and Implementation Support for EDM (US$1.5million)	
Objective	To conduct capacity building for EDM
Contents	● Financing consultancy services that will be required to complement and build capacity in EDM for the effective implementation of the NESP and the Master Plan. ● Technical assistance to support two technical studies on the review of the network's protection system and a review of the existing national grid code

Source: WB

2.2.2 Support by USAID

In 2016, USAID launched energy activities within the scope of the Power Africa program. The Supporting the Policy Environment for Economic Development (SPEED+) activity works with public, private, and civil society stakeholders to strengthen the business enabling environment to attract investment, expand markets, and reduce costs, thus contributing to broad-based and inclusive economic growth and conservation of natural resources. SPEED+ includes a flexible energy component of technical assistance and capacity building that is currently focused on (1) On-grid IPP legal reform, and legal and transaction support. Activities include transaction and legal support to MIREME for IPPs and REFIT implementation if required. (2) Off-grid IPP law and regulatory environment. These activities are in coordination with DFID, and include assistance to the Government of Mozambique to review and potentially revise off-grid IPP enabling legislation and fiscal incentives for renewable energy equipment. (3) Support to Independent Regulator. Activities include review of ARENE draft law and implementing regulations and support to ARENE to define capacity needs and principles. Further support to ARENE is being evaluated in line with the planned Norwegian support. (4) Strengthening EDM: Activities include exploring options to implement an energy efficiency activity, support the establishment of a clear and transparent interconnection process to encourage new investments, and reducing costs for customers' connections. Support to the interconnection process is being coordinated with the AfDB. The work plan for 2018-2020 will change based on demand from stakeholders and alignment with Power Africa goals.

Power Africa: In June 2013 President Obama announced Power Africa - an initiative to double the number of people with access to power in Sub-Saharan Africa by unlocking the wind, solar, hydropower, natural gas, and geothermal resources in the region. Power Africa aims to work with African governments, the private sector, and other partners such as the World Bank and the African Development Bank to enhance energy security, reduce poverty, and advance economic growth across the continent. The overarching goals are to add 60 million new electricity connections and 30,000 megawatts of new and cleaner power generation. Power Africa activities in Mozambique are coordinated by the United States Embassy Economic Section, in conjunction with USAID. Other United States Agencies implementing activities in Mozambique include the U.S. Trade and Development Agency and the U.S. Foreign Commercial Service. Areas of intervention include early stage transaction support, finance, and policy / regulatory design and reform. The Power Africa website contains more information on the activities and toolbox available to partners. (https://www.usaid.gov/powerafrica)

2.2.3 Support by AfDB

AfDB is executing Energy IV Project which was approved in September 2006. In this project, transmission lines, transformers, distribution facilities, and meters are installed, more than that issues on social environmental and social consideration are responded. As for transmission lines, AfDB is considering "CAIA-NACALA Electricity Transmission Project".

AfDB is also considering future project of electricity. However, funding will be supposed to respond while looking at the results of IMF program concerning hidden debt. Although IMF require to disclose sufficient information and to reduce national government debts, there is no progress for over a year. AfDB expect to cooperate this master plan through extraction the sub projects such as future distribution projects.

2.2.4 Support for generation development by other donors

Cooperation projects related to generation projects by other donors are described below:

・Rehabilitation of Mavuzi hydropower station (operation capacity: 52MW) and Chicamba hydropower station (operation capacity: 38MW)
They are the projects to upgrade the supply capacity toward Beira area as 90MW base load operation in total. Commissioning year is 2017. Grant aid by AFD, SIDA and KfW.

・Connection to grid from Mocuba PV power station
Transmission lines and Mocuba substation expansion project. Commissioning year is 2018. Grant aid by Norway.

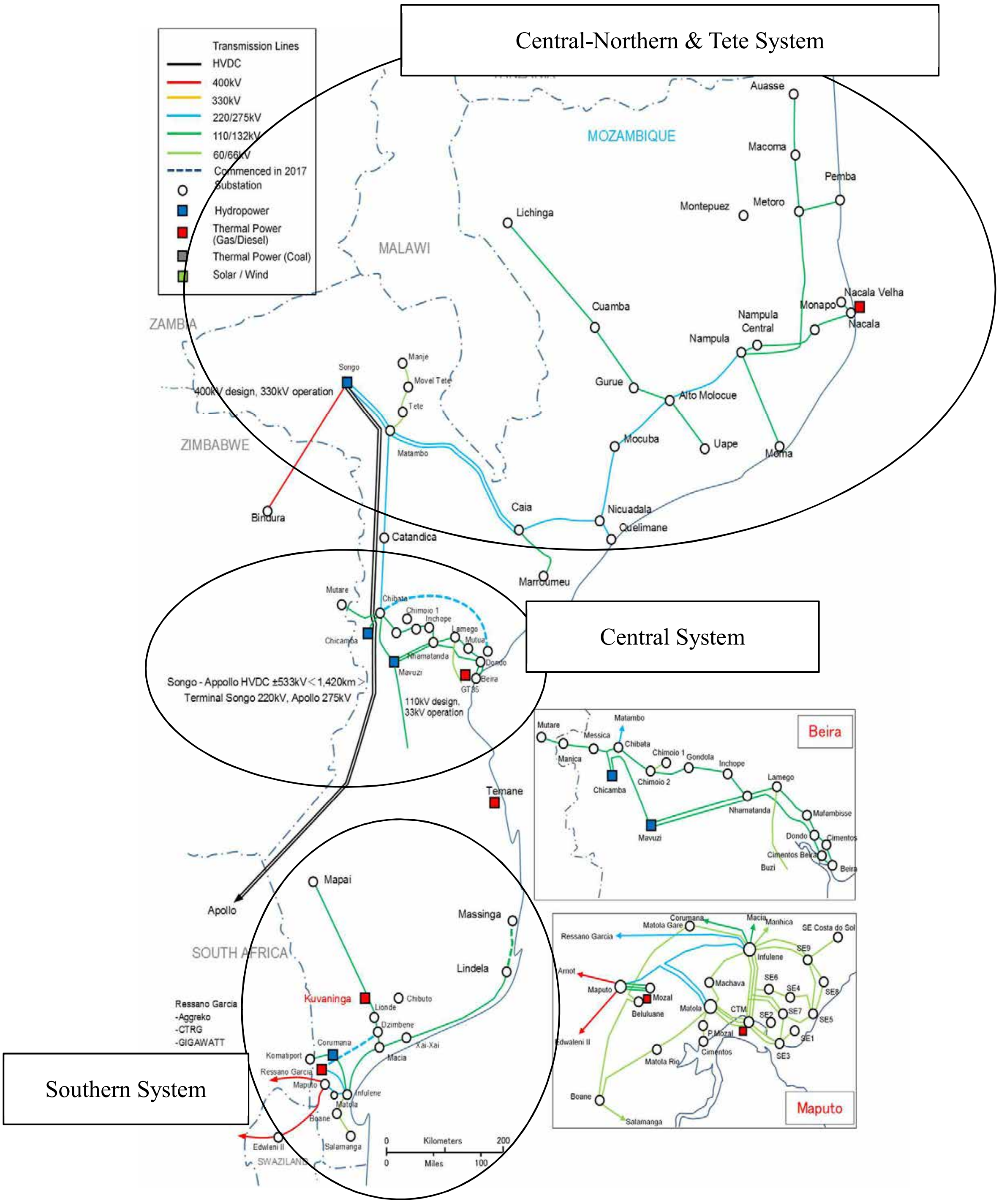
・Development of Metoro PV power station (40MW)
Commissioning year is 2019. Loan aid by AFD.

・Development of Taste hydro power station (operation capacity: 50MW)
The project is under preparation to meet the target that commissioning year is 2025. Grant aid and loan aid by EID, SIDA and KfW.

2.3 Power Supply and Demand

2.3.1 Power System Configuration and Geographical Condition

From the north to south, power system consists of Central-Northern & Tete System, Central System and Southern System. Among them, Central-Northern & Tete System and Central System are connected through 220kV lines between Matambo Substation (S/S) and Chibata S/S. Therefore, there are 2 independent system. Figure 2.3-1 shows present power system.



Source: JICA Study Team

Figure 2.3-1 Present Power System (Including power lines that will commence in 2017)

Power demand record is supervised by ASCs (Área de Serviço ao Cliente) individually. ASC Cuamba and ASC Angoche newly entered in 2016, then total 16 ASCs cover whole nation.

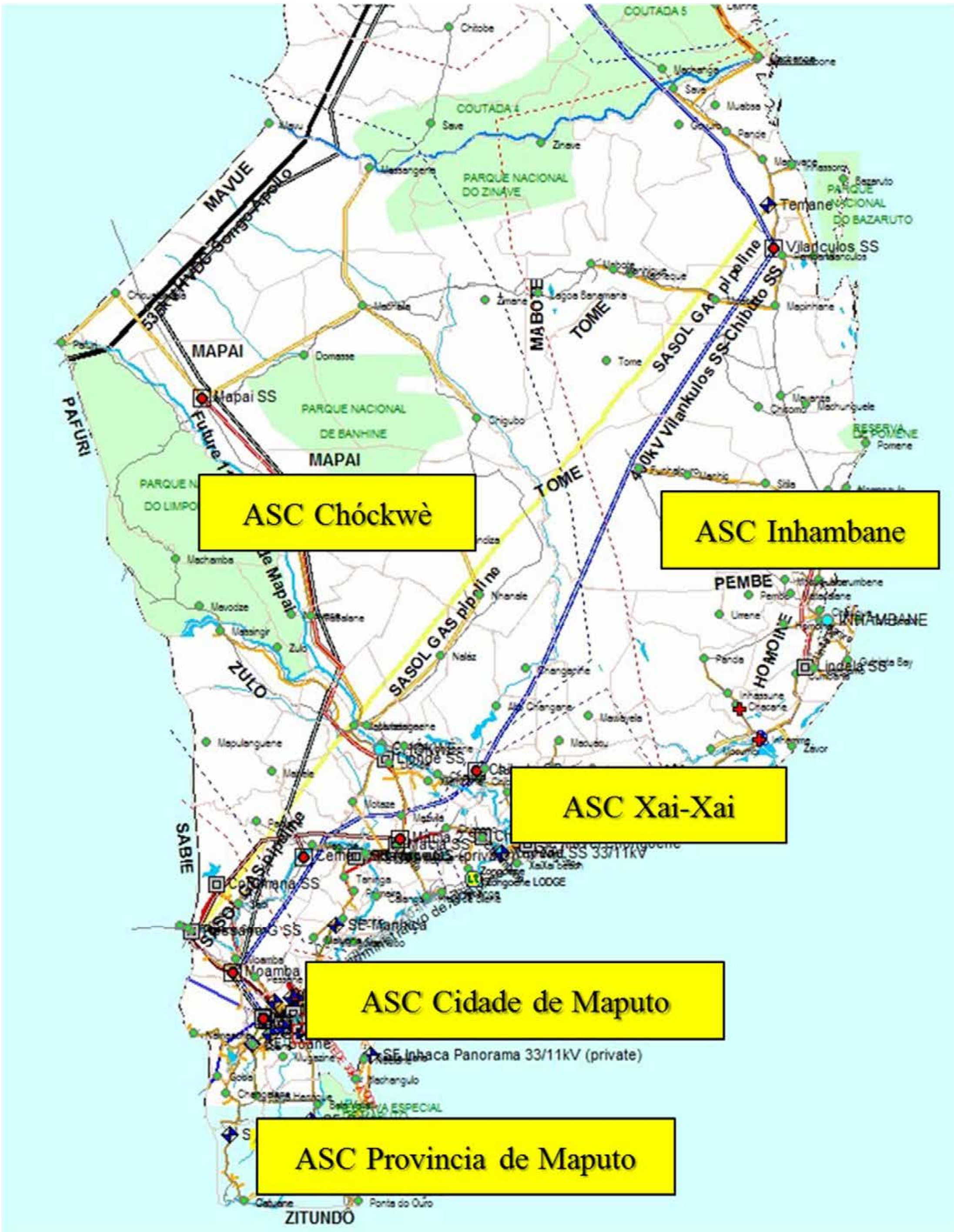
Figure 2.3-4, Figure 2.3-3 and Figure 2.3-4 show areas covered by each ASC, which is 2014 situation that ASC Cuamba and ASC Angoche do not come in. Table 2.3-1 shows which province ASC belongs to.

Source: EDM

Figure 2.3-2 Area covered by each ASC (West of Mozambique)

Source: EDM

Figure 2.3-3 Area covered by each ASC (North of Mozambique)



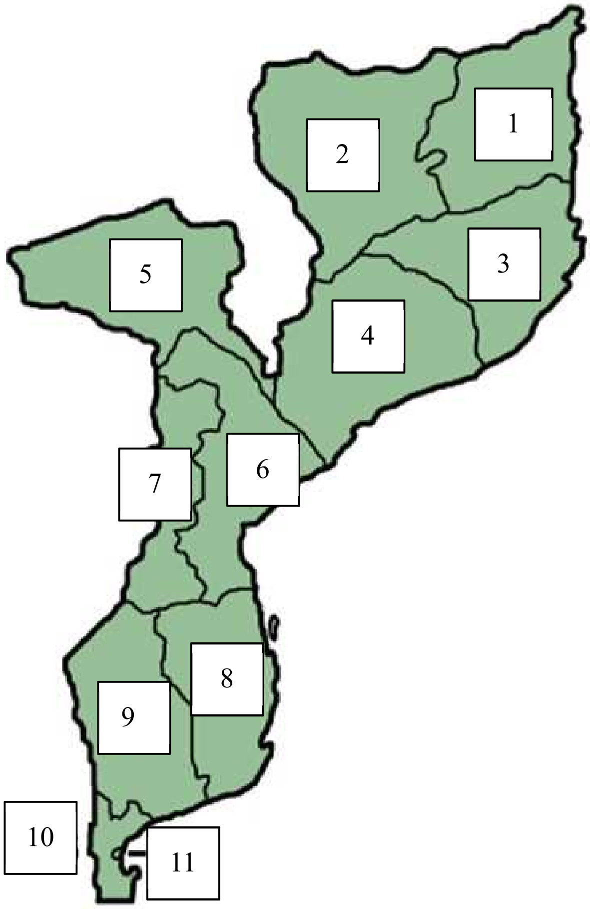
Source: EDM

Figure 2.3-4 Area covered by each ASC (South of Mozambique)

Table 2.3-1 ASCs in the Provinces

	Province	Provincial Capital	ASC
1	Cabo Delgado	Pemba	Pemba
2	Niassa	Lichinga	Lichinga, Cuamba
3	Nampula	Nampula	Nampula, Nacala, Angoche
4	Zambezia	Quelimane	Mocuba, Quelimane
5	Tete	Tete	Tete
6	Sofala	Beira	Beira
7	Manica	Chimoio	Chimoio
8	Inhambane	Inhambane	Inhambane
9	Gaza	Xai-Xai	Chóckwè, Xai-Xai
10	Maputo Province	Matola	Provincia de Maputo
11	Maputo City	-	Cidade de Maputo

Source: JICA Study Team based on EDM information



Source: JICA Study Team

Figure 2.3-5 Provinces in Mozambique

2.3.2 Record of the Demand

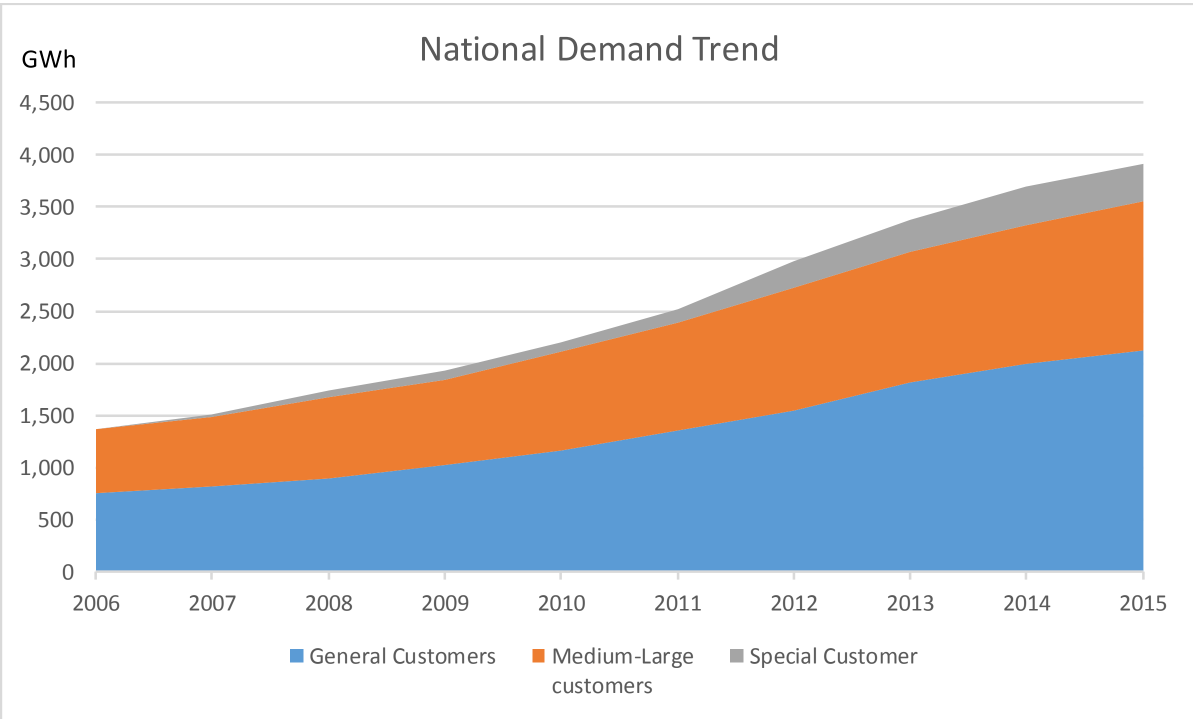
Table 2.3-2 and Figure 2.3-6 show the demand at receiving end from 2006 to 2015. Demand has increased in accordance with economic growth and has reached around 3,908GWh in 2015 including Special Customer. Average Annual Growth Rate (AAGR) was 12.4%. Special customers have come in and its ratio is increasing from 2017.

Table 2.3-2 Record of the Demand from 2006 to 2015 (National)

(Unit: GWh)

Year	General Customers						Medium-Large Customers			Special Customers	Total (Excluding Special Customers)	Total (Including Special Customers)
	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	0.1	42	9.6	751	89	535	624	0	1,375	1,375
2007	195	581	0.1	39	5.6	820	103	567	671	14	1,491	1,505
2008	198	648	0.1	38	6.0	890	112	672	784	60	1,674	1,734
2009	222	751	0.3	42	6.0	1,021	125	701	826	88	1,847	1,935
2010	219	897	0.3	45	6.2	1,168	143	795	938	96	2,106	2,202
2011	245	1,052	0.8	50	5.9	1,354	150	890	1,040	122	2,395	2,517
2012	258	1,233	0.1	53	5.9	1,550	169	1,007	1,175	253	2,725	2,978
2013	322	1,416	25.0	52	6.2	1,821	170	1,080	1,250	310	3,071	3,381
2014	369	1,538	26.1	52	5.9	1,991	174	1,156	1,330	371	3,321	3,692
2015	421	1,653	28.8	17	1.7	2,121	173	1,263	1,436	351	3,557	3,908
											AAGR (2006-2015)	12.4%

Source: JICA Study Team based on EDM Data



Source: JICA Study Team

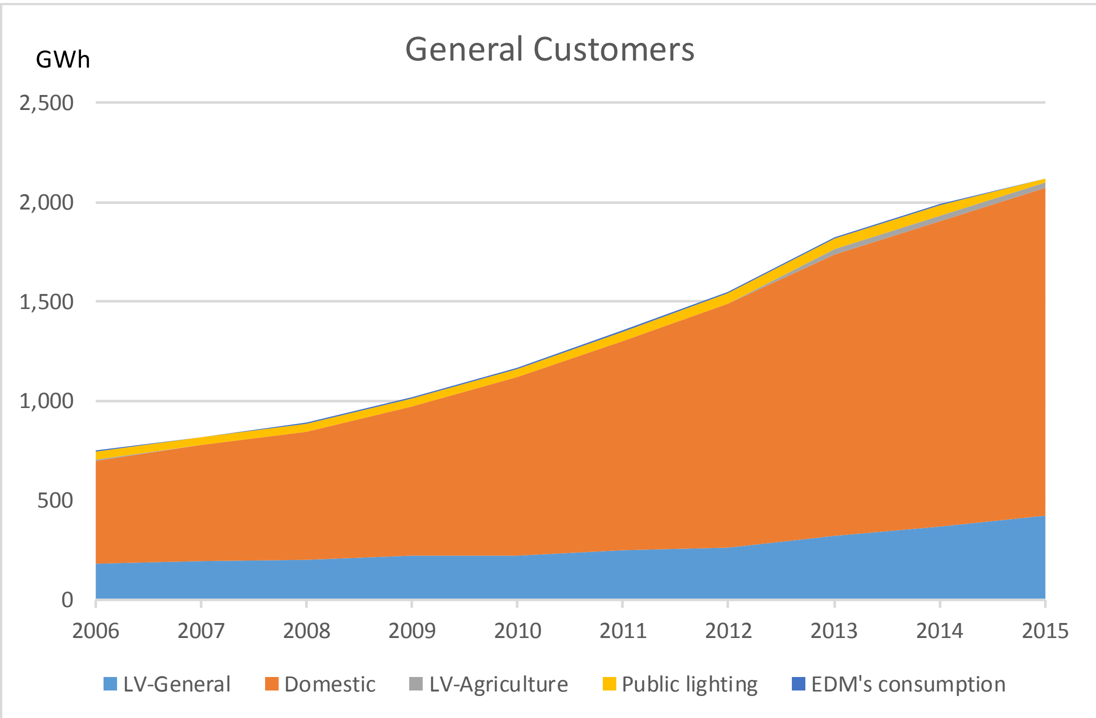
Figure 2.3-6 Record of the Demand from 2006 to 2015 (National)

Figure 2.3-7 shows each element of General Customer. Domestic (household) is the dominant and is followed by LV-General (small consumer supplied by low voltage). The portion of agriculture is not big. On the other hand, Figure 2.3-8 shows each element of Medium-Large Customer. Medium Voltage (MV) or High Voltage (HV) Customer is dominant and has being increasing its ratio and is followed by LV-

Big Customer. LV means 1kV and less, MV means more than 1kV and less than 66kV, HV means 66kV and more. The detail is described in the Table 2.3-3.

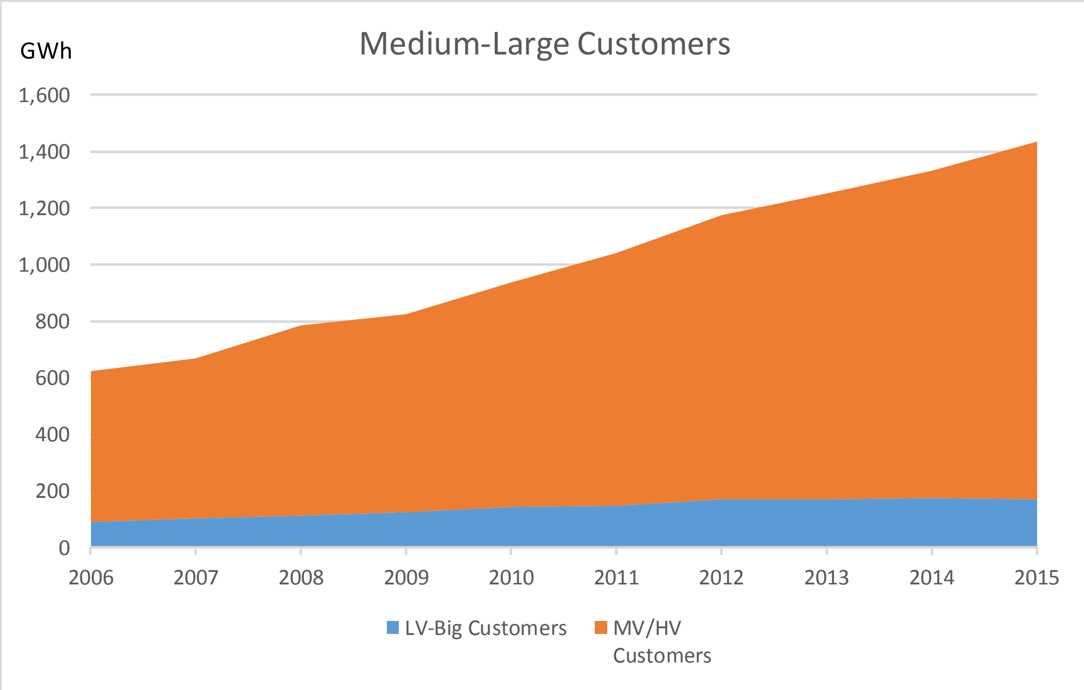
Table 2.3-3 Definition of Voltage and Customer

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



Source: JICA Study Team

Figure 2.3-7 Record of the General Customer from 2006 to 2015



Source: JICA Study Team

Figure 2.3-8 Record of the Medium-Large Customer from 2006 to 2015

Table 2.3-4 and Figure 2.3-9 show record of maximum demand (sending end) of national level and 3 system level (Southern System、Central System、Central-North & Tete System) from 2006 to 2015 respectively.

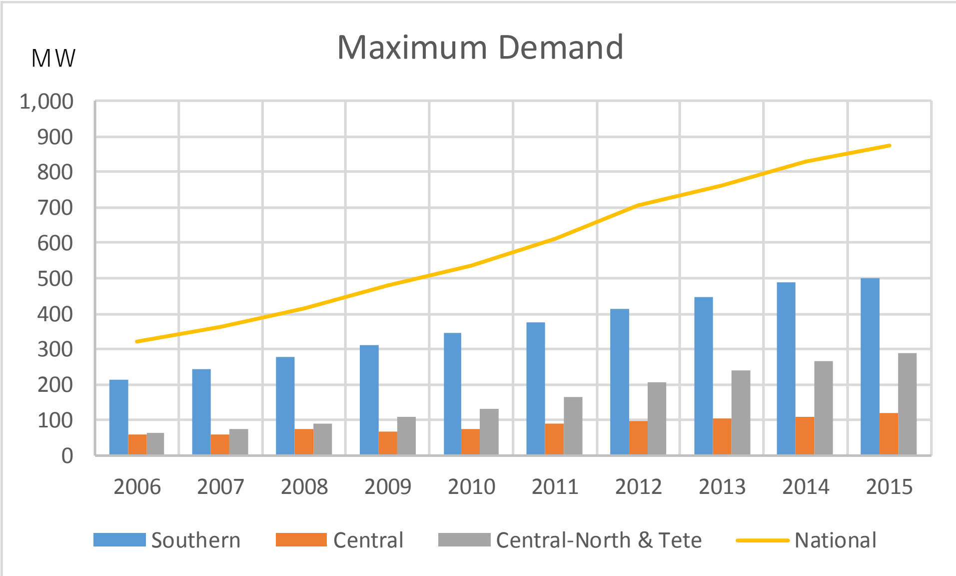
National demand reached 875MW in 2015. With respect to AAGR, national level was 11.9%, on the other hand AAGR of Central-North & Tete which has Tete province where coal mining is under development and Nampula province was 18.4%.

Table 2.3-4 Record of the Maximum Demand (sending end) from 2006 to 2015

(MW)

Year	Southern	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	121	291	875
AAGR (2006-2015)	9.8%	8.9%	18.4%	11.9%

Source: EDM Annual Report



Source: EDM Annual Report

Figure 2.3-9 Record of the Maximum Demand (sending end) from 2006 to 2015

2.3.3 Record of the Power Supply

Table 2.3-5 shows the power supply record and its ratio by suppliers from 2006 to 2015. The share of EDM has been decreasing and it was only 3% in 2015. On the other hand, HCB was a major supplier. Up to 2014 HCB had kept 90% share however the ratio reduced to 76% in 2015 because CTRG (IPP) and others started operation.

Table 2.3-5 Power Supply Record from 2006 to 2015

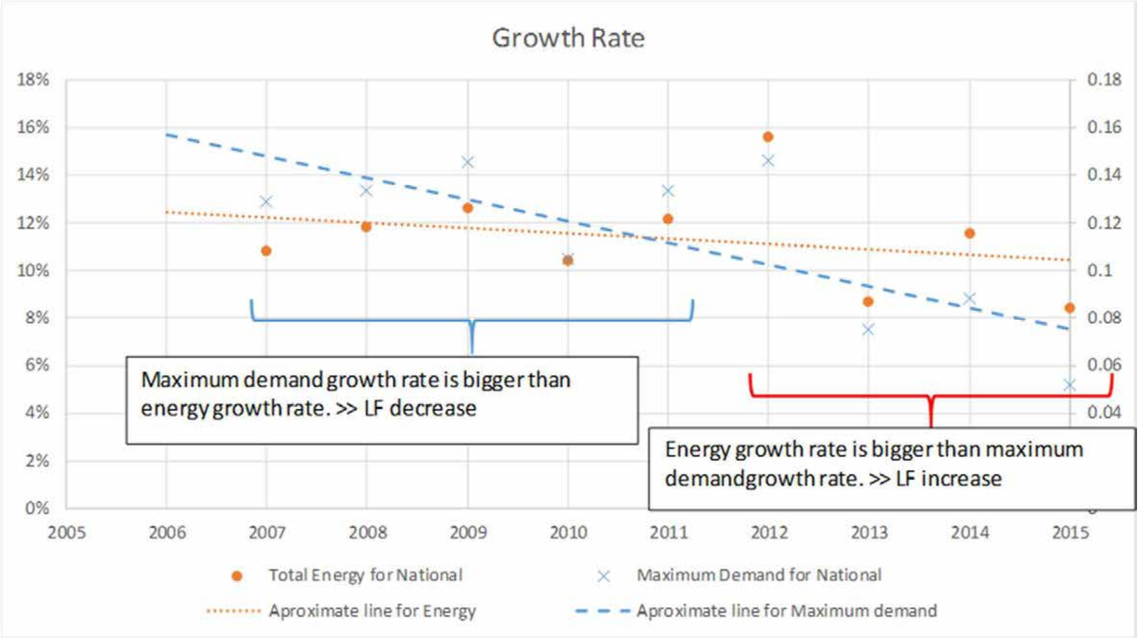
(GWh)

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

Source: EDM Annual Report

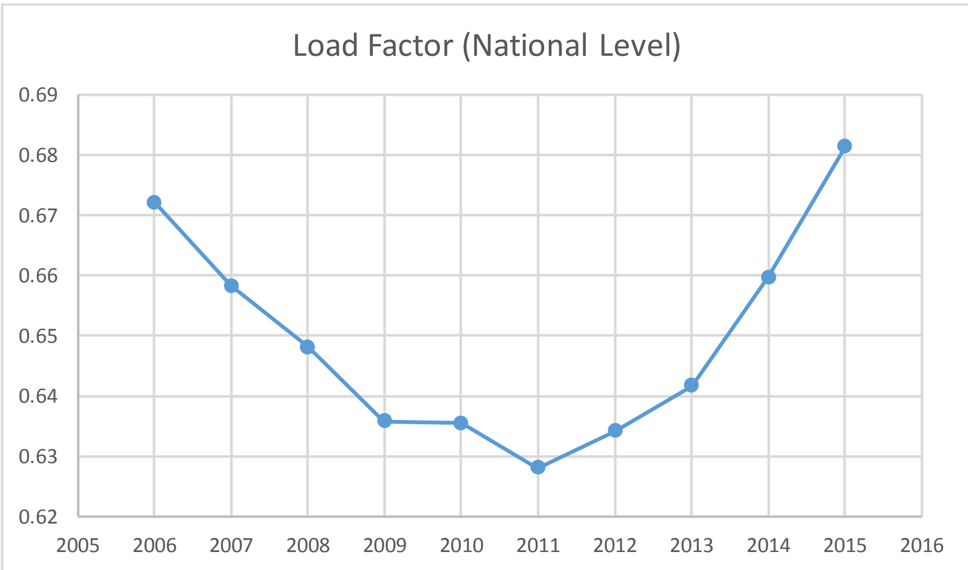
2.3.4 Comparison of Growth Ratio between Energy Consumption and Maximum Demand

Figure 2.3-10 shows the Comparison of growth ratio between energy consumption and maximum demand at the sending end. Maximum demand growth ratio exceeded energy consumption growth ratio until 2010, then it reversed the order. This represents the decreasing trend of load factor have changed with increasing trend since 2012. Figure 2.3-11 also shows this condition visually.



Source: JICA Study Team

Figure 2.3-10 Comparison of Growth Ratio between Energy Consumption and Maximum Demand from 2006 to 2015



Source: EDM Annual Report

Figure 2.3-11 Record of the Load Factor from 2006 to 2015

2.3.5 Coincidence Factor for Consolidation

Maximum demand at the sending end of the national level is different from the total of 3 power system at the sending end. Because that time maximum demand of one system occurs is different from the others. Table 2.3-6 shows the 5-year record of the coincidence factor for 3 power systems consolidation. It was 0.96 in 2015 and this value had leveled off recently. In addition, Table 2.3-7 shows the 5-year record of the coincidence factor for 11 provinces consolidation. Here, maximum demand at the sending end of province is calculated from the consumption at the receiving end utilizing loss ratio and load factor. It has been decreasing and it was 0.89 in 2015.

Table 2.3-6 Record of the Coincidence Factor for 3 Power Systems Consolidation

Year	Southern (MW)	Central (MW)	Central-North & Tete (MW)	National (MW)	Coincidence Factor
2011	374	88	164	610	0.974
2012	412	96	206	706	0.989
2013	448	103	241	761	0.961
2014	487	109	265	831	0.965
2015	499	121	291	875	0.960

Source: EDM Annual Report

Table 2.3-7 Record of the Coincidence Factor for 11 Provinces Consolidation

(MW)

	Cabo Delgado	Niassa	Nampula	Zambézia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo city	Total of Province	National_from AR	Coincidence Factor
2011	15.1	9.2	69.5	22.4	23.0	29.5	60.4	14.7	32.5	155.5	187.6	619.4	610.0	0.985
2012	19.5	10.8	84.6	28.9	32.2	58.6	70.3	19.1	48.7	159.9	205.1	737.7	706.0	0.957
2013	24.1	13.8	100.0	32.4	41.0	74.9	78.3	21.3	47.5	169.7	211.0	813.9	761.0	0.935
2014	27.9	17.8	104.7	38.2	32.7	80.9	84.7	23.5	67.1	158.3	222.0	857.7	831.0	0.969
2015	34.4	19.0	128.0	43.6	33.8	88.3	95.8	24.0	54.3	225.5	231.3	978.1	875.0	0.895

Source: EDM Annual Report

2.3.6 REFIT

REFIT (Regulamento que Estabelece o Regime Tarifario para as Energias Novas e Renovaveis), which is the FIT scheme in Mozambique that electricity generated by renewable energy is purchased at the predefined price. This scheme was approved in the cabinet council on September 30th, 2014 as Decree No. 58. Main items prescribed in this decree are as follows:

- Projects whose capacity is between 10 kW and 10 MW are the target
- Projects either government or private entities is acceptable
- The distance to the connecting point of EDM should be less than 10km and there is no impact to the power system
- Off-taker is EDM
- Construction cost is on project owners
- Purchase price shall be revised every 3 years by the Minister of MIREME with the opinions of Minister of Ministério da Economia e Finanças (MEF)

Table 2.3-8Table 2.3-8 shows the purchase price.

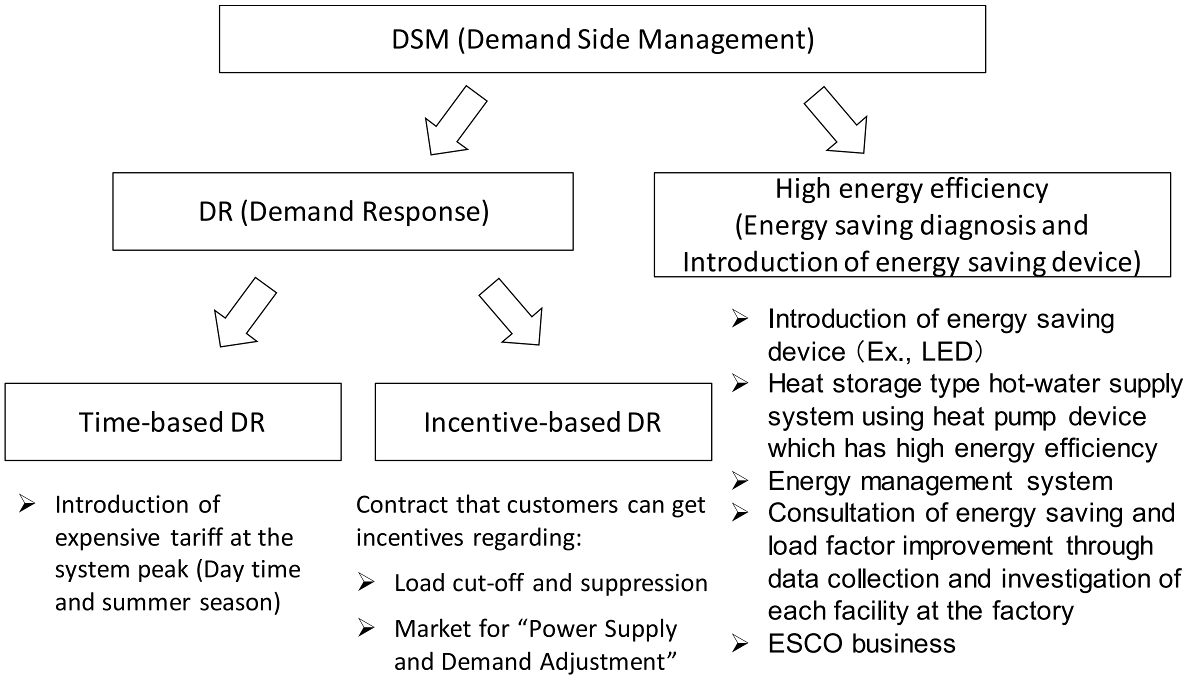
Table 2.3-8 Purchase Price of Renewable Energy

Installed capacity	Biomass (Mt/kWh)	Wind Power (Mt/kWh)	Hydro Power (Mt/kWh)	PV (Mt/kWh)
10kW		8.00	4.81	13.02
50kW		7.63	4.59	12.71
100kW		7.13	4.34	12.31
150kW		6.67	4.09	11.90
200kW		6.39	3.94	11.69
250kW		6.36	3.91	11.63
500kW	5.74	6.11	3.75	11.32
750kW	5.46	5.86	3.60	11.04
1MW	5.36	5.61	3.44	10.73
2MW	5.02	5.27	3.16	9.86
3MW	4.65	4.99	2.95	9.02
4MW	4.56	4.81	2.79	8.56
5MW	4.43	4.65	2.70	8.40
6MW	4.34	4.50	2.57	8.25
7MW	4.25	4.34	2.48	8.09
8MW	4.15	4.22	2.39	8.00
9MW	4.12	4.19	2.36	7.94
10MW	4.06	4.12	2.29	7.91

Source: Decree No.58

2.3.7 DSM（Demand Side Management）

It is common that generation is prepared to meet increasing demand. On the contrary, DSM (Demand Side Management) is the countermeasure focusing on demand side, which has the equivalent effect of generation installation. Figure 2.3-12 shows the outline of DSM. DSM is mainly divided into two categories. One is DR (Demand Response) which is expecting consumption response of customers, the other is Energy efficiency. Furthermore, DR consists of Time-based DR and Incentive-based DR. Table 2.3-9 shows it in detail.



Source: JICA Study Team

Figure 2.3-12 Outline of DSM

Table 2.3-9 Classification of DR

Classification	Contents
Time-based DR	To set the tariff deference (setting tariff high during peak time) leads to the fact that customers voluntary shift the electricity consumption from the peak time to the off-peak time that tariff is low.
Incentive-based DR	➢ Reward is given to customers by contracting with supplier on acceptance of load shedding and load suppression during severe supply-demand situation ➢ Reward is given to customers toward the trade the reduced load of customers in the market.

Source: JICA Study Team

Energy management system is the series consist of system generating, storage and usage effectively. When it comes to household level, it is HEMS (Home Energy Management System), on the other hand, building like commercial level, it is BEMS (Building Energy Management System).

Furthermore, ESCO (Energy Service Companies) is the business that providing comprehensive service on energy saving and contributing to customer profit and global environmental protection. It started in late 1990's in Japan. In USA, it started as business in 1970's.

EDM realizes DSM is one of the effective approaches against the demand increase and organized the department, Energy Efficiency Directorate (EED), seven years ago so that EDM could promote the activities on energy efficiency especially. In addition, EDM prepared the *Energy Efficient and Demand Side Management Strategy / Master Plan, Demand Market Participation (DMP) Strategy* based on the proposal of the consultant to accelerate DSM activities. Table 2.3-10 shows the outline of *Energy Efficient and*

Demand Side Management Strategy / Master Plan and Table 2.3-11 shows the outline *Demand Market Participation (DMP) Strategy.*

Table 2.3-10 Outline of *Energy Efficient and Demand Side Management Strategy / Master Plan* (As of April 2012)

Comprehensive strategies that EDM should take
● Support for the demand decline with the enhancement of the DSM activities ● Tariff setting leads to the peak cut ● Requirement of the legal system development ● Reasonable incentive offers related to the finance ● Requirement of private sector for procurement, construction and O&M
Strategy for the short term (1 year) (As of April 2012)
● Adoption of TOU (Time of Use) tariff for MV customers and HV customers ● The launch of service to promote peak shift ● The launch of Demand Market Participation (DMP) for the top 100 customers ● The Selection of the target customers to grant high efficient lamp ● Promotion of the loss reduction by the split meter installation ● Expansion of the subsidy offer toward heat pump, heating system by solar power, etc. ● Publication of the pilot study implementation ● Holding the conference on DSM and energy efficiency

Source: EDM

Table 2.3-11 Outline of *Demand Market Participation (DMP) Strategy* (As of September 2012)

Comprehensive strategies that EDM should take
● Maximum utilization of both ends facilities, supply and receiving in emergency ● Regulation of power system operation in emergency ● Achievement of DMP 20MW in 2012
Practical activities to achieve the above strategies
● Introduction to large-size MV customers and HV customers about DMP ● Relationship development between customers above and EDM ● Contracting with customers willing to participate in exchange for fair compensation ● The Optimal dispatch of declined demand by SO ● Compensation for DMP will be by way of direct payment to the customer. ● DMP participation and price determination based on market principles. ● Optimal control of available supply / demand options by SO ● Proper metering of reduced demand

Source: EDM

DMP is to conclude contract with customers which have customers reduce their load in case of supply shortage. EDM give the reward to customers based on the amount of reduction.

EDM have conducted the project in the norther area, Nampula, Nacala and Pemba which 500,000 conventional lamps are changed with CFL (Compact Fluorescent Lamp) for free. As Table 2.3-12 shows that about 380,000 lamps have been replaced and 16MW power reduction has been achieved. Amount of CO2 emission was reduced 36,200t/year as well. In this project, EDM held on-site meetings to get the residents understandings in advance. Figure 2.3-13 shows the on-site meetings.

Table 2.3-12 Achievement of Replacement to CFL (EDM Energy Efficiency Activities)

(Unit: number)

	L.INCANDESCENTES		CFL		RESULTADOS TEÓRICOS	
	40W+60W	75W+100W	15W	20W	TOTAL	POUPANÇA [MW]
NACALA	97 361	32 007	98 264	30 673	128 937	6
NAMPULA	149 268	32 028	149 412	31 992	181 404	7
PEMBA	49 846	20 076	50 033	19 894	69 927	3
TOTAL	296 475	84 111	297 709	82 559	380 268	16

Source: EDM

Source: EDM

Figure 2.3-13 On-site Meetings of Replacement to CFL (EDM)

EDM is planning to propose the law development by 2018 to accelerate the CFL installation.

2.3.8 Captive Power

Captive power is an independent power owned by customers. It is commonly installed in big customers which cannot stop their production line, hospitals, broadcasting stations, etc. In addition, in case of computing business, even though instantaneous voltage drop is not allowed, therefore there are some customers that install both captive power and battery.

Captive power whose capacity is 10kVA and more is registered with MIREME (755 units and 104MVA in capacity have been registered as of March 2017). Small captive power less than 10kVA and 10kVA and more captive power before 2005 are not registered. There is no obligation for owners of captive power to report the data of electricity production. Therefore, electricity production from captive power is not available.

Table 2.3-13 shows the list of 1MVA and more captive power.

Table 2.3-13 Captive Power whose capacity is 1MVA and more

Nº & Category of Instalation	Power (KVA)	Owner	Location
4090/5ª C/07	6,000.0	Kemene Moma Processing	Moma - Nampula
6143/5ª C/16	5,600.0	Coca-Cola Moçambique, Lda	Matola Gare
6114/5ª C/16	3,200.0	INCT - Instituto Nacional de Ciências e tecnologia - E.P Maluane	Maluane - Manhiça
6091/5ª C/15	2,000.0	Vodacom Moçambique Central	
6089/5ª C/15	1,800.0	Edificio Plantinum Promovolor Moçambique Imobiliario S.A	Bairro da Polana Cimento
4981/5ª C/12	1,600.0	Movitel S.A	Av.Mohamed Saiad Barre, nº.225
4999/5ª C/12	1,600.0	JAT Constroi, Lda	Rua dos Disportista, nº.833
5286/5ª C/13	1,347.5	Gigawatt - Ressano Garcia	Bairro Ressano Garcia
5289/5ª C/13	1,250.0	Gigawatt - Ressano Garcia	Bairro Ressano Garcia
5504/5ª C/14	1,250.0	Banco Standard Bank - Nova Sede	
4808/5ª C/11	1,000.0	Construções Catembe, Lda "Edificio da Vodacom"	Rua presidente Carmona
5116/5ª C/12	1,000.0	Incomati - River Paulo Houwana	Bairro da Massinga - Marracuene
5207/5ª C/13	1,000.0	Cartrack	Av.Moçambique, nº.2600, Bairro de Jardim
5241/5ª C/13	1,000.0	Investimentos Imobiliario, S.A	Av.J.Nyerere, nº.882
5303/5ª C/13	1,000.0	Millennium Bim - Nova Sede	Rua dos disportistas
5983/5ª C/15	1,000.0	Souther Sun Moçambique, Lda	Av. Da Marginal-4096
6125/5ª C/16	1,000.0	Inalca - Industria Alimentar de Carne	Av.Moçambique Km 9.5

Source: MIREME

There is no obligation for owners of captive power to report actual data of electricity production. Therefore, to evaluate the influence of captive power was not possible.

2.4 Social and Economic Situation

2.4.1 Political Situation

The western countries assisted Mozambique in the years immediately following its independence including the Scandinavian countries. Then the Soviet Union became the primary economic, military and political supporter, and its foreign policy reflected the socialist policy. This began to change in 1983; in 1984 Mozambique joined the World Bank and International Monetary Fund. The supports from the Scandinavian countries of Sweden, Norway, Denmark and Iceland quickly replaced the Soviet Union's support.

In 1980s, the economy of Mozambique was devastated due to the civil war and drought. After the 1992 civil war peace agreement, the political situation was stabilized and the country's first democratic election of 1994 was realized. As a result, the Front for the Liberation of Mozambique (FRELIMO) became the dominant political force in the country. In January of 2015 Mozambique's fourth president, Filipe Nyusi, came into office following FRELIMO's victory in the October 2014 general elections. RELIMO also secured a strong majority in the parliament.

Finland and the Netherlands are becoming increasingly important sources of development assistance. Italy also maintains the foreign relations with Mozambique. Portugal, the former colonial power, continues to be important because Portuguese investors play a visible role in Mozambique's economy.

2.4.2 Economic Situation

The peace agreement of civil war and the successful economic reform have led to a high economic growth. The country achieved an average annual rate of economic growth of 8% between 1996 and 2006 and between 6 to 7% from 2006 to 2011. The devastating floods of early 2000 slowed GDP growth to 2.1% but a full recovery was achieved in 2001 with growth of 14.8%.

The previously undisclosed debt worth $1.4 billion, 10.7% of Mozambique's gross domestic product (GDP), was discovered in April 2016. This has led to a substantial increase in debt ratios and the debt service burden along with the deterioration of the exchange rate. As a result, the fiscal position is likely to remain uncertain for some years to come. The large-scale gas development projects may not yield significant fiscal revenues before the large external debt obligations fall due.

Table 2.4-1 Major Economic Indicator

<table>
<tr><th>Information</th><th>Data</th><th>Source</th></tr>
<tr><td>Population</td><td>28.751 million (2017, estimate)</td><td>IMF World Economic Outlook</td></tr>
<tr><td>Gross Domestic Product - GDP</td><td>USD 11.4 billion (2017, estimate)</td><td>International Monetary Fund (IMF) World Economic Outlook (WEO) database</td></tr>
<tr><td>Real GDP growth</td><td><table>
<tr><td>2006</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td></tr>
<tr><td>9.9%</td><td>7.4%</td><td>6.9%</td><td>6.4%</td><td>6.7%</td><td>7.1%</td></tr>
<tr><td>2012</td><td>2013</td><td>2014</td><td>2015</td><td>2016*</td><td>2017*</td></tr>
<tr><td>7.2%</td><td>7.1%</td><td>7.4%</td><td>6.6%</td><td>4.5%</td><td>5.5%</td></tr>
</table>*Estimate</td><td>Ditto</td></tr>
<tr><td>GDP per capita - current prices</td><td>USD 387.5 (2017, estimate)</td><td>Ditto</td></tr>
<tr><td>GDP - composition by sector</td><td>agriculture: 25.3%
industry: 19.8%
services: 54.9%
(2016 estimate)</td><td>CIA - World Fact Book</td></tr>
<tr><td>Inflation</td><td><table>
<tr><td>2013</td><td>2014</td><td>2015</td><td>2016*</td><td>2017*</td></tr>
<tr><td>4.2%</td><td>2.3%</td><td>2.4%</td><td>16.7%</td><td>15.5%</td></tr>
</table>*Estimate</td><td>International Monetary Fund (IMF) World Economic Outlook (WEO) database</td></tr>
<tr><td>Public debt (General government gross debt as a % of GDP)</td><td><table>
<tr><td>2013</td><td>2014</td><td>2015</td><td>2016*</td><td>2017*</td></tr>
<tr><td>53.1%</td><td>62.4%</td><td>86%</td><td>112.6%</td><td>103.2%</td></tr>
</table>*Estimate</td><td>Ditto</td></tr>
<tr><td>Public deficit (General government net lending/borrowing as a % of GDP)</td><td><table>
<tr><td>2013</td><td>2014</td><td>2015</td><td>2016*</td><td>2017*</td></tr>
<tr><td>-2.6%</td><td>-10.7%</td><td>-7.4%</td><td>-5.8%</td><td>-4%</td></tr>
</table>*Estimate</td><td>Ditto</td></tr>
<tr><td>Current account balance</td><td>US$ --3.235 billion (2017 estimate)</td><td>IMF World Economic Outlook</td></tr>
<tr><td>Current account balance by percentage of GDP</td><td>-28.26%</td><td>Ditto</td></tr>
</table>

As stated above, the economy of Mozambique in 2017 will be below the level of 2015. The inflation rate will also remain higher than that of 2015. The economy is expected to regain the strength by the new IMF program that started in 2017.

2.4.3 Major Industry

It is recognized that more than fifty percentage of the GDP by sector accounts for the service industry, which is followed by the agriculture (25%), and mining industry (20%). The agricultural industries used to be the main such as fishery and nuts production. Mozambique is rich in the mineral resources such as coal, ruby and garnet. In addition, the large-scale natural gas resources have been found and developed since 2012.

Coal is one of the major mineral resources in Mozambique, of which the projected amount of deposit would be approximately 700 million tons. The" five-year development plan for coal industry" study is implemented with the support from Japan. The deposit amount of 20,000 million tons has been reported in the Tete province as a result of the survey activities.

The gas fields in Mozambique have also been found, which have significant amounts of reserves in the world. The investment from South Africa has been increasing. The gas pipelines from the on-shore gas fields are used for exporting gas to South Africa since 2003. The liquefaction project of natural gas has been proceeded including a Japanese company at the northern area of Mozambique. The production capacity of LNG is 12 million tons. The investment amount would be expected to be the scale of 1,000 billion yen including the associated infrastructure.

Chapter 3 Demand Forecasts

3.1 Outline of Demand Forecast

3.1.1 EDM Current Condition of Demand Forecast

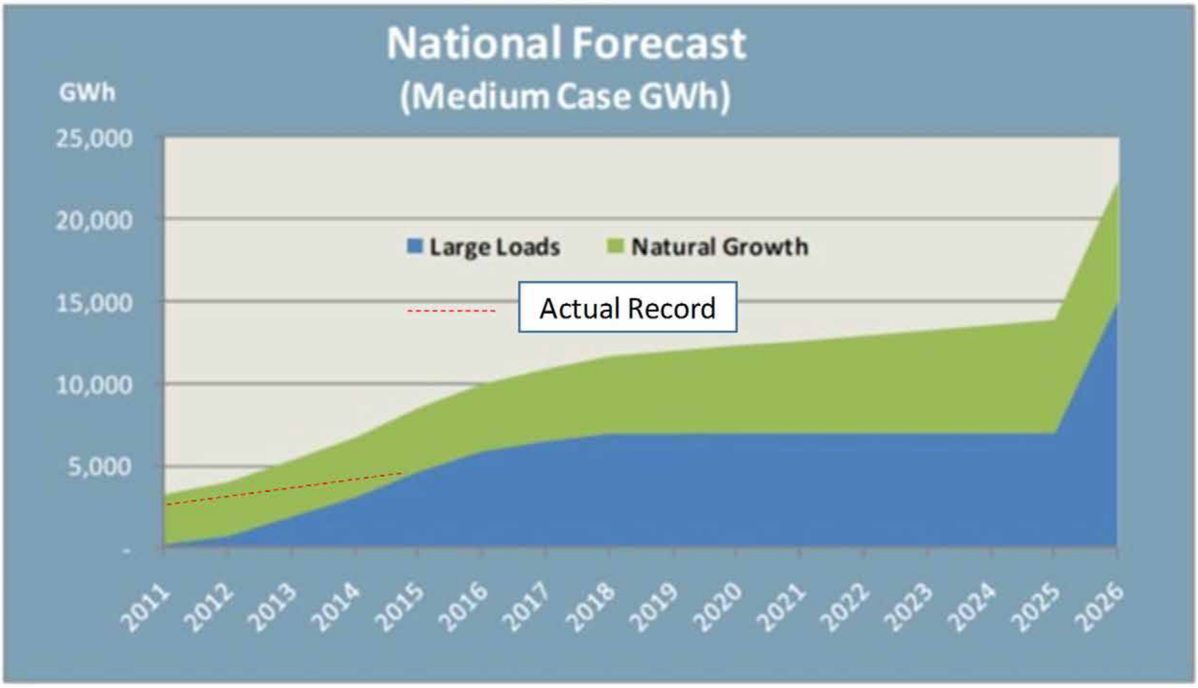
EDM do not forecast demand by themselves and employs the demand forecast in the existing master plan. When some power generation project emerges, area demand is investigated by EDM.

EDM is supposed to assign full-time demand forecast staffs and conduct the demand forecast every year with the knowledge obtained through the JST activities after this master plan is over. Considering these current circumstance, JST created the simple model using available data so that EDM can revise demand forecast.

3.1.2 Demand Forecast of Existing Master Plan and Actual Record

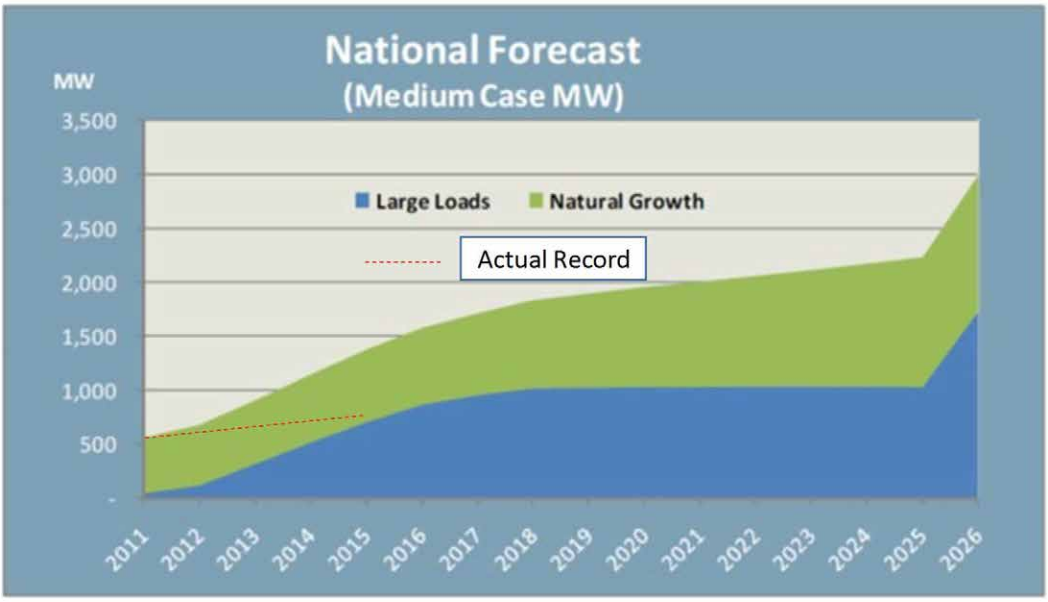
In the existing Master Plan, demand is categorized into two. One of them is "Natural Growth" and forecasted utilizing economic indicators such as GDP growth ratio, income elasticity and price elasticity. The other is "Large Loads" that is large customers with a contract of 2MW and more, which is forecasted by one by one accumulation.

Figure 3.1-1 and Figure 3.1-2 show the forecasted demand in the existing master plan and actual record up to 2015.



Source: Master Plan Update Project, 2012 - 2027

Figure 3.1-1 Demand Forecast of Existing Master Plan (Energy Consumption at the Receiving End)



Source: Master Plan Update Project, 2012 - 2027

Figure 3.1-2 Demand Forecast of Existing Master Plan (Maximum Demand at the Sending End)

Actual record is under the forecast due to the slowdown of the economic growth and the fact that the volume of large customers was lower than estimated.

3.1.3 Customer Categorization

Demand is divided into 3 categories described as Table 3.1-1. Firstly "General Customer" which is households and small customers supplied by LV (Low Voltage). Secondly "Medium-Large (M-L) Customer" which is big customers supplied by LV and MV (Medium Voltage) customers and HV (High Voltage) customers. Finally, "Special Customer", which is customers whose contract is 1MW and more and supplied by 66kV and more.

Table 3.1-1 Customer Categorization

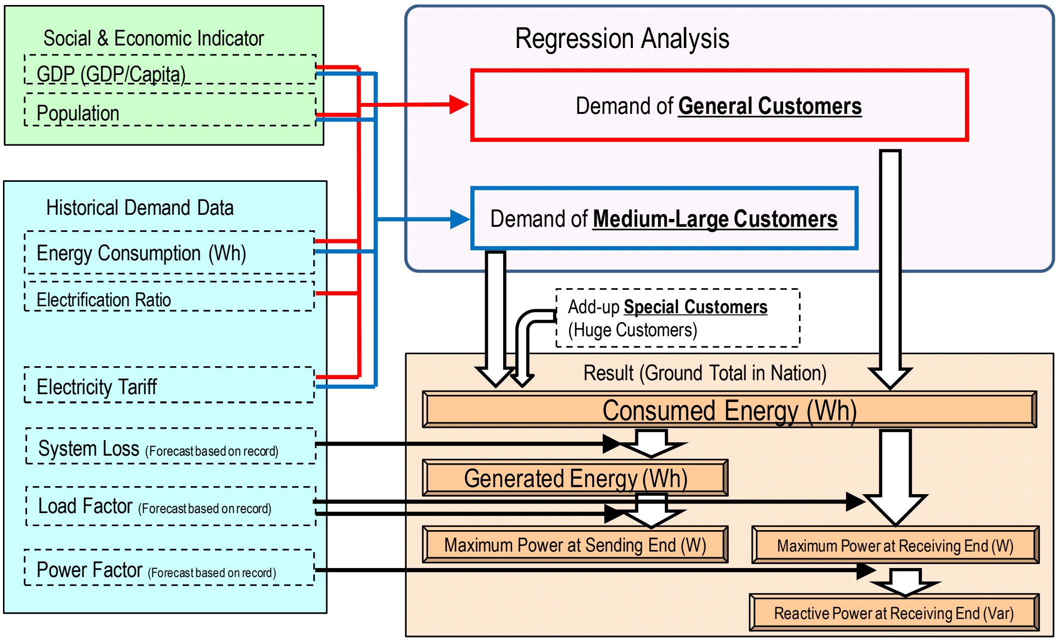
Classification	Customers
General Customer	Domestic, LV (Low Voltage) General, Agriculture, Public Lighting, EDM's consumption
M-L Customer	LV Big customer, MV/HV Customer
Special Customer	Contract is 1MW and more 66kV and more

Source: JICA Study Team

3.1.4 Methodology of Demand Forecast

Demand forecast is generally divided into 2 methods, macro analysis and micro analysis. Macro analysis is the macroscopic analyzing method focusing on broad economic condition of nation or province utilizing indicators like GDP and population with chronological order. On the other hand, micro analysis is the microscopic method focusing on individual and momentary economic condition without chronological order. Considering both methods characteristic, macro analysis is applied to "General Customer" and "M-L Customer". In view of the condition difference between the "General Customer", which is mainly household demand, and "M-L Customer", which is business demand, the demand analyzed by macro analysis is divided into 2 to improve the accuracy. Micro analysis is applied to the "Special Customer" because company condition can be considered individually. Figure 3.1-3 shows the methodology of national level demand forecast.

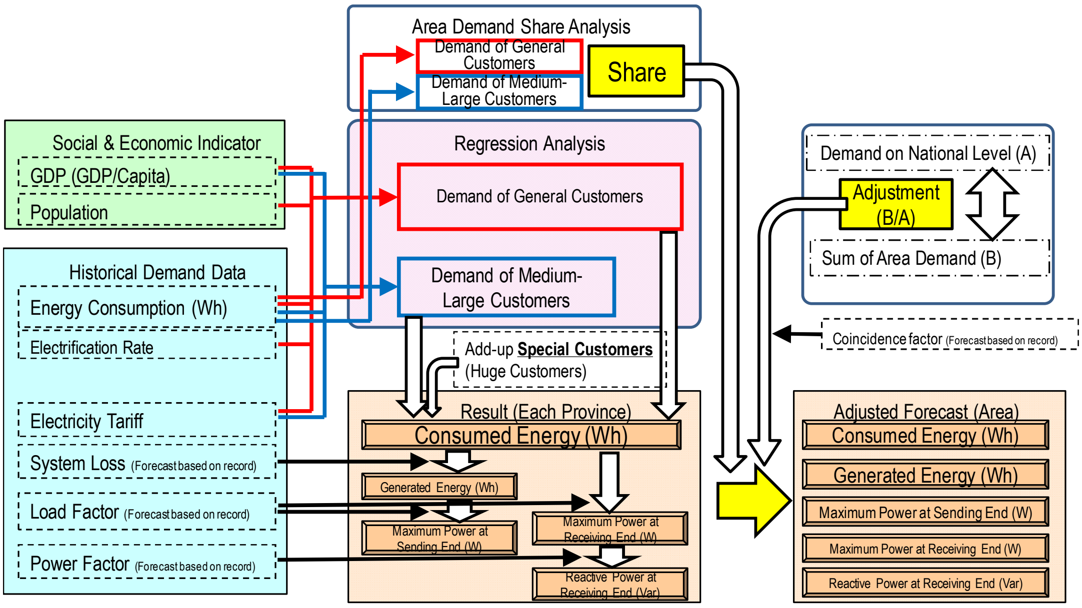
When it comes to the captive power stated in section 2.3.8, it is impossible to evaluate quantitatively because there is no data, however, if there are concrete plan of special customers, they will be counted as minus (-) load. More than that, there was no potential demand data available to evaluate quantitatively. In this demand forecast, past actual data is considered to include both factors, captive power and potential demand, and is used for macro analysis. Regarding DSM stated in section 2.3.7, it can have an impact of demand decrease however presently there is not any practical plan in the future, therefore it was impossible to evaluate quantitatively.



Source: JICA Study Team

Figure 3.1-3 Methodology of National Level Demand Forecast

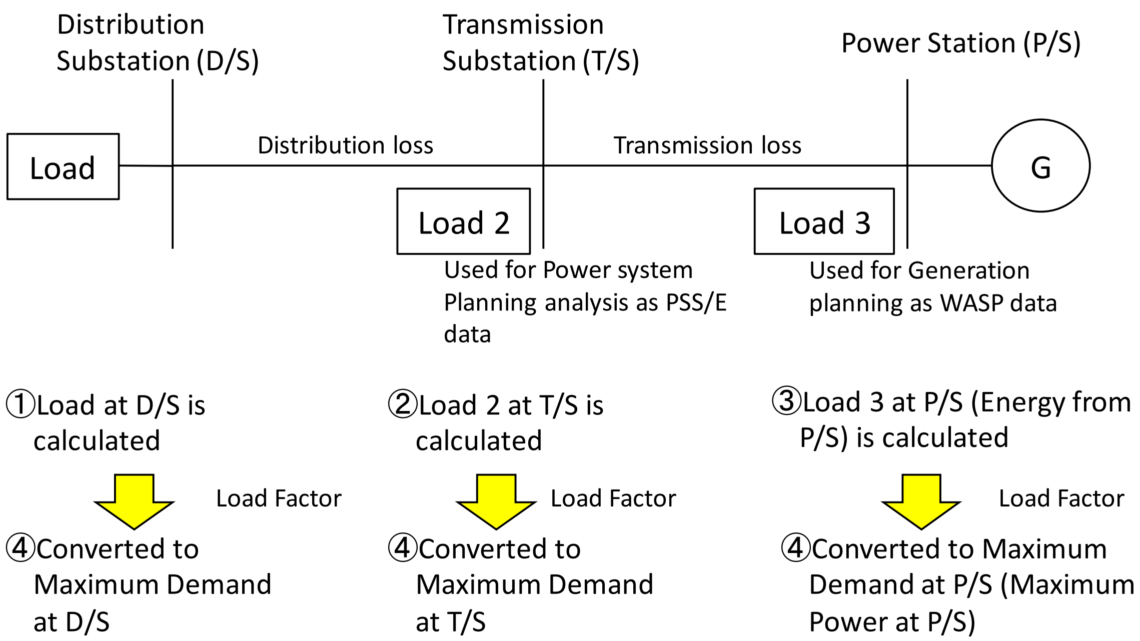
Figure 3.1-4 shows the methodology of provincial level demand forecast. Basic approach is as same as the national level; however the total demand of province demand is adjusted to match the national one with the ratio of province share.



Source: JICA Study Team

Figure 3.1-4 Methodology of Provincial Level Demand Forecast

The demand forecast is the bottom-up approach. At first ① customer side load is calculated then ② load at transmission substation is calculated taking distribution loss into account and then ③ load at power station is calculated taking transmission loss into account. Demand at 3 levels is converted to maximum demand utilizing load factor. Figure 3.1-5 shows the bottom-up approach image.



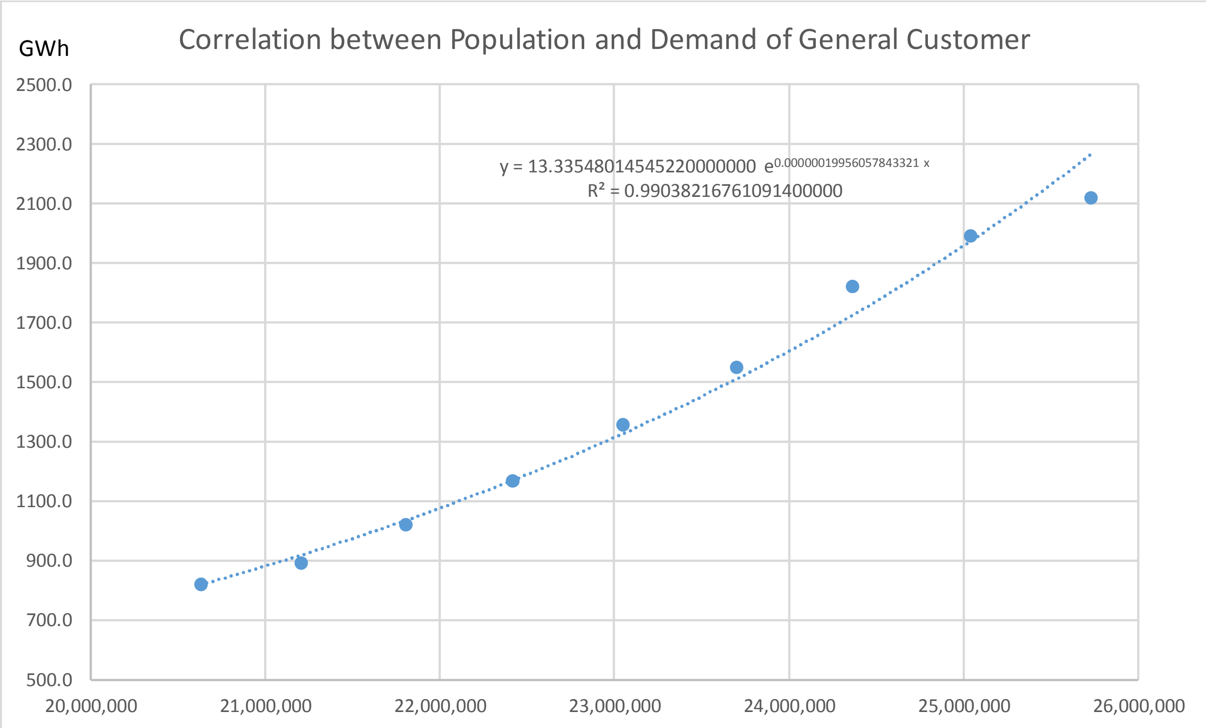
Source: JICA Study Team

Figure 3.1-5 Calculated Point of the Demand Forecast and Image of Bottom-up Approach

3.2 Demand Forecast Precondition of National Level

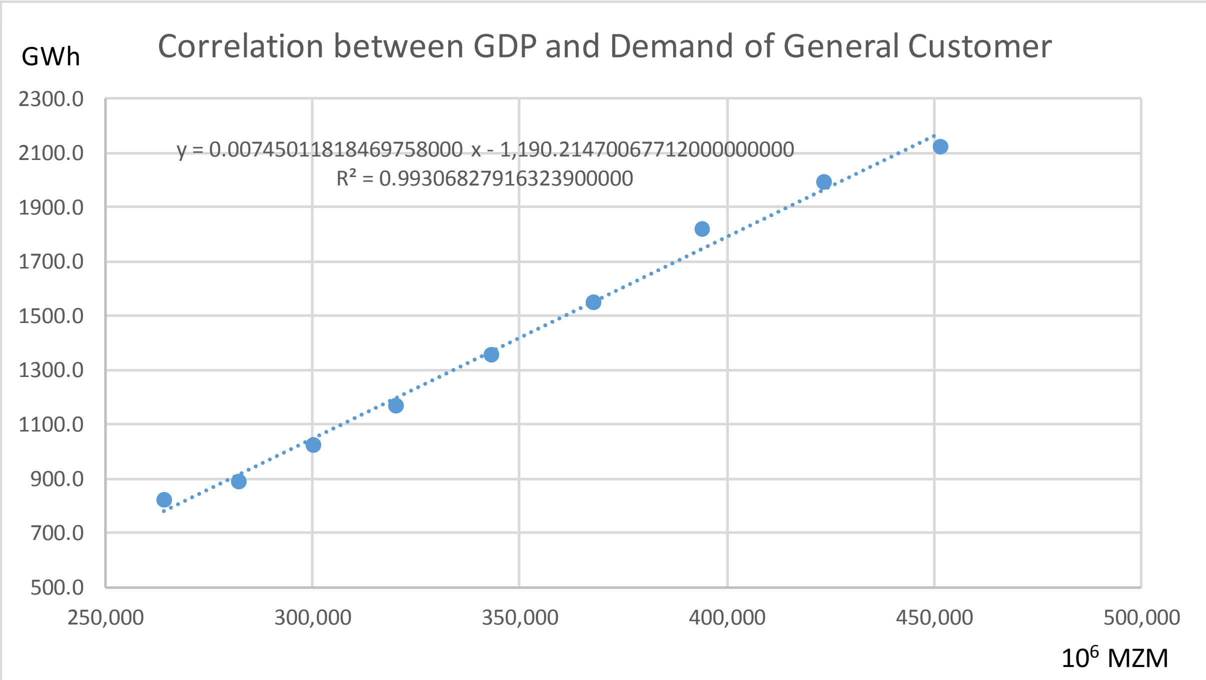
3.2.1 General Customer

The data from 2007 to 2015 in annual report is used. Population, real GDP (2009 is base), electrification ratio and electricity tariff are considered as prospective indicators. Correlation between each indicator and demand of "General Customer" at the receiving end is shown in Figure 3.2-1, Figure 3.2-2, Figure 3.2-3 and Figure 3.2-4.



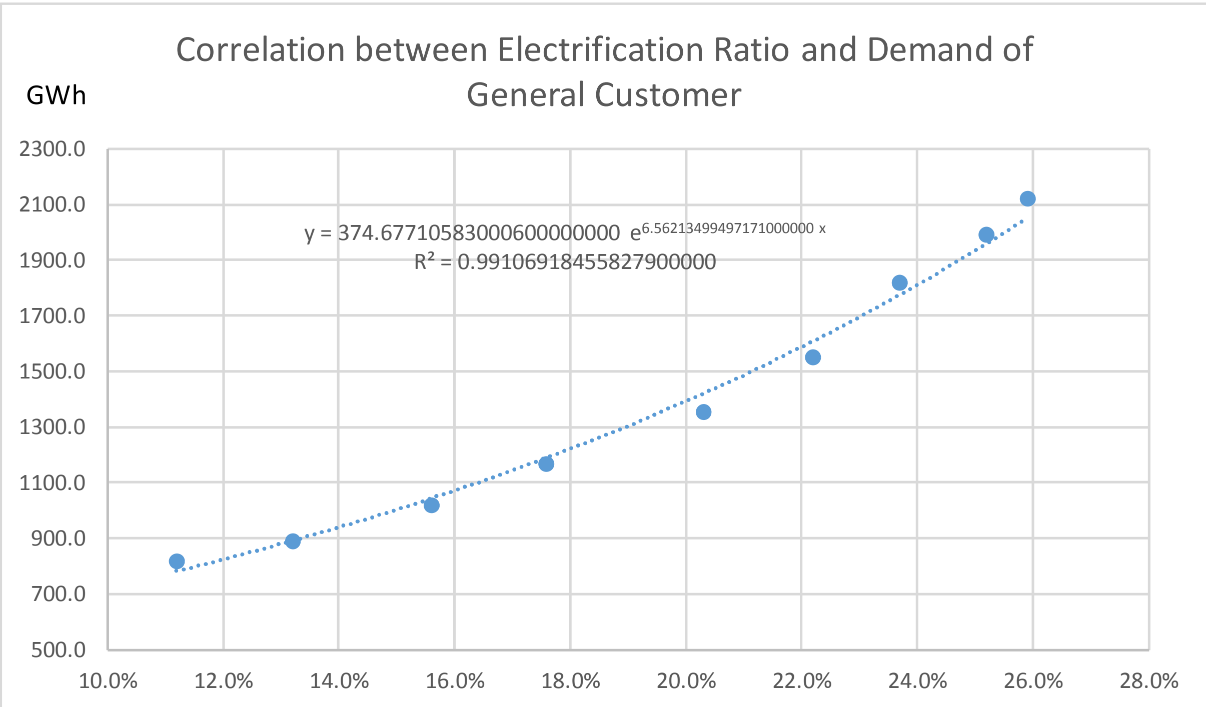
Source: JICA Study Team

Figure 3.2-1 Correlation between Population and Demand of General Customer



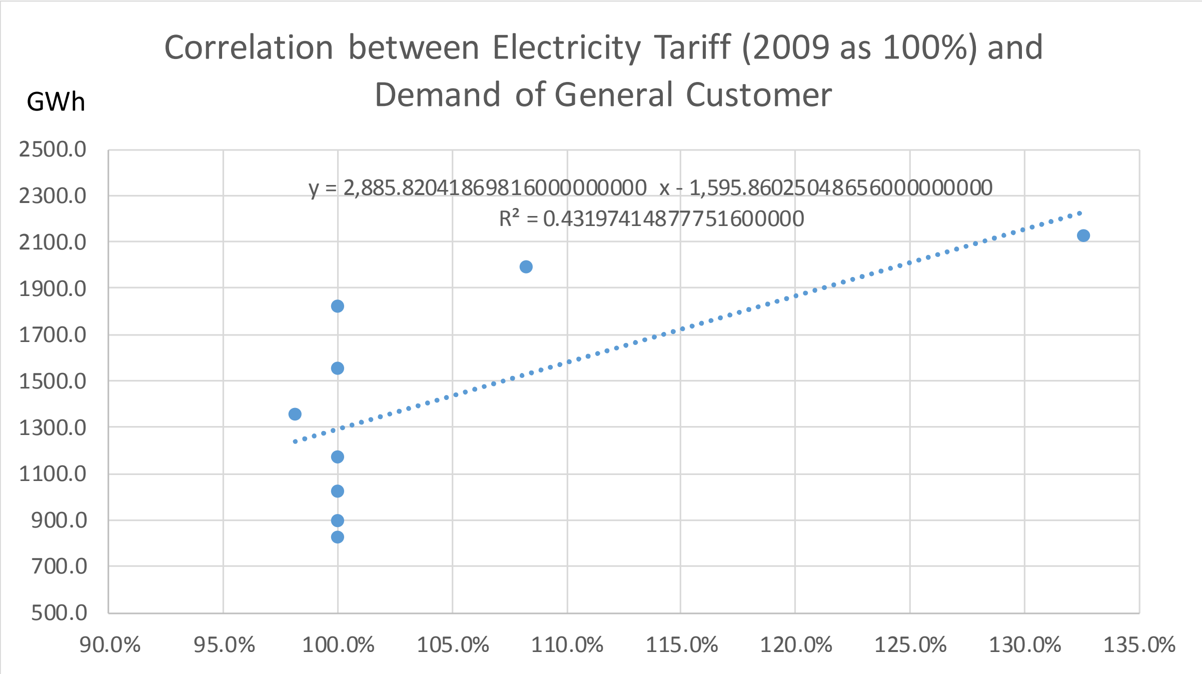
Source: JICA Study Team

Figure 3.2-2 Correlation between GDP and Demand of General Customer



Source: JICA Study Team

Figure 3.2-3 Correlation between Electrification Ratio and Demand of General Customer



Source: JICA Study Team

Figure 3.2-4 Correlation between Electricity Tariff and Demand of General Customer

Table 3.2-1 shows coefficient of determination (R^2), which represents correlation level between each indicator and the target. R^2 is from -1 to 1. When R^2 is close to -1, it means negative strong correlation. On the other hand, when R^2 is close to 1, it means positive strong correlation.

Table 3.2-1 Coefficient of Determination (R^2)

Indicator	R^2
Population	0.990
GDP	0.993
Electrification Ratio	0.991
Electricity Tariff (2009 as 100%)	0.432

Source: JICA Study Team

This result shows there is strong correlation between demand and indicators (population, GDP and electrification ratio). It certifies that they can be adopted as indicator. On the other hand, as Table 3.2-1 shows the correlation between electricity tariff and demand is very weak, because the tariff was unchanged for a long time. Therefore, electricity tariff was not selected as an indicator.

Data of population up to 2040 was provided by INE (Instituto Nacional de Estatistica) then the data of 2041 and 2042 was estimated by the trend from 2030 to 2040. Table 3.2-2 shows the population data for the analysis.

Table 3.2-2 Population Data (National)

	Population	Note
2016	26,423,623	INE Data
2017	27,128,530	
2018	27,843,933	
2019	28,571,310	
2020	29,310,474	
2021	30,061,139	
2022	30,822,552	
2023	31,593,882	
2024	32,374,779	
2025	33,164,996	
2026	33,964,025	
2027	34,770,750	
2028	35,584,273	
2029	36,403,929	
2030	37,228,722	
2031	38,063,907	
2032	38,914,860	
2033	39,780,776	
2034	40,660,733	
2035	41,553,734	
2036	42,458,812	
2037	43,375,091	
2038	44,301,636	
2039	45,237,348	
2040	46,181,058	
2041	47,240,887	Projected utilizing trend from 2031to 2040
2042	48,267,464	

Source: INE and JICA Study Team

Data of GDP was estimated up to 2042 by the trend from 2002 to 2015 which was provided by INE. Table 3.2-2 shows the data for the analysis. Scenario will be described in the 3.2.4 in detail.

Table 3.2-3 GDP Data (National)

(Unit: 10^6 MZN)

	Low Case	Base Case	High Case
Increase Ratio	6.38%	7.38%	8.38%
2016	485,937	490,505	495,073
2017	516,928	526,692	536,548
2018	549,895	565,550	581,498
2019	584,966	607,273	630,213
2020	622,272	652,076	683,010
2021	661,958	700,183	740,230
2022	704,175	751,840	802,243
2023	749,085	807,307	869,452
2024	796,858	866,867	942,291
2025	847,679	930,821	1,021,233
2026	901,740	999,493	1,106,787
2027	959,249	1,073,232	1,199,509
2028	1,020,426	1,152,411	1,299,999
2029	1,085,505	1,237,431	1,408,908
2030	1,154,734	1,328,723	1,526,941
2031	1,228,378	1,426,751	1,654,862
2032	1,306,719	1,532,011	1,793,499
2033	1,390,057	1,645,037	1,943,751
2034	1,478,709	1,766,401	2,106,591
2035	1,573,015	1,896,719	2,283,072
2036	1,673,335	2,036,651	2,474,339
2037	1,780,054	2,186,907	2,681,629
2038	1,893,578	2,348,248	2,906,285
2039	2,014,343	2,521,492	3,149,761
2040	2,142,810	2,707,517	3,413,636
2041	2,279,469	2,907,267	3,699,616
2042	2,424,845	3,121,753	4,009,555

Source: JICA Study Team

Data of electrification ratio was prepared up to 2042 utilizing trend from 2002 to 2015. Table 3.2-4 shows the used data for the analysis.

Table 3.2-4 Electrification Data (National)

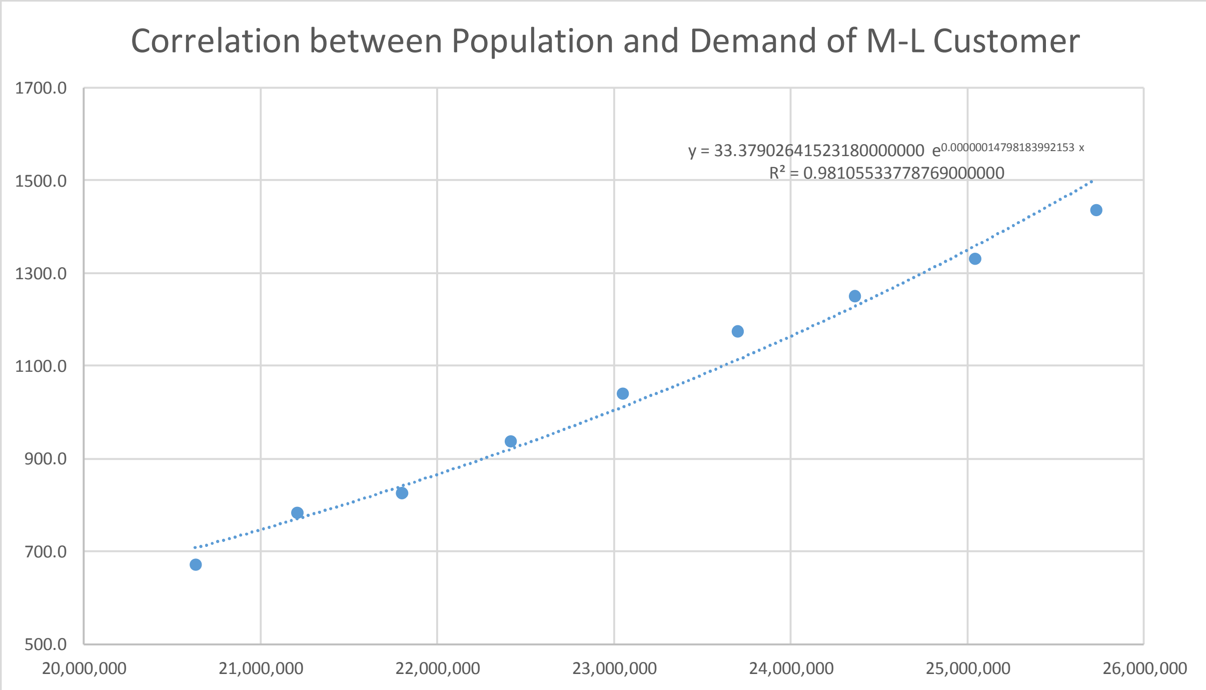
	Electrification Ratio National
2016	28.7%
2017	30.6%
2018	32.5%
2019	34.4%
2020	36.2%
2021	38.1%
2022	40.0%
2023	41.9%
2024	43.7%
2025	45.6%
2026	47.5%
2027	49.4%
2028	51.2%
2029	53.1%
2030	55.0%
2031	56.8%
2032	58.7%
2033	60.6%
2034	62.5%
2035	64.3%
2036	66.2%
2037	68.1%
2038	70.0%
2039	71.8%
2040	73.7%
2041	75.6%
2042	77.5%

Source: JICA Study Team

This result comes from the trend projection of On-Grid electrification. In addition to this On-Grid electrification, universal access will be achieved by adding Off-Grid electrification that is supposed to proceed strongly politically. The detail will be described in 3.3.1, however electrification ratio was not applied as indicator finally.

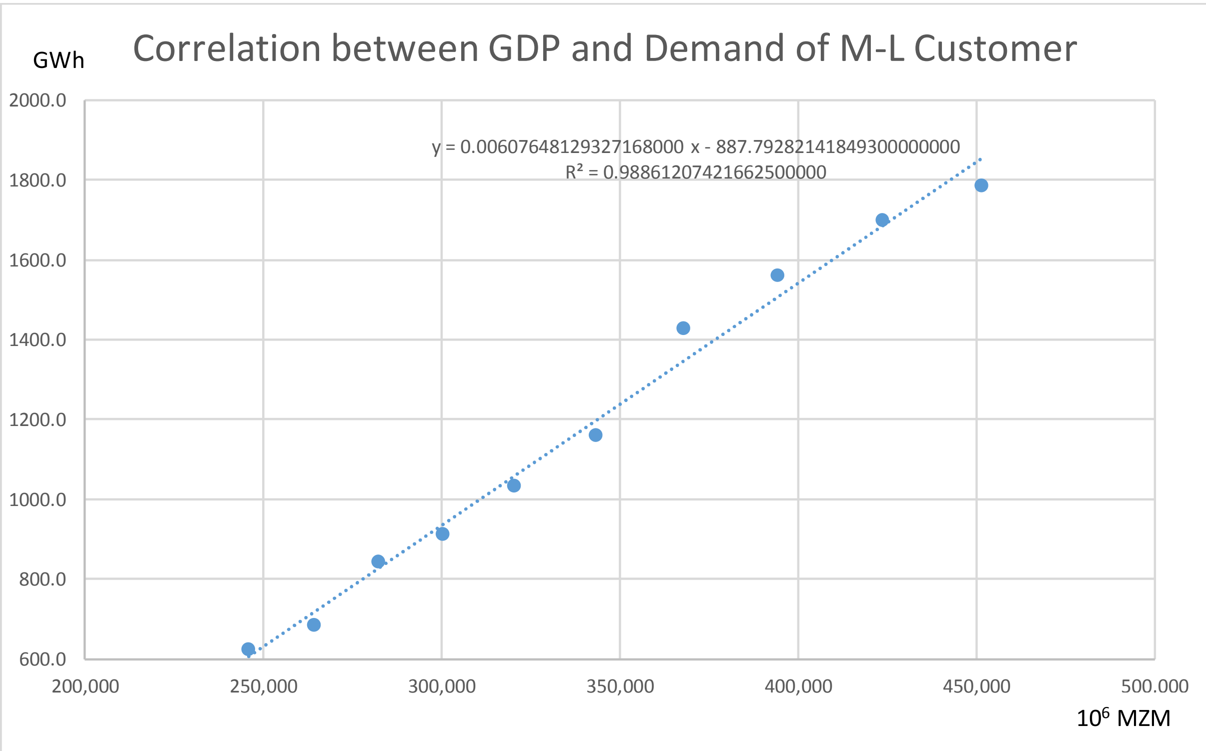
3.2.2 M-L Customer

The data from 2007 to 2015 in annual report is used. Population, real GDP (2009 is base), and electricity tariff are considered as prospective indicators. Correlation between each indicator and demand of “General Customer” at the receiving end is shown in Figure 3.2-5, Figure 3.2-6 and Figure 3.2-7.



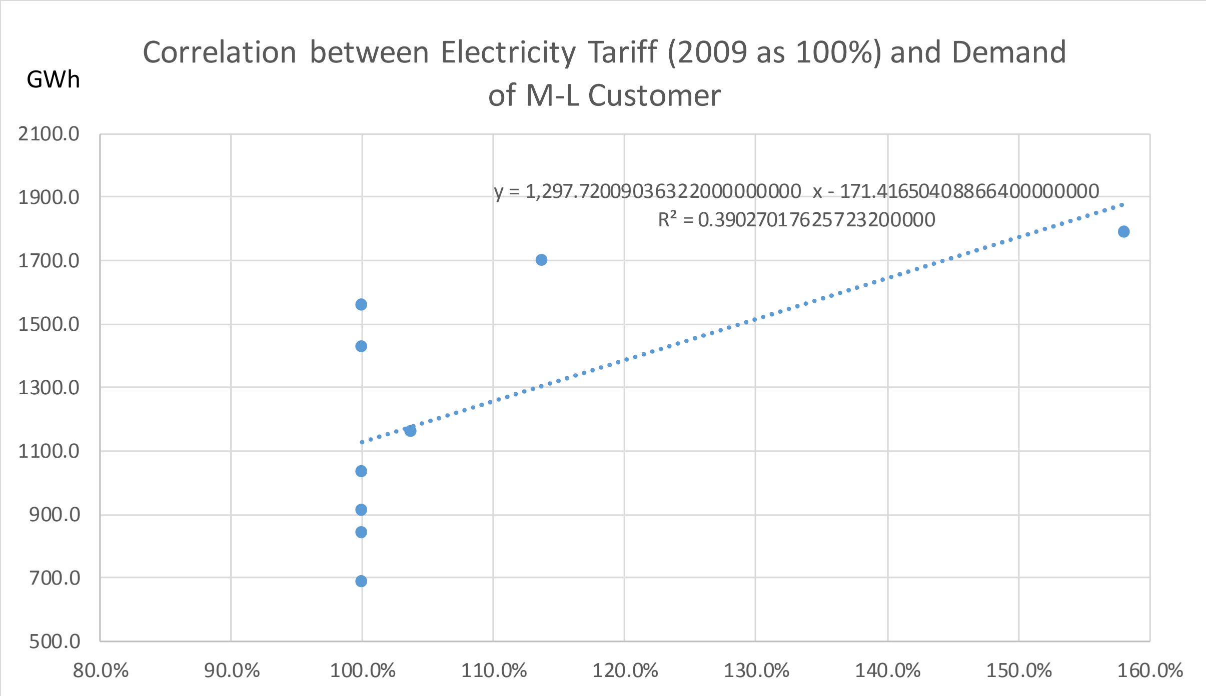
Source: JICA Study Team

Figure 3.2-5 Correlation between Population and Demand of M-L Customer



Source: JICA Study Team

Figure 3.2-6 Correlation between GDP and Demand of M-L Customer



Source: JICA Study Team

Figure 3.2-7 Correlation between Electricity Tariff and Demand of M-L Customer

Table 3.2-5 shows coefficient of determination (R^2)

Table 3.2-5 Coefficient of Determination (R^2)

Indicator	R^2
Population	0.981
GDP	0.989
Electricity Tariff (2009 as 100%)	0.390

Source: JICA Study Team

This result shows there is strong correlation between demand and indicators (population and GDP). It certifies that they can be adopted as indicators. On the other hand, as Table 3.2-5 shows the correlation between electricity tariff and demand is very weak, because the tariff was unchanged for a long time. Therefore, electricity tariff was not selected as an indicator.

Data of population and GDP which is utilized in this demand forecast analysis is as same as the data of "General Customer".

3.2.3 Special Customer

Energy consumption of each special customer is huge hence they give big impact to the demand. Therefore, JST tried to collect as much information as possible. Particularly, customers applying system connection to EDM, customers that CPI (Centro de Promoção de Investimentos) grasps, and customers that Ministry of Industry and Trade grasps are counted. In addition, big development projects such as mining, port, industrial park are also included. With regard to electrifying of Nacala corridor, there was not any practical plan.

In addition, most of all customers have only close future plan for 5 years, however do not have long term plan for 25 years. In other words, to accumulate close 5 years' demand from 2016 to 2020 is possible however it is impossible to accumulate demand after 2021. Therefore, it was assumed that demand from 2016 to 2020 is added-up and then is supposed to increase after 2021 constantly keeping annual average increase volume between 2016 and 2020.

Furthermore, special customers are the prospective projects apply the system connection and all customers will not be installed on schedule. Therefore, it was discussed and agreed at JCC that 30% of all prospective customers will be installed on energy consumption base considering following reasons;

- Project feasibility
- Operation capacity is basically under contract
- Insufficient power system capacity at that time and delay of power generation development

As shown in the Figure 3.1-1 and Figure 3.1-2, existing master plan employs all special customers, therefore there is big gap between the forecast and the actual.

3.2.4 Scenario Preparation

GDP increase ratio, 7.38%, calculated utilizing INE data from 2002 to 2015 is employed as base case. Sensitivity analysis is conducted to evaluate the demand variation when GDP (key indicator) varies ±1%. Their results are prepared as high case and low case. Table 3.2-6 shows the summary of scenario clarification. The other indicators, population and electrification ratio are fixed which means one condition is prepared. On the other hand, Special customer demand is forecasted as described in the Table 3.2-6.

Generation development plan and power system plan are studied based on this base case.

Table 3.2-6 Scenario for the Demand Forecast from 2016 to 2042

<table>
<tr><th></th><th>General Customer</th><th>M-L Customer</th><th>Special Customer</th></tr>
<tr><td>Low Case</td><td>GDP increase ratio: 6.38%
Population increase ratio: 2.1% - 2.7%
Electrification ration (On-grid): 29%→78%</td><td>GDP increase ratio: 6.38%
Population increase ratio: 2.1% - 2.7%</td><td rowspan="3">2016 to 2020: Add-up
After 2021: Constant increase keeping annual average increase volume between 2016 and 2020
Employing ratio: 30%</td></tr>
<tr><td>Base Case</td><td>GDP increase ratio: 7.38%
Population increase ratio: 2.1% - 2.7%
Electrification ration (On-grid): 29%→78%</td><td>GDP increase ratio: 7.38%
Population increase ratio: 2.1% - 2.7%</td></tr>
<tr><td>High Case</td><td>GDP increase ratio: 8.38%
Population increase ratio: 2.1% - 2.7%
Electrification ration (On-grid): 29%→78%</td><td>GDP increase ratio: 8.38%
Population increase ratio: 2.1% - 2.7%</td></tr>
</table>

Source: JICA Study Team

3.2.5 Transmission and Distribution Loss Ratio

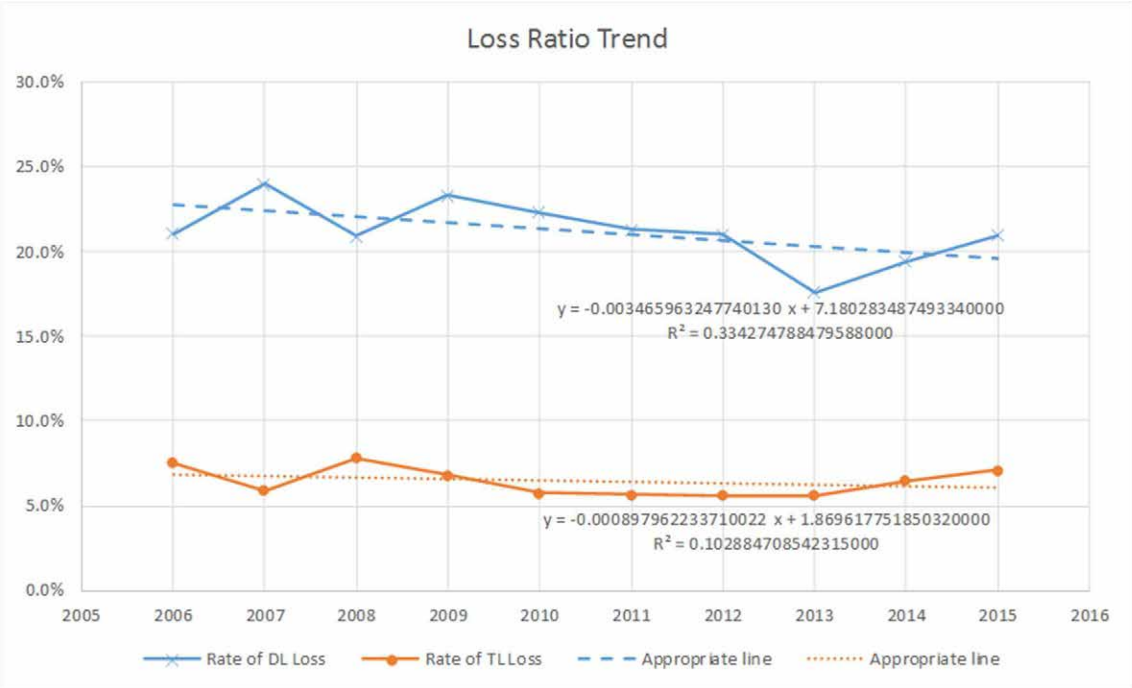
To evaluate system loss more accurately, EDM is trying to revise the calculation method. In line with this approach, distribution loss ratio is calculated based on the total energy for distribution line not the generated energy.

Table 3.2-7 and Figure 3.2-8 show the transmission and distribution loss ratio.

Table 3.2-7 Transmission and Distribution Loss Ratio

	Transmission Lines (TL)			Distribution Lines (DL)		
	Transmission Loss (Including Auxialiary Consumption)	Total Energy for TL	Rate of TL Loss	Distribution Loss	Total Energy for DL (Invoice + DL Loss)	Rate of DL Loss
	(GWh)	(GWh)		(GWh)	(GWh)	
2006	142	1,883	7.5%	367	1,742	21.1%
2007	123	2,084	5.9%	470	1,960	24.0%
2008	185	2,362	7.8%	443	2,117	20.9%
2009	182	2,678	6.8%	562	2,409	23.3%
2010	171	2,973	5.8%	605	2,712	22.3%
2011	190	3,356	5.7%	649	3,044	21.3%
2012	220	3,922	5.6%	725	3,450	21.0%
2013	240	4,278	5.6%	657	3,728	17.6%
2014	310	4,802	6.5%	800	4,120	19.4%
2015	371	5,222	7.1%	944	4,500	21.0%

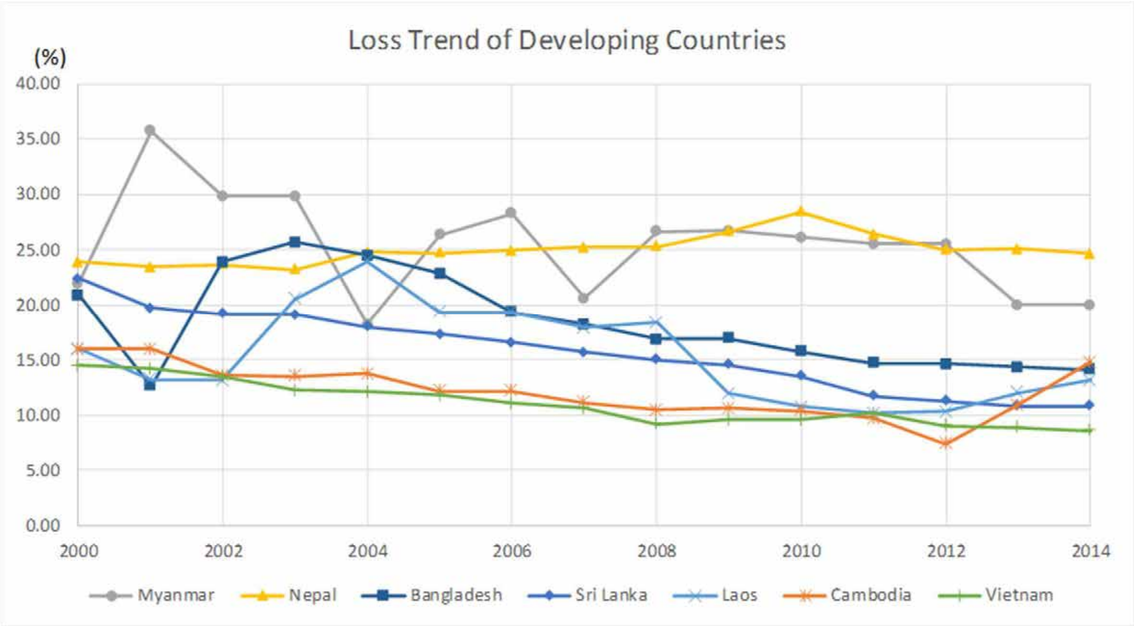
Source: JICA Study Team



Source: JICA Study Team

Figure 3.2-8 Transmission and Distribution Loss Ratio

Transmission line loss ratio shows the 0.0898% decrease and distribution line loss ratio shows the 0.3466% decrease trend. Therefore, it was determined that these decreasing trends will continue in terms of the expectation that transmission line voltage and capacity will increase and distribution line non-technical countermeasure and technical countermeasure (shortening the low voltage lines) will be proceeded. On the other hand, there is limitation of loss reduction. Figure 3.2-9 shows the loss trend of other developing countries. Basically, loss ratio decreases however it was realized that there are some countries that could not improve and it is hard to decrease further under 15%. Therefore, it was determined that the limitation of transmission loss ratio is set to 5% and distribution loss ratio is set to 10% for the safe side.



Source: JEPIC (Japan Electric Power Information Center)

Figure 3.2-9 Loss Record in other Developing Countries (Total of Transmission and Distribution)

The loss ratio utilized in the demand forecast is shown in Table 3.2-8.

Table 3.2-8 Transmission and Distribution Loss Ratio (National)

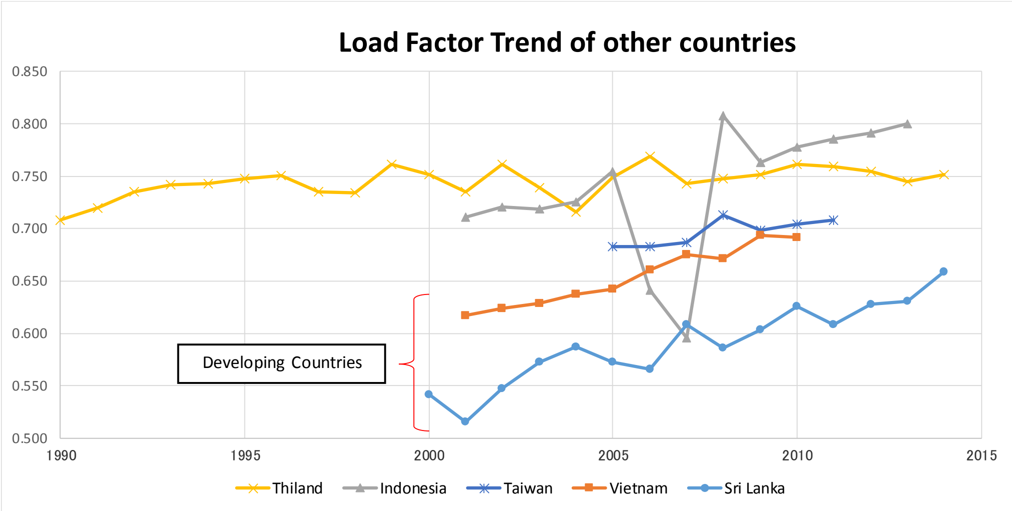
	Rate of DL Loss	Rate of TL Loss
2016	19.3%	5.9%
2017	18.9%	5.8%
2018	18.6%	5.8%
2019	18.3%	5.7%
2020	17.9%	5.6%
2021	17.6%	5.5%
2022	17.2%	5.4%
2023	16.9%	5.3%
2024	16.5%	5.2%
2025	16.2%	5.1%
2026	15.8%	5.0%
2027	15.5%	5.0%
2028	15.1%	5.0%
2029	14.8%	5.0%
2030	14.4%	5.0%
2031	14.1%	5.0%
2032	13.7%	5.0%
2033	13.4%	5.0%
2034	13.1%	5.0%
2035	12.7%	5.0%
2036	12.4%	5.0%
2037	12.0%	5.0%
2038	11.7%	5.0%
2039	11.3%	5.0%
2040	11.0%	5.0%
2041	10.6%	5.0%
2042	10.3%	5.0%

Source: JICA Study Team

3.2.6 Load Factor

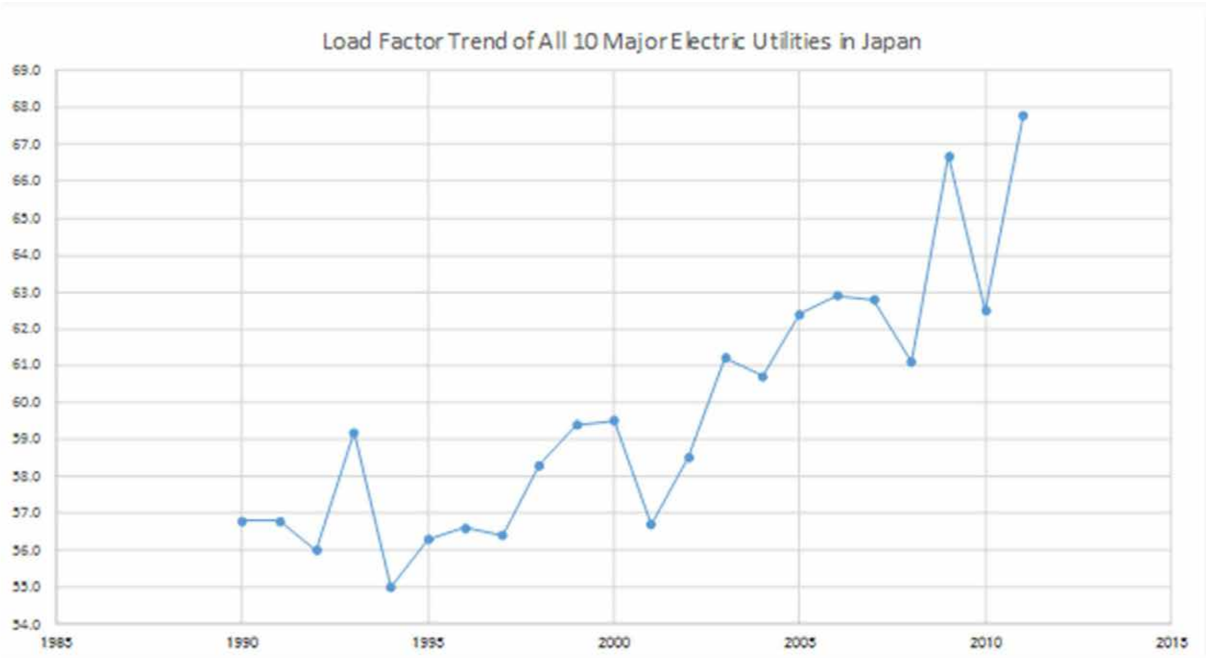
Load factors of other developing countries and newly industrialized countries and Japan are shown in

Figure 3.2-10 and Figure 3.2-11. Developing countries load factor may become bigger due to the peak cut, on the other hand for newly industrialized countries and developed countries, it tends to become bigger with the measures of DSM and others. Load factor changes based on the power supply and demand condition, therefore to determine it very difficult. Considering these conditions and recent trend described in Figure 2.3-11, 0.68 as of 2015 (latest data from 2006 to 2015) is employed.



Source: JEPIC

Figure 3.2-10 Load Factor Trend of Other Developing Countries and Newly Industrialized Countries



Source: FEPC (The Federation of Electric Power Companies of Japan)

Figure 3.2-11 Load Factor Trend in Japan

3.3 Demand Forecast of National Level

3.3.1 General Customer

Following multiple regression formula was prepared including GDP/Capita that includes elements of

GDP and population, and electrification ratio as indicators.

$Y=a*X_1+b*X_2+d$

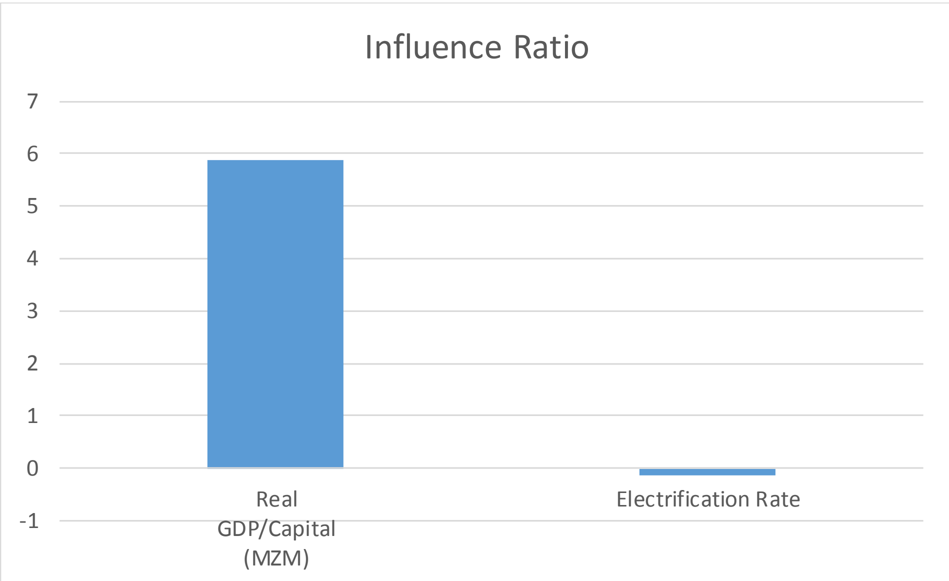
Here, X_1: GDP/Capita (MZN)

X_2: Electrification Ratio (%)

Analyzed result utilizing 2 indicators is represented as below:

$Y=0.30057*X_1-225.29*X_2-3057.2$

From the result, coefficient of electrification is minus (-), it is not proper because it does not show the actual situation. The reason is considered Multicollinearity[3]. To employ more indicators does not always mean more accurate forecast. On the contrary, to select only truly indicators that give influence leads to the accuracy improvement. Here, influence ratio of each indicator is shown in Figure 3.3-1. When influence ratio of GDP/Capita is considered 100%, electrification ratio is only 2.4%. It is clearly shown that GDP/Capita is the dominant toward demand.



Source: JICA Study Team

Figure 3.3-1 Influence Ratio of each Indicator

Next, when it comes to the "P-value", GDP/Capita is 0.1% on the contrary electrification ratio is 89.1%. "P-value" is called as risk rate. As it becomes bigger, the error becomes bigger when the indicator is employed. Therefore, electrification ratio that has fig "P-value" and small influence is eliminated and conducted regression analysis. The result is shown below:

[3] When multi regression analysis is conducted, situation that sign of coefficient does not match the actual condition or is unstable or can not be calculated sometimes occurs. It happens when there is strong correlation among indicators. It is called multicollinearity.

$Y=0.29340*X_1-2993.1$

Finally, it is evaluated which regression formula shows more accurate with the *Selection criterion of indicators (Ru)*.

$$Ru = 1 - (1 - R^2)\frac{n + k + 1}{n - k - 1}$$

R: Correlation coefficient
n: No. of data
k: No. of indicators

Table 3.3-1 shows the result. Ru becomes bigger in case that indicator of electrification ratio is eliminated.

Table 3.3-1 Calculation Result of Ru

	GDP/Capita	Electrification Ratio	Ru
Case 1 No. of indicators: 2	○	○	0.987
Case 2 No. of indicators: 1	○		**0.990**

Source: JICA Study Team

Considering this result, it was determined that single regression formula utilizing indicator of GDP/Capita is to use for the demand forecast.

3.3.2 M-L Customer

Following single regression formula was prepared including GDP/Capita that includes elements of GDP and population.

$Y=a*X_1+ d$

Here, X_1: GDP/Capita (MZN)

Analyzed result is represented as below:

$Y=0.16093*X_1-1367.8$

3.3.3 Special Customer

125 new special customers are expected to enter power system from 2016 to 2020 on the other hand 10 special customers are existing. There are more new customers in Maputo province and Maputo City in southern area then also more new customers in Cabo Delgado and Nampula in northern area than other provinces. Table 3.3-2 shows the No. of special customers of existing and new. Energy consumption and maximum power for national level is described in 3.3.4. Furthermore, demand forecast for each special customer is described in 3.5.3 in detail.

Table 3.3-2 No. of Special Customer

	Existing	New
Cabo Delgado	0	18
Niassa	0	7
Nampula	2	12
Zambezia	0	7
Manica	0	9
Tete	3	3
Sofala	2	7
Inhambane	0	1
Gaza	0	1
Maputo Province	2	34
Maputo City	1	26
Total	10	125

Source: JICA Study Team

3.3.4 Demand Forecast

Table 3.3-3 and Table 3.3-4 show demand forecast by customer categories on base case. Besides, Table 3.3-5 and Table 3.3-6 show the result by scenarios. 3-level results, Distribution substation level (receiving end), Transmission substation level, and Power station level (sending end) are shown in each result. More than that, the result of receiving end (Distribution substation level) are shown as graph in Figure 3.3-2 and Figure 3.3-3.

At the receiving end, the demand was 3,908GWh and 655MW in 2015. In 2042, in the base case, the demand reaches 35,444GWh (AAGR: 8.58%) and 5,950MW. In the low case, the demand reaches 28,884GWh (AAGR: 7.76%) and 4,849MW. In the high case, the demand reaches 43,801GWh (AAGR: 9.44%) and 7,353MW. If demand increases following the high case scenario, it is necessary to push the generation expansion schedule forward by about 2 years in 2030. On the other hand, if demand increase following low case scenario, it is able to push it back by about two years in 2030.

Table 3.3-3 Energy Consumption by Categories on Base Case

(Unit: GWh)

	Distribution Substation				Transmission Substation				Power Station			
	General customers	Medium-Large customers	Special Customers	Total	General customers	Medium-Large customers	Special Customers	Total	General customers	Medium-Large customers	Special Customers	Total
2015	2,121	1,436	351	3,908	2,684	1,817	351	4,852	2,889	1,956	378	5,223
2016	2,453	1,620	496	4,569	3,040	2,007	496	5,542	3,231	2,133	527	5,892
2017	2,703	1,757	659	5,119	3,335	2,167	659	6,161	3,542	2,302	700	6,544
2018	2,966	1,901	1,382	6,249	3,644	2,335	1,382	7,361	3,866	2,478	1,467	7,811
2019	3,243	2,053	2,030	7,325	3,967	2,511	2,030	8,508	4,205	2,662	2,152	9,018
2020	3,534	2,212	2,215	7,962	4,305	2,695	2,215	9,215	4,559	2,854	2,346	9,759
2021	3,841	2,381	2,588	8,810	4,659	2,888	2,588	10,135	4,929	3,055	2,739	10,722
2022	4,164	2,558	2,961	9,683	5,029	3,089	2,961	11,080	5,316	3,266	3,130	11,712
2023	4,504	2,744	3,334	10,583	5,418	3,301	3,334	12,053	5,721	3,486	3,521	12,728
2024	4,863	2,941	3,707	11,511	5,825	3,523	3,707	13,056	6,145	3,717	3,911	13,774
2025	5,241	3,149	4,080	12,471	6,253	3,756	4,080	14,089	6,590	3,959	4,301	14,850
2026	5,641	3,368	4,453	13,462	6,701	4,001	4,453	15,156	7,057	4,213	4,689	15,959
2027	6,063	3,600	4,826	14,489	7,173	4,259	4,826	16,258	7,551	4,483	5,080	17,114
2028	6,509	3,844	5,199	15,552	7,669	4,529	5,199	17,398	8,073	4,768	5,473	18,313
2029	6,980	4,103	5,572	16,655	8,191	4,814	5,572	18,577	8,622	5,068	5,865	19,555
2030	7,478	4,376	5,945	17,799	8,740	5,114	5,945	19,800	9,200	5,384	6,258	20,842
2031	8,004	4,664	6,318	18,987	9,317	5,430	6,318	21,065	9,808	5,715	6,651	22,173
2032	8,557	4,968	6,691	20,216	9,921	5,759	6,691	22,371	10,443	6,063	7,043	23,549
2033	9,140	5,287	7,064	21,491	10,554	6,105	7,064	23,723	11,109	6,426	7,436	24,971
2034	9,753	5,623	7,437	22,813	11,217	6,468	7,437	25,121	11,807	6,808	7,828	26,443
2035	10,399	5,978	7,810	24,187	11,912	6,848	7,810	26,570	12,539	7,208	8,221	27,969
2036	11,080	6,352	8,183	25,615	12,643	7,247	8,183	28,073	13,308	7,629	8,614	29,551
2037	11,799	6,746	8,556	27,101	13,410	7,667	8,556	29,633	14,116	8,071	9,006	31,193
2038	12,559	7,163	8,929	28,650	14,217	8,108	8,929	31,254	14,965	8,535	9,399	32,899
2039	13,361	7,602	9,302	30,265	15,066	8,573	9,302	32,940	15,859	9,024	9,791	34,674
2040	14,208	8,067	9,675	31,950	15,959	9,062	9,675	34,696	16,799	9,539	10,184	36,522
2041	15,063	8,536	10,048	33,647	16,854	9,551	10,048	36,452	17,741	10,054	10,577	38,371
2042	15,983	9,041	10,421	35,444	17,814	10,076	10,421	38,311	18,751	10,607	10,969	40,327

Source: JICA Study Team

Table 3.3-4 Maximum Power by Categories on Base Case

(Unit: MW)

	Distribution Substation				Transmission Substation				Power Station			
	General customers	Medium-Large customers	Special Customers	Total	General customers	Medium-Large customers	Special Customers	Total	General customers	Medium-Large customers	Special Customers	Total
2015	355	241	59	655	450	304	59	813	484	328	63	875
2016	398	263	81	742	494	326	81	900	525	346	86	957
2017	454	295	111	859	560	364	111	1,034	595	386	118	1,098
2018	498	319	232	1,049	612	392	232	1,236	649	416	246	1,311
2019	544	345	341	1,230	666	422	341	1,428	706	447	361	1,514
2020	593	371	372	1,337	723	452	372	1,547	765	479	394	1,638
2021	645	400	435	1,479	782	485	435	1,701	827	513	460	1,800
2022	699	429	497	1,625	844	519	497	1,860	892	548	525	1,966
2023	756	461	560	1,777	909	554	560	2,023	960	585	591	2,137
2024	816	494	622	1,932	978	591	622	2,192	1,032	624	657	2,312
2025	880	529	685	2,094	1,050	631	685	2,365	1,106	665	722	2,493
2026	947	565	748	2,260	1,125	672	748	2,544	1,185	707	787	2,679
2027	1,018	604	810	2,432	1,204	715	810	2,729	1,268	753	853	2,873
2028	1,093	645	873	2,611	1,287	760	873	2,921	1,355	800	919	3,074
2029	1,172	689	935	2,796	1,375	808	935	3,119	1,447	851	985	3,283
2030	1,255	735	998	2,988	1,467	859	998	3,324	1,545	904	1,051	3,499
2031	1,344	783	1,061	3,187	1,564	911	1,061	3,536	1,646	959	1,116	3,722
2032	1,437	834	1,123	3,394	1,665	967	1,123	3,756	1,753	1,018	1,182	3,953
2033	1,534	888	1,186	3,608	1,772	1,025	1,186	3,982	1,865	1,079	1,248	4,192
2034	1,637	944	1,248	3,830	1,883	1,086	1,248	4,217	1,982	1,143	1,314	4,439
2035	1,746	1,004	1,311	4,060	2,000	1,150	1,311	4,460	2,105	1,210	1,380	4,695
2036	1,860	1,066	1,374	4,300	2,122	1,217	1,374	4,713	2,234	1,281	1,446	4,961
2037	1,981	1,133	1,436	4,550	2,251	1,287	1,436	4,975	2,370	1,355	1,512	5,237
2038	2,108	1,202	1,499	4,810	2,387	1,361	1,499	5,247	2,512	1,433	1,578	5,523
2039	2,243	1,276	1,562	5,081	2,529	1,439	1,562	5,530	2,662	1,515	1,644	5,821
2040	2,385	1,354	1,624	5,364	2,679	1,521	1,624	5,825	2,820	1,601	1,710	6,131
2041	2,529	1,433	1,687	5,648	2,829	1,603	1,687	6,119	2,978	1,688	1,776	6,442
2042	2,683	1,518	1,749	5,950	2,990	1,692	1,749	6,431	3,148	1,781	1,841	6,770

Source: JICA Study Team

Table 3.3-5 Energy Consumption by Scenarios

(Unit: GWh)

	Distribution Substation			Transmission Substation			Power Station		
	Low Case	Base Case	High Case	Low Case	Base Case	High Case	Low Case	Base Case	High Case
2015	3,908	3,908	3,908	4,852	4,852	4,852	5,223	5,223	5,223
2016	4,490	4,569	4,647	5,445	5,542	5,639	5,788	5,892	5,995
2017	4,955	5,119	5,284	5,959	6,161	6,365	6,329	6,544	6,760
2018	5,994	6,249	6,510	7,048	7,361	7,681	7,478	7,811	8,150
2019	6,971	7,325	7,690	8,074	8,508	8,954	8,558	9,018	9,491
2020	7,500	7,962	8,441	8,652	9,215	9,799	9,163	9,759	10,378
2021	8,232	8,810	9,415	9,434	10,135	10,869	9,981	10,722	11,499
2022	8,980	9,683	10,426	10,231	11,080	11,977	10,815	11,712	12,660
2023	9,745	10,583	11,476	11,046	12,053	13,128	11,665	12,728	13,863
2024	10,529	11,511	12,570	11,879	13,056	14,323	12,532	13,774	15,111
2025	11,332	12,471	13,709	12,730	14,089	15,567	13,418	14,850	16,407
2026	12,155	13,462	14,897	13,602	15,156	16,861	14,324	15,959	17,755
2027	12,999	14,489	16,138	14,496	16,258	18,210	15,259	17,114	19,168
2028	13,867	15,552	17,436	15,412	17,398	19,618	16,223	18,313	20,650
2029	14,758	16,655	18,795	16,352	18,577	21,089	17,213	19,555	22,199
2030	15,676	17,799	20,218	17,318	19,800	22,627	18,230	20,842	23,818
2031	16,619	18,987	21,709	18,309	21,065	24,234	19,272	22,173	25,509
2032	17,586	20,216	23,269	19,322	22,371	25,911	20,339	23,549	27,274
2033	18,579	21,491	24,902	20,360	23,723	27,662	21,432	24,971	29,118
2034	19,599	22,813	26,614	21,424	25,121	29,493	22,552	26,443	31,045
2035	20,648	24,187	28,411	22,516	26,570	31,409	23,701	27,969	33,062
2036	21,727	25,615	30,299	23,637	28,073	33,417	24,881	29,551	35,176
2037	22,840	27,101	32,283	24,790	29,633	35,523	26,095	31,193	37,392
2038	23,987	28,650	34,373	25,976	31,254	37,733	27,343	32,899	39,719
2039	25,171	30,265	36,575	27,197	32,940	40,055	28,628	34,674	42,164
2040	26,395	31,950	38,897	28,455	34,696	42,499	29,953	36,522	44,735
2041	27,609	33,647	41,267	29,697	36,452	44,979	31,260	38,371	47,346
2042	28,884	35,444	43,801	30,999	38,311	47,625	32,631	40,327	50,131
AAGR 2016-2042	7.76%	8.58%	9.44%						

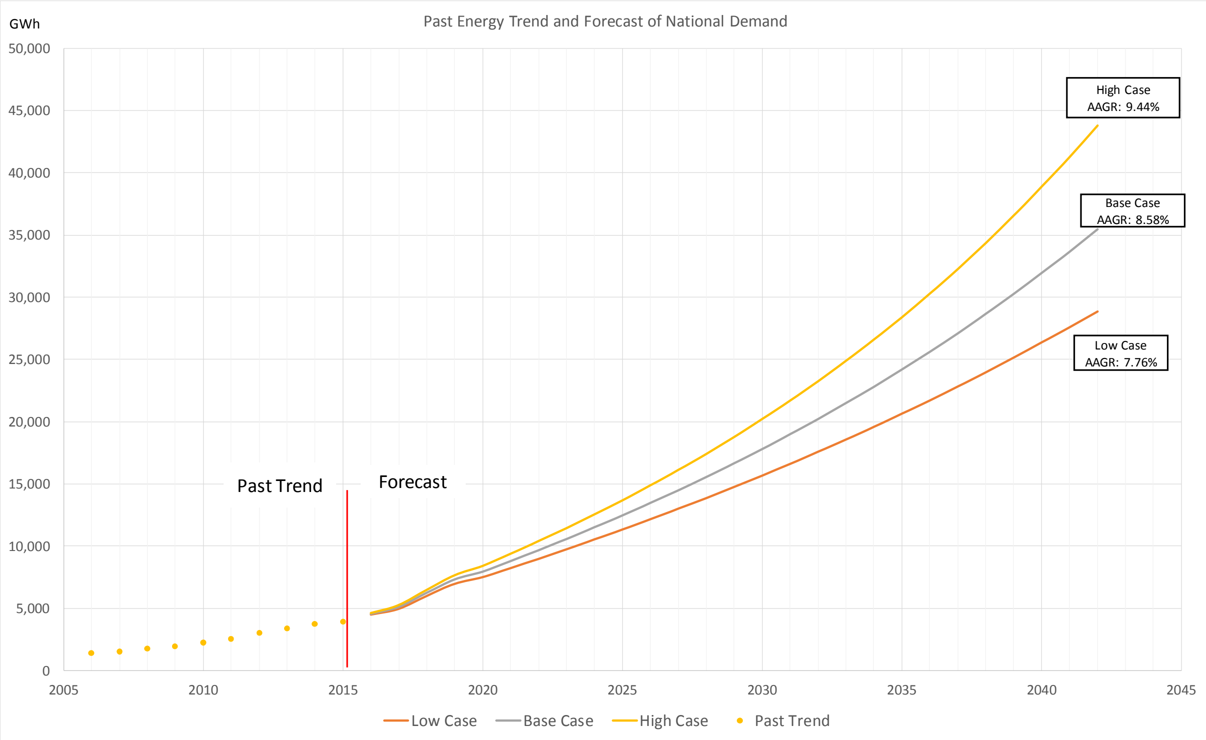
Source: JICA Study Team

Table 3.3-6 Maximum Power by Scenarios

(Unit: MW)

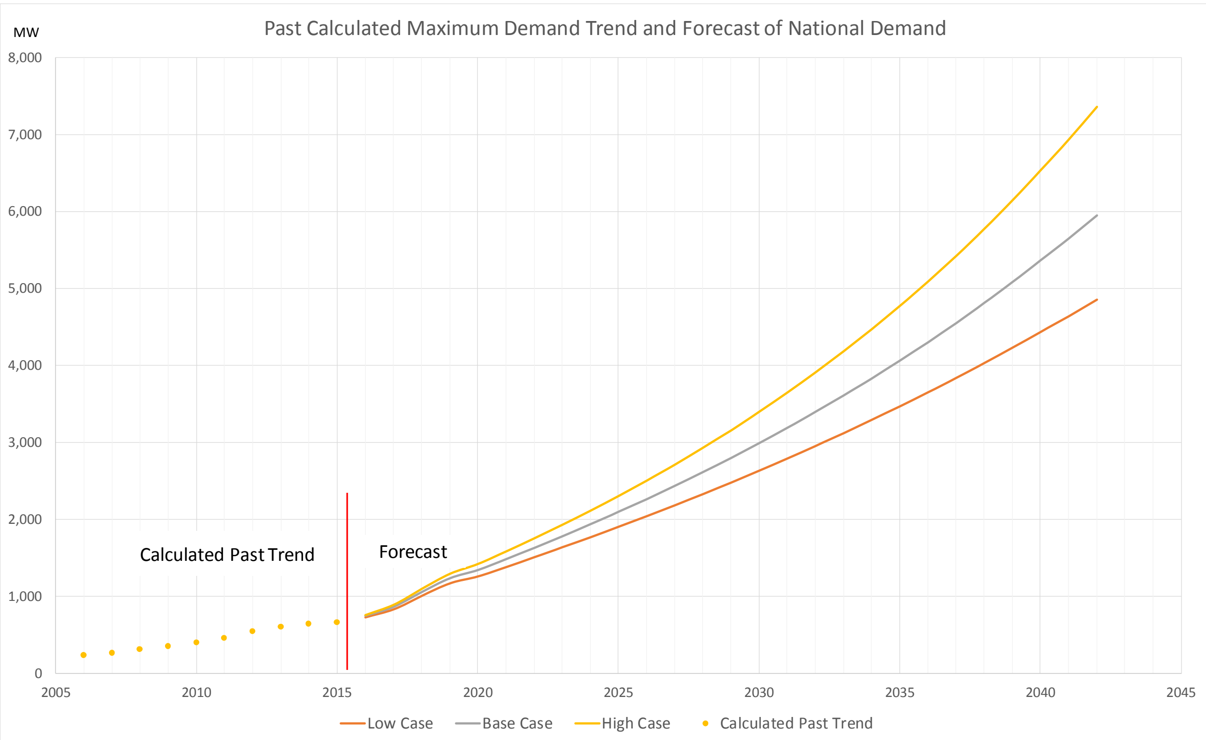
	Distribution Substation			Transmission Substation			Power Station		
	Low Case	Base Case	High Case	Low Case	Base Case	High Case	Low Case	Base Case	High Case
2015	655	655	655	813	813	813	875	875	875
2016	729	742	755	884	900	916	940	957	974
2017	832	859	887	1,000	1,034	1,068	1,063	1,098	1,135
2018	1,006	1,049	1,093	1,183	1,236	1,289	1,255	1,311	1,368
2019	1,170	1,230	1,291	1,355	1,428	1,503	1,437	1,514	1,593
2020	1,259	1,337	1,417	1,453	1,547	1,645	1,538	1,638	1,742
2021	1,382	1,479	1,581	1,584	1,701	1,825	1,676	1,800	1,930
2022	1,508	1,625	1,750	1,718	1,860	2,011	1,815	1,966	2,125
2023	1,636	1,777	1,927	1,854	2,023	2,204	1,958	2,137	2,327
2024	1,768	1,932	2,110	1,994	2,192	2,405	2,104	2,312	2,537
2025	1,902	2,094	2,301	2,137	2,365	2,613	2,253	2,493	2,754
2026	2,040	2,260	2,501	2,284	2,544	2,831	2,405	2,679	2,981
2027	2,182	2,432	2,709	2,433	2,729	3,057	2,562	2,873	3,218
2028	2,328	2,611	2,927	2,587	2,921	3,293	2,723	3,074	3,467
2029	2,478	2,796	3,155	2,745	3,119	3,540	2,890	3,283	3,727
2030	2,632	2,988	3,394	2,907	3,324	3,799	3,060	3,499	3,998
2031	2,790	3,187	3,644	3,074	3,536	4,068	3,235	3,722	4,282
2032	2,952	3,394	3,906	3,244	3,756	4,350	3,414	3,953	4,579
2033	3,119	3,608	4,180	3,418	3,982	4,644	3,598	4,192	4,888
2034	3,290	3,830	4,468	3,597	4,217	4,951	3,786	4,439	5,212
2035	3,466	4,060	4,770	3,780	4,460	5,273	3,979	4,695	5,550
2036	3,647	4,300	5,086	3,968	4,713	5,610	4,177	4,961	5,905
2037	3,834	4,550	5,420	4,162	4,975	5,963	4,381	5,237	6,277
2038	4,027	4,810	5,770	4,361	5,247	6,334	4,590	5,523	6,668
2039	4,226	5,081	6,140	4,566	5,530	6,724	4,806	5,821	7,078
2040	4,431	5,364	6,530	4,777	5,825	7,134	5,028	6,131	7,510
2041	4,635	5,648	6,928	4,985	6,119	7,551	5,248	6,442	7,948
2042	4,849	5,950	7,353	5,204	6,431	7,995	5,478	6,770	8,416

Source: JICA Study Team



Source: JICA Study Team

Figure 3.3-2 Energy Consumption at Receiving end



Source: JICA Study Team

Figure 3.3-3 Maximum Power at Receiving end

3.3.5 Demand Forecast (with Mozal)

Mozal, aluminum smelter company, has a contract with Eskom and power is supplied from South Africa. The maximum power is 950MW which is huge and as almost same as whole Mozambique country-wide maximum power. Therefore, if supplier is changed with EDM instead of Eskom at the next contract renewal, EDM power system will be much influenced. Consequently, another case, case with Mozal was prepared and analyzed.

Table 3.3-7 and Table 3.3-8 show the result by scenarios. 3-level results, Distribution substation level (receiving end), Transmission substation level, and Power station level (sending end) are shown in each result. More than that, the result of receiving end (Distribution substation level) are shown as graph in Figure 3.3-4 and Figure 3.3-5.

At the receiving end in 2042, in the base case, the demand reaches 43,683GWh and 6,900MW. In the low case, the demand reaches 37,123GWh and 5,799MW. In the high case, the demand reaches 52,039GWh and 8,303MW.

Table 3.3-7 Energy Consumption by Scenarios (with Mozal)

(Unit: GWh)

	Distribution Substation			Transmission Substation			Power Station		
	Low Case	Base Case	High Case	Low Case	Base Case	High Case	Low Case	Base Case	High Case
2015	3,908	3,908	3,908	4,852	4,852	4,852	5,223	5,223	5,223
2016	4,490	4,569	4,647	5,445	5,542	5,639	5,788	5,892	5,995
2017	4,955	5,119	5,284	5,959	6,161	6,365	6,329	6,544	6,760
2018	5,994	6,249	6,510	7,048	7,361	7,681	7,478	7,811	8,150
2019	6,971	7,325	7,690	8,074	8,508	8,954	8,558	9,018	9,491
2020	7,500	7,962	8,441	8,652	9,215	9,799	9,163	9,759	10,378
2021	8,232	8,810	9,415	9,434	10,135	10,869	9,981	10,722	11,499
2022	8,980	9,683	10,426	10,231	11,080	11,977	10,815	11,712	12,660
2023	9,745	10,583	11,476	11,046	12,053	13,128	11,665	12,728	13,863
2024	10,529	11,511	12,570	11,879	13,056	14,323	12,532	13,774	15,111
2025	11,332	12,471	13,709	12,730	14,089	15,567	13,418	14,850	16,407
2026	20,393	21,701	23,136	21,841	23,395	25,100	22,999	24,635	26,430
2027	21,238	22,727	24,377	22,735	24,497	26,449	23,931	25,786	27,841
2028	22,105	23,791	25,675	23,651	25,636	27,857	24,896	26,986	29,323
2029	22,997	24,893	27,033	24,591	26,816	29,327	25,885	28,227	30,871
2030	23,915	26,038	28,457	25,557	28,039	30,866	26,902	29,514	32,490
2031	24,858	27,226	29,948	26,547	29,303	32,473	27,945	30,846	34,182
2032	25,825	28,455	31,508	27,561	30,610	34,150	29,011	32,221	35,947
2033	26,817	29,729	33,141	28,599	31,961	35,901	30,104	33,644	37,790
2034	27,837	31,052	34,853	29,663	33,360	37,732	31,224	35,116	39,718
2035	28,886	32,426	36,650	30,755	34,809	39,648	32,373	36,641	41,735
2036	29,966	33,854	38,537	31,876	36,312	41,656	33,554	38,223	43,848
2037	31,079	35,340	40,522	33,029	37,872	43,761	34,767	39,865	46,065
2038	32,226	36,889	42,612	34,215	39,493	45,972	36,015	41,572	48,391
2039	33,410	38,504	44,813	35,436	41,179	48,294	37,301	43,346	50,836
2040	34,634	40,189	47,136	36,694	42,934	50,737	38,625	45,194	53,408
2041	35,848	41,886	49,506	37,936	44,691	53,217	39,932	47,043	56,018
2042	37,123	43,683	52,039	39,238	46,549	55,863	41,303	48,999	58,804

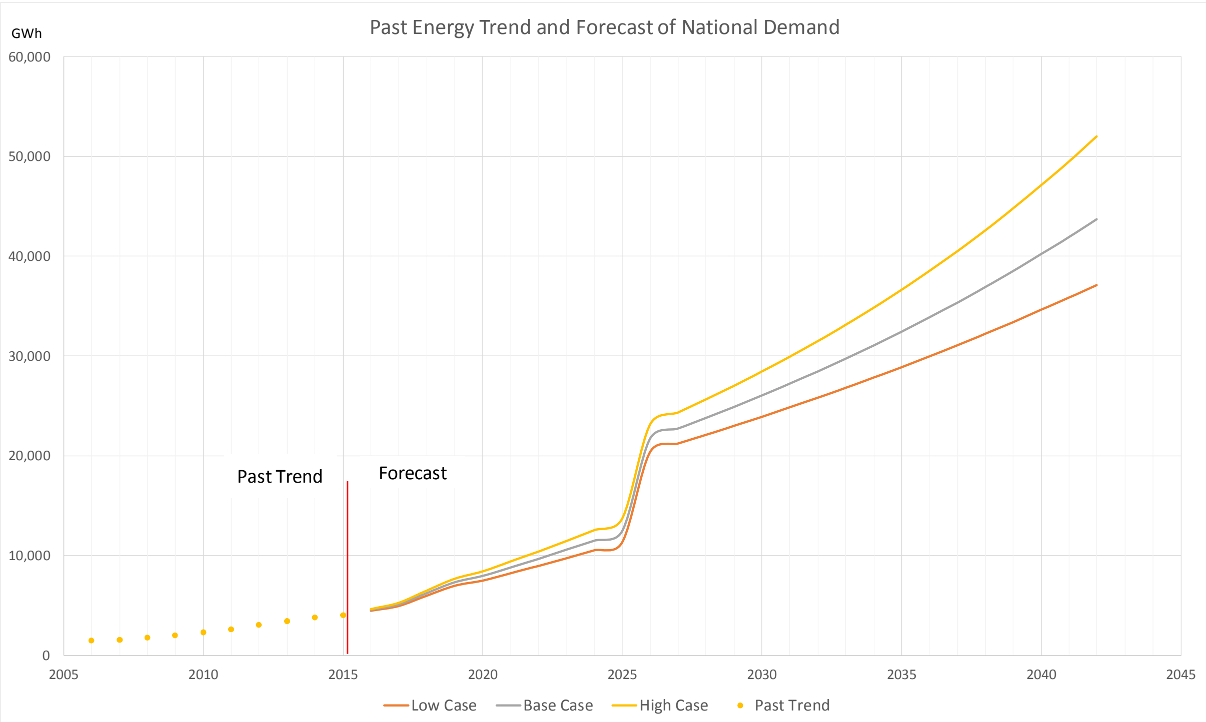
Source: JICA Study Team

Table 3.3-8 Maximum Power by Scenarios (with Mozal)

(Unit: MW)

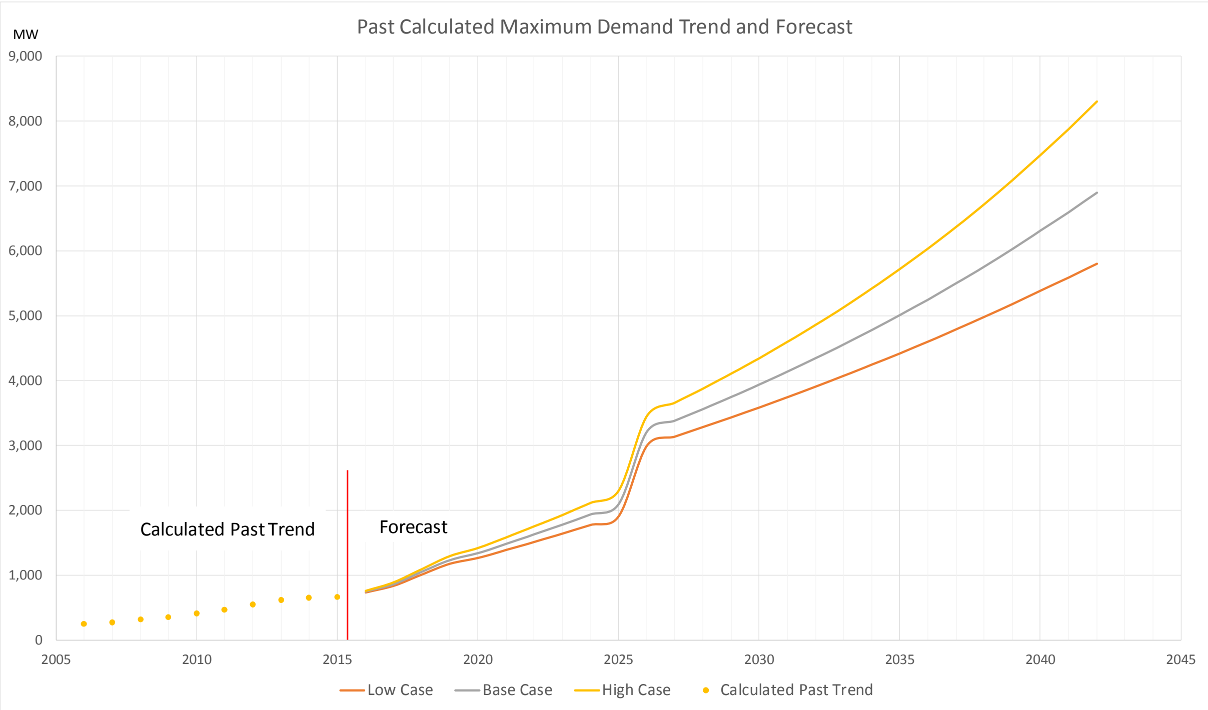
	Distribution Substation			Transmission Substation			Power Station		
	Low Case	Base Case	High Case	Low Case	Base Case	High Case	Low Case	Base Case	High Case
2015	655	655	655	813	813	813	875	875	875
2016	729	742	755	884	900	916	940	957	974
2017	832	859	887	1,000	1,034	1,068	1,063	1,098	1,135
2018	1,006	1,049	1,093	1,183	1,236	1,289	1,255	1,311	1,368
2019	1,170	1,230	1,291	1,355	1,428	1,503	1,437	1,514	1,593
2020	1,259	1,337	1,417	1,453	1,547	1,645	1,538	1,638	1,742
2021	1,382	1,479	1,581	1,584	1,701	1,825	1,676	1,800	1,930
2022	1,508	1,625	1,750	1,718	1,860	2,011	1,815	1,966	2,125
2023	1,636	1,777	1,927	1,854	2,023	2,204	1,958	2,137	2,327
2024	1,768	1,932	2,110	1,994	2,192	2,405	2,104	2,312	2,537
2025	1,902	2,094	2,301	2,137	2,365	2,613	2,253	2,493	2,754
2026	2,990	3,210	3,451	3,234	3,494	3,781	3,405	3,680	3,981
2027	3,132	3,382	3,659	3,383	3,679	4,007	3,562	3,873	4,218
2028	3,278	3,561	3,877	3,537	3,871	4,243	3,723	4,074	4,467
2029	3,428	3,746	4,105	3,695	4,069	4,490	3,890	4,283	4,727
2030	3,582	3,938	4,344	3,857	4,274	4,749	4,060	4,499	4,998
2031	3,740	4,137	4,594	4,024	4,486	5,018	4,235	4,722	5,282
2032	3,902	4,344	4,856	4,194	4,706	5,300	4,414	4,953	5,579
2033	4,069	4,558	5,130	4,368	4,932	5,594	4,598	5,192	5,888
2034	4,240	4,780	5,418	4,547	5,167	5,901	4,786	5,439	6,212
2035	4,416	5,010	5,720	4,730	5,410	6,223	4,979	5,695	6,550
2036	4,597	5,250	6,036	4,918	5,663	6,560	5,177	5,961	6,905
2037	4,784	5,500	6,370	5,112	5,925	6,913	5,381	6,237	7,277
2038	4,977	5,760	6,720	5,311	6,197	7,284	5,590	6,523	7,668
2039	5,176	6,031	7,090	5,516	6,480	7,674	5,806	6,821	8,078
2040	5,381	6,314	7,480	5,727	6,775	8,084	6,028	7,131	8,510
2041	5,585	6,598	7,878	5,935	7,069	8,501	6,248	7,442	8,948
2042	5,799	6,900	8,303	6,154	7,381	8,945	6,478	7,770	9,416

Source: JICA Study Team



Source: JICA Study Team

Figure 3.3-4 Energy Consumption at Receiving end (with Mozal)



Source: JICA Study Team

Figure 3.3-5 Maximum Power at Receiving end (with Mozal)

3.4 Demand Forecast Precondition of Provincial Level

3.4.1 General Customer

The data from 2007 to 2015 in annual report is used as same as national level. To synchronize the national level analysis, GDP/Capita is used as indicator.

3.4.2 M-L Customer

The data from 2007 to 2015 in annual report is used as same as national level. To synchronize the national level analysis, GDP/Capita is used as an indicator.

3.4.3 Special Customer

Customers applying system connection to EDM, customers that CPI (Centro de Promoção de Investimentos) grasps, and customers that Ministry of Industry and Trade grasps are counted. Demand from 2016 to 2020 is added-up and then is supposed to increase after 2021 constantly keeping annual average increase volume between 2016 and 2020.

3.4.4 Scenario Preparation

3 scenarios are prepared in a similar manner with national level. To synchronize the national level analysis, electrification ratio is not employed for "General Customer" demand forecast. Table 3.4-1 shows the GDP growth rate which is used in 3 scenarios of "General Customer" and "M-L Customer".

Table 3.4-1 GDP Growth Rate from 2016 – 2042 by Scenarios

	Low Case	Base Case	High Case
Cabo Delgado	6.56%	7.56%	8.56%
Niassa	5.66%	6.66%	7.66%
Nampula	5.70%	6.70%	7.70%
Zambézia	5.86%	6.86%	7.86%
Manica	5.63%	6.63%	7.63%
Tete	7.24%	8.24%	9.24%
Sofala	6.08%	7.08%	8.08%
Inhambane	5.97%	6.97%	7.97%
Gaza	5.69%	6.69%	7.69%
Maputo Province	5.74%	6.74%	7.74%
Maputo city	6.00%	7.00%	8.00%

Source: JICA Study Team

3.4.5 Transmission and Distribution Loss Ratio

In a similar manner with national level, past trend was evaluated and decreasing loss ratio will continue following this trend. JST determined that the limitation of transmission loss ratio is set to 5% and distribution loss ratio is set to 10% for the safe side. The loss ratio utilized in the demand forecast is shown in Table 3.4-2.

Table 3.4-2 Distribution Loss Ratio by Provinces

	Cabo Delgado	Niassa	Nampula	Zambézia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo city
2016	15.4%	18.8%	19.2%	15.5%	13.4%	17.7%	16.2%	16.2%	13.9%	19.6%	22.3%
2017	14.6%	18.3%	18.9%	14.3%	12.9%	16.7%	15.8%	15.2%	13.2%	19.5%	22.0%
2018	13.7%	17.7%	18.6%	13.2%	12.4%	15.8%	15.4%	14.2%	12.5%	19.5%	21.8%
2019	12.9%	17.1%	18.3%	12.0%	11.9%	14.9%	15.1%	13.2%	11.8%	19.5%	21.5%
2020	12.1%	16.5%	18.0%	10.8%	11.4%	13.9%	14.7%	12.3%	11.2%	19.4%	21.2%
2021	11.2%	16.0%	17.7%	10.0%	10.9%	13.0%	14.4%	11.3%	10.5%	19.4%	21.0%
2022	10.4%	15.4%	17.4%	10.0%	10.4%	12.0%	14.0%	10.3%	10.0%	19.4%	20.7%
2023	10.0%	14.8%	17.1%	10.0%	10.0%	11.1%	13.6%	10.0%	10.0%	19.4%	20.4%
2024	10.0%	14.3%	16.8%	10.0%	10.0%	10.2%	13.3%	10.0%	10.0%	19.3%	20.1%
2025	10.0%	13.7%	16.5%	10.0%	10.0%	10.0%	12.9%	10.0%	10.0%	19.3%	19.9%
2026	10.0%	13.1%	16.2%	10.0%	10.0%	10.0%	12.6%	10.0%	10.0%	19.3%	19.6%
2027	10.0%	12.5%	15.9%	10.0%	10.0%	10.0%	12.2%	10.0%	10.0%	19.2%	19.3%
2028	10.0%	12.0%	15.6%	10.0%	10.0%	10.0%	11.8%	10.0%	10.0%	19.2%	19.0%
2029	10.0%	11.4%	15.2%	10.0%	10.0%	10.0%	11.5%	10.0%	10.0%	19.2%	18.8%
2030	10.0%	10.8%	14.9%	10.0%	10.0%	10.0%	11.1%	10.0%	10.0%	19.2%	18.5%
2031	10.0%	10.2%	14.6%	10.0%	10.0%	10.0%	10.8%	10.0%	10.0%	19.1%	18.2%
2032	10.0%	10.0%	14.3%	10.0%	10.0%	10.0%	10.4%	10.0%	10.0%	19.1%	18.0%
2033	10.0%	10.0%	14.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	19.1%	17.7%
2034	10.0%	10.0%	13.7%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	19.0%	17.4%
2035	10.0%	10.0%	13.4%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	19.0%	17.1%
2036	10.0%	10.0%	13.1%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	19.0%	16.9%
2037	10.0%	10.0%	12.8%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	19.0%	16.6%
2038	10.0%	10.0%	12.5%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	18.9%	16.3%
2039	10.0%	10.0%	12.2%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	18.9%	16.1%
2040	10.0%	10.0%	11.9%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	18.9%	15.8%
2041	10.0%	10.0%	11.6%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	18.9%	15.5%
2042	10.0%	10.0%	11.3%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	18.8%	15.2%

Source: JICA Study Team

3.4.6 Load Factor

It was assumed that average of 2006 to 2015 is employed for future load factor of each province up to 2042. Table 3.4-3 shows the load factor by provinces used for demand forecast.

Table 3.4-3 Load Factor by Provinces used for Demand Forecast

Cabo Delgado	Niassa	Nampula	Zambézia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo city
0.62	0.55	0.64	0.63	0.62	0.59	0.64	0.70	0.56	0.66	0.67

Source: JICA Study Team

3.5 Demand Forecast of Provincial Level

3.5.1 General Customer

In line with national level, following single regression formula was prepared including GDP/Capita that includes elements of GDP and population.

$Y=a*X_1+d$

Here, X_1: GDP/Capita (MZN)

Table 3.5-1 shows the analyzed result.

Table 3.5-1 Regression Analysis Result of "General Customer"

Province	Analyzed Regression Formula
Cabo Delgado	$Y=0.0073112*X_1-45.558$
Niassa	$Y=0.0068914*X_1-41.873$
Nampula	$Y=0.031025*X_1-251.27$
Zambézia	$Y=0.0070308*X_1-20.800$
Manica	$Y=0.017864*X_1-103.44$
Tete	$Y=0.019624*X_1-148.23$
Sofala	$Y=0.013315*X_1-125.05$
Inhambane	$Y=0.0025364*X_1-30.178$
Gaza	$Y=0.014323*X_1-119.76$
Maputo Province	$Y=0.023612*X_1-643.48$
Maputo city	$Y=0.0076232*X_1-117.29$

Source: JICA Study Team

3.5.2 M-L Customer

The following single regression formula was prepared including GDP/Capita that includes elements of GDP and population.

$Y=a*X_1+d$

Here, X_1: GDP/Capita (MZN)

Table 3.5-2 shows the analyzed result.

Table 3.5-2 Regression Analysis Result of "M-L Customer"

Province	Analyzed Regression Formula
Cabo Delgado	$Y=0.0016855*X_1-110.14$
Niassa	$Y=0.0023820*X_1-144.61$
Nampula	$Y=0.044054*X_1-361.28$
Zambézia	$Y=0.032487*X_1-165.03$
Manica	$Y=0.017864*X_1-103.44$
Tete	$Y=0.029098*X_1-213.16$
Sofala	$Y=0.016509*X_1-195.28$
Inhambane	$Y=0.0086781*X_1-113.11$
Gaza	$Y=0.019289*X_1-149.52$
Maputo Province	$Y=0.045677*X_1-1572.3$
Maputo city	$Y=0.013182*X_1-256.96$

Source: JICA Study Team

3.5.3 Special Customer

From Table 3.5-3 to Table 3.5-15 show "Special Customer" list of provinces. As described in 3.2.3, in terms of new customers, 30% of all prospective customers will be installed on energy consumption base and in regard to existing customers, present customer consumption will continue up to 2042. Maximum power is calculated utilizing province load factor where customers belong to. In addition, Mozal operates almost base load, it is very unique that Mozal is individually evaluated.

Table 3.5-3 Special Customer List of Cabo Delgado Province (Energy consumption, Maximum power)

Cabo Delgado (GWh)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<New Customer>																											
SIRAH RESOURSES					43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4
Portos de Cabo Delgado				17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4	17.4
EMI Electrical and Mechanical Installations Limitada	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9
~~Wimbi Village LDA~~																											
Grafex Limitada					43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4
Pemba Bay		4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Pedreira Dong Zheng	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Moçambique, Meihua Cimento Lda.				119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5	119.5
Grafex Limitada			43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4	43.4
GK Ancuabe	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Fabrica de Cimentos de Cabo Delgado	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6
Renco Tek	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Entreposto Hotel	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Condominio de Fundo Fomento e Habitacao (1200 Casas)	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Hotel Pemba Bay	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Fipag	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7
Grupo Aevitas		16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Macomo Propriedades		16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
MIA Group	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
Future increase after 2021						84.0	168.0	252.0	336.0	420.0	504.1	588.1	672.1	756.1	840.1	924.1	1,008.1	1,092.1	1,176.1	1,260.1	1,344.2	1,428.2	1,512.2	1,596.2	1,680.2	1,764.2	1,848.2
Total (Employing ratio: 30%)	34.8	45.9	58.9	99.9	126.0	151.2	176.4	201.6	226.8	252.0	277.2	302.4	327.6	352.8	378.0	403.2	428.4	453.7	478.9	504.1	529.3	554.5	579.7	604.9	630.1	655.3	680.5

Cabo Delgado (MW)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<New Customer>																											
SIRAH RESOURSES					8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Portos de Cabo Delgado				3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
EMI Electrical and Mechanical Installations Limitada	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
~~Wimbi Village LDA~~																											
Grafex Limitada					8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Pemba Bay		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Pedreira Dong Zheng	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Moçambique, Meihua Cimento Lda.				22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Grafex Limitada			8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
GK Ancuabe	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Fabrica de Cimentos de Cabo Delgado	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Renco Tek	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Entreposto Hotel	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Condominio de Fundo Fomento e Habitacao (1200 Casas)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Hotel Pemba Bay	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fipag	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Grupo Aevitas		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Macomo Propriedades		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
MIA Group	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Future increase after 2021						15.5	30.9	46.4	61.9	77.3	92.8	108.3	123.7	139.2	154.7	170.1	185.6	201.1	216.6	232.0	247.5	263.0	278.4	293.9	309.4	324.8	340.3
Total (Employing ratio: 30%)	6.4	8.4	10.8	18.4	23.2	27.8	32.5	37.1	41.8	46.4	51.0	55.7	60.3	65.0	69.6	74.2	78.9	83.5	88.2	92.8	97.4	102.1	106.7	111.4	116.0	120.7	125.3

Source: JICA Study Team

Table 3.5-4 Special Customer List of Niassa Province (Energy consumption, Maximum power)

Niassa (GWh)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<New Customer>																											
Fábrica de racção		19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3
Matadouro de frangos				24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1
Green Resources			4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Florestas do Niassa			4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Fábrica de aço			19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3
Fábrica de cimento			19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.3
Fundição de calcário			48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2	48.2
Future increase after 2021						27.9	55.9	83.8	111.8	139.7	167.7	195.6	223.6	251.5	279.4	307.4	335.3	363.3	391.2	419.2	447.1	475.1	503.0	530.9	558.9	586.8	614.8
Total (Employing ratio: 30%)		5.8	34.7	41.9	41.9	50.3	58.7	67.1	75.4	83.8	92.2	100.6	109.0	117.4	125.7	134.1	142.5	150.9	159.3	167.7	176.0	184.4	192.8	201.2	209.6	218.0	226.3

Niassa (MW)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<New Customer>																											
Fábrica de racção		4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Matadouro de frangos				5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Green Resources			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Florestas do Niassa			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fábrica de aço			4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Fábrica de cimento			4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Fundição de calcário			10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Future increase after 2021						5.8	11.6	17.4	23.2	29.0	34.8	40.6	46.4	52.2	58.0	63.8	69.6	75.4	81.2	87.0	92.8	98.6	104.4	110.2	116.0	121.8	127.6
Total (Employing ratio: 30%)		1.2	7.2	8.7	8.7	10.4	12.2	13.9	15.7	17.4	19.1	20.9	22.6	24.4	26.1	27.8	29.6	31.3	33.1	34.8	36.5	38.3	40.0	41.8	43.5	45.2	47.0

Source: JICA Study Team

Table 3.5-5 Special Customer List of Nampula Province (Energy consumption, Maximum power)

Nampula (GWh)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<Existing Customer>																											
MOMA	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9	153.9
MMI	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
<New Customer>																											
Fabrica coca-cola sabco	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
Banco de Moçambique			5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
MEREC INDUSTRIES,SA	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Sedgley Developments(Nacala Business Campus City of Nacala development Zone)		17.9	40.4	67.3	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2	94.2
Indico Dourado				13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Industria Cimenteira de Nacala Lda	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9	35.9
S&S Refinária de óleo	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9
Fabrica de Cimentos Nacala Porto		44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
Nacala Cimentos			56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1
Frabrica de Cimentos de Maiaia		9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
GAZEDA - Nacala			420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5	420.5
Zona Industrial de Nacala			308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4	308.4
Future increase after 2021						206.0	412.0	618.0	824.0	1,030.0	1,236.0	1,442.0	1,648.0	1,854.0	2,060.0	2,266.0	2,472.0	2,678.0	2,884.0	3,090.0	3,296.0	3,502.0	3,708.0	3,914.0	4,120.0	4,326.0	4,532.0
Total (Employing ratio: 30%)	179.8	201.4	445.2	457.3	465.4	527.2	589.0	650.8	712.6	774.4	836.2	898.0	959.8	1,021.6	1,083.4	1,145.2	1,207.0	1,268.8	1,330.6	1,392.4	1,454.2	1,516.0	1,577.8	1,639.6	1,701.4	1,763.2	1,825.0

Nampula (MW)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<Existing Customer>																											
MOMA	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5
MMI	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
<New Customer>																											
Fabrica coca-cola sabco	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Banco de Moçambique			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
MEREC INDUSTRIES,SA	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Sedgley Developments(Nacala Business Campus City of Nacala development Zone)		3.2	7.2	12.0	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8
Indico Dourado				2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Industria Cimenteira de Nacala Lda	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
S&S Refinária de óleo	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Fabrica de Cimentos Nacala Porto		8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Nacala Cimentos			10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Frabrica de Cimentos de Maiaia		1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
GAZEDA - Nacala			75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0
Zona Industrial de Nacala			55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0
Future increase after 2021						36.7	73.5	110.2	147.0	183.7	220.5	257.2	294.0	330.7	367.4	404.2	440.9	477.7	514.4	551.2	587.9	624.6	661.4	698.1	734.9	771.6	808.4
Total (Employing ratio: 30%)	30.9	34.7	78.2	80.4	81.8	92.9	103.9	114.9	125.9	136.9	148.0	159.0	170.0	181.0	192.1	203.1	214.1	225.1	236.2	247.2	258.2	269.2	280.2	291.3	302.3	313.3	324.3

Source: JICA Study Team

Table 3.5-6 Special Customer List of Zambezia Province (Energy consumption, Maximum power)

Zambezia (GWh)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<New Customer>																											
PORTUCEL, CENNERGI		35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3	35.3
Minas de Muiro			8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Zona Franca Industrial de Mocuba					22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
Mocotex				4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
Minas de Moiane					8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Área do Industrial do Projecto Avícola																											
Africa Great Wall Mining Development Company, Lda.				275.9	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1
Hospital Central de Quelimane	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3
Future increase after 2021						85.0	170.0	255.0	340.0	424.9	509.9	594.9	679.9	764.9	849.9	934.9	1,019.9	1,104.9	1,189.9	1,274.8	1,359.8	1,444.8	1,529.8	1,614.8	1,699.8	1,784.8	1,869.8
Total (Employing ratio: 30%)	4.3	14.9	17.5	101.7	127.5	153.0	178.5	204.0	229.5	255.0	280.5	306.0	331.5	357.0	382.5	407.9	433.4	458.9	484.4	509.9	535.4	560.9	586.4	611.9	637.4	662.9	688.4

Zambezia (MW)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<New Customer>																											
PORTUCEL, CENNERGI		6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Minas de Muiro			1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Zona Franca Industrial de Mocuba					4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Mocotex				0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Minas de Moiane					1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Área do Industrial do Projecto Avícola																											
Africa Great Wall Mining Development Company, Lda.				50.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Hospital Central de Quelimane	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Future increase after 2021						15.4	30.8	46.2	61.6	77.0	92.4	107.8	123.2	138.6	154.0	169.4	184.8	200.2	215.6	231.0	246.4	261.8	277.2	292.6	308.0	323.4	338.8
Total (Employing ratio: 30%)	0.8	2.7	3.2	18.4	23.1	27.7	32.3	37.0	41.6	46.2	50.8	55.4	60.1	64.7	69.3	73.9	78.5	83.2	87.8	92.4	97.0	101.6	106.3	110.9	115.5	120.1	124.7

Source: JICA Study Team

Table 3.5-7 Special Customer List of Manica Province (Energy consumption, Maximum power)

Manica (GWh)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<New Customer>																											
PORTUCEL, CENNERGI		34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8	34.8
Banco de Moçambique			4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Explorator Limitada			61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5
PORTUCEL, CENNERGI		4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
OMNIA MINING LDA/CLEAN TECH MINING		13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
MOZ BIF	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
PEMAR	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
MACS IN MOZ		4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
VODACOM-CHIMOIO		4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Future increase after 2021						27.4	54.8	82.2	109.6	137.0	164.4	191.8	219.2	246.6	273.9	301.3	328.7	356.1	383.5	410.9	438.3	465.7	493.1	520.5	547.9	575.3	602.7
Total (Employing ratio: 30%)	3.1	21.3	41.1	41.1	41.1	49.3	57.5	65.7	74.0	82.2	90.4	98.6	106.8	115.1	123.3	131.5	139.7	147.9	156.2	164.4	172.6	180.8	189.0	197.2	205.5	213.7	221.9

Manica (MW)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<New Customer>																											
PORTUCEL, CENNERGI		6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Banco de Moçambique			0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Explorator Limitada			11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
PORTUCEL, CENNERGI		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
OMNIA MINING LDA/CLEAN TECH MINING		2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
MOZ BIF	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
PEMAR	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
MACS IN MOZ		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
VODACOM-CHIMOIO		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Future increase after 2021						5.0	10.1	15.1	20.2	25.2	30.3	35.3	40.4	45.4	50.4	55.5	60.5	65.6	70.6	75.7	80.7	85.7	90.8	95.8	100.9	105.9	111.0
Total (Employing ratio: 30%)	0.6	3.9	7.6	7.6	7.6	9.1	10.6	12.1	13.6	15.1	16.6	18.2	19.7	21.2	22.7	24.2	25.7	27.2	28.8	30.3	31.8	33.3	34.8	36.3	37.8	39.3	40.9

Source: JICA Study Team

Table 3.5-8 Special Customer List of Tete Province (Energy consumption, Maximum power)

Tete (GWh)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<Existing Customer>																											
Vale	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8	133.8
RIO TINTO	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2
JINDAL	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
<New Customer>																											
PPC Cimento		18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6
Parque Industrial				62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0
Blue Fisher **		7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Future increase after 2021						17.5	35.1	52.6	70.1	87.7	105.2	122.7	140.2	157.8	175.3	192.8	210.4	227.9	245.4	263.0	280.5	298.0	315.6	333.1	350.6	368.2	385.7
Total (Employing ratio: 30%)	163.4	171.1	171.1	189.7	189.7	195.0	200.2	205.5	210.7	216.0	221.3	226.5	231.8	237.0	242.3	247.6	252.8	258.1	263.3	268.6	273.9	279.1	284.4	289.6	294.9	300.2	305.4

Tete (MW)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<Existing Customer>																											
Vale	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9	25.9
RIO TINTO	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
JINDAL	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
<New Customer>																											
PPC Cimento		3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Parque Industrial				12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Blue Fisher **		1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Future increase after 2021						3.4	6.8	10.2	13.6	17.0	20.4	23.7	27.1	30.5	33.9	37.3	40.7	44.1	47.5	50.9	54.3	57.7	61.1	64.4	67.8	71.2	74.6
Total (Employing ratio: 30%)	28.6	30.1	30.1	33.7	33.7	34.8	35.8	36.8	37.8	38.8	39.8	40.9	41.9	42.9	43.9	44.9	45.9	47.0	48.0	49.0	50.0	51.0	52.1	53.1	54.1	55.1	56.1

Source: JICA Study Team

Table 3.5-9　Special Customer List of Sofala Province (Energy consumption, Maximum power)

Sofala (GWh)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<Existing Customer>																											
CIMENTOS DE DONDO	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8
CIM BEIRA	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
<New Customer>																											
Austral Cimentos Sofala SA			196.2	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4
Banco de Moçambique			4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
China Mozambique Cement & Mining Development Company., Ltd			291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5	291.5
Sofala Cement Industries Limited			100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9
Biworld International Ltd				56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1
GAZEDA - Manga/Mungassa			392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4	392.4
Zona Industrial de Dongo			140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2	140.2
Future increase after 2021						275.6	551.2	826.8	1,102.4	1,378.1	1,653.7	1,929.3	2,204.9	2,480.5	2,756.1	3,031.7	3,307.3	3,582.9	3,858.5	4,134.2	4,409.8	4,685.4	4,961.0	5,236.6	5,512.2	5,787.8	6,063.4
Total (Employing ratio: 30%)	21.8	21.8	359.5	435.2	435.2	517.9	600.6	683.2	765.9	848.6	931.3	1,014.0	1,096.7	1,179.3	1,262.0	1,344.7	1,427.4	1,510.1	1,592.8	1,675.4	1,758.1	1,840.8	1,923.5	2,006.2	2,088.9	2,171.5	2,254.2

Sofala (MW)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<Existing Customer>																											
CIMENTOS DE DONDO	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
CIM BEIRA	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
<New Customer>																											
Austral Cimentos Sofala SA			35.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Banco de Moçambique			0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
China Mozambique Cement & Mining Development Company., Ltd			52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0	52.0
Sofala Cement Industries Limited			18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Biworld International Ltd				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
GAZEDA - Manga/Mungassa			70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Zona Industrial de Dongo			25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Future increase after 2021						49.2	98.3	147.5	196.6	245.8	295.0	344.1	393.3	442.4	491.6	540.8	589.9	639.1	688.2	737.4	786.6	835.7	884.9	934.0	983.2	1,032.4	1,081.5
Total (Employing ratio: 30%)	3.7	3.7	64.0	77.5	77.5	92.2	107.0	121.7	136.5	151.2	165.9	180.7	195.4	210.2	224.9	239.7	254.4	269.2	283.9	298.7	313.4	328.2	342.9	357.7	372.4	387.2	401.9

Source: JICA Study Team

Table 3.5-10 Special Customer List of Inhambane Province (Energy consumption, Maximum power)

Inhambane (GWh)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<New Customer>																											
Rio Tinto					30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7
Future increase after 2021						6.1	12.3	18.4	24.5	30.7	36.8	42.9	49.1	55.2	61.3	67.5	73.6	79.7	85.8	92.0	98.1	104.2	110.4	116.5	122.6	128.8	134.9
Total (Employing ratio: 30%)					9.2	11.0	12.9	14.7	16.6	18.4	20.2	22.1	23.9	25.8	27.6	29.4	31.3	33.1	35.0	36.8	38.6	40.5	42.3	44.2	46.0	47.8	49.7

Inhambane (MW)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<New Customer>																											
Rio Tinto					5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Future increase after 2021						1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0
Total (Employing ratio: 30%)					1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.1

Source: JICA Study Team

Table 3.5-11 Special Customer List of Gaza Province (Energy consumption, Maximum power)

Gaza (GWh)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<New Customer>																											
Anhiu Foreingn Economic Construction (Group)		58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9	58.9
Future increase after 2021						11.8	23.5	35.3	47.1	58.9	70.6	82.4	94.2	106.0	117.7	129.5	141.3	153.1	164.8	176.6	188.4	200.1	211.9	223.7	235.5	247.2	259.0
Total (Employing ratio: 30%)		17.7	17.7	17.7	17.7	21.2	24.7	28.3	31.8	35.3	38.9	42.4	45.9	49.4	53.0	56.5	60.0	63.6	67.1	70.6	74.2	77.7	81.2	84.8	88.3	91.8	95.4

Gaza (MW)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<New Customer>																											
Anhiu Foreingn Economic Construction (Group)		12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Future increase after 2021						2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0	26.4	28.8	31.2	33.6	36.0	38.4	40.8	43.2	45.6	48.0	50.4	52.8
Total (Employing ratio: 30%)		3.6	3.6	3.6	3.6	4.3	5.0	5.8	6.5	7.2	7.9	8.6	9.4	10.1	10.8	11.5	12.2	13.0	13.7	14.4	15.1	15.8	16.6	17.3	18.0	18.7	19.4

Source: JICA Study Team

Table 3.5-12 Special Customer List of Maputo Province (Energy consumption)

Maputo Province with Mozal (GWh)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<Existing Customer>																											
KOSIBAY																											
MIDAL	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
<New Customer>																											
~~PEPSI~~																											
Elite Industries Lda			46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3
Pure Diets Moçambique			16.2	16.2	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1
~~Grindrod Terminals (Terminal de Carvão da Matola)~~																											
Coca -Cola	11.6	11.6	11.6	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7
GS Cimentos				27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8
Limak Cimentos		37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0
Pure Diets Moçambique	16.2	39.3	74.0	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3	120.3
Home Center		6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Shimada	5.8	5.8	5.8	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2	20.2
Simbe			14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
Premier Group		14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
ATA construcoes	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
~~Mozal Harbour (Eliminated)~~																											
We Consult, Fabrica de Cerveja				69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4
Africa Great Wall Mining			98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3
Penintenciaria da Moamba					74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
PRAGOSA INDUSTRIA MOÇAMBIQUE, SA	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
DHC	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
YAAFICO INDUSTRIAL, Lda	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
MIDAL CABLES(Expansion)		17.3	17.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3	46.3
GAMMA CEMENT INTERNATIONAL			8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
MAQBUL IBRAIM ADEM	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
ARA-SUL			9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3
PUMA ENERGY MOÇAMBIQUE		7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4
GIMTL		4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
ACADEMIA AGA KHAN			19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4
AURECON				9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3
FIPAG				11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
CIMENTO NACIONAL, LDA		11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
BELEZA MOÇAMBIQUE				4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Arcellor Mittal				86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7
Cimco Pipes Pty				86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7	86.7
Monte Binga, SA				28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9
Titanium Smelting Plant				289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1	289.1
DHT Holding Africa Pty				462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5	462.5
CIF Moz				115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6	115.6
Mozal											8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8	8,238.8
Future increase after 2021						367.5	735.0	1,102.4	1,469.9	1,837.4	2,204.9	2,572.3	2,939.8	3,307.3	3,674.8	4,042.3	4,409.7	4,777.2	5,144.7	5,512.2	5,879.7	6,247.1	6,614.6	6,982.1	7,349.6	7,717.0	8,084.5
Total (Employing ratio: 30%)	27.9	64.7	138.8	530.2	556.6	666.9	777.1	887.3	997.6	1,107.8	9,456.9	9,567.1	9,677.3	9,787.6	9,897.8	10,008.1	10,118.3	10,228.6	10,338.8	10,449.0	10,559.3	10,669.5	10,779.8	10,890.0	11,000.3	11,110.5	11,220.7

Source: JICA Study Team

Table 3.5-13 Special Customer List of Maputo Province (Maximum power)

Maputo Province with Mozal (MW)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
<Existing Customer>																											
KOSIBAY																											
MIDAL	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
<New Customer>																											
~~PEPSI~~																											
Elite Industries Lda			8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Pure Diets Moçambique			2.8	2.8	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
~~Grindrod Terminals (Terminal de Carvão da Matola)~~																											
Coca -Cola	2.0	2.0	2.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
GS Cimentos				4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Limak Cimentos		6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Pure Diets Moçambique	2.8	6.8	12.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8
Home Center		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Shimada	1.0	1.0	1.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Simbe			2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Premier Group		2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
ATA construcoes	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
~~Mozal Harbour (Eliminated)~~																											
We Consult, Fabrica de Cerveja				12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Africa Great Wall Mining			17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Penintenciaria da Moamba					12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
PRAGOSA INDUSTRIA MOÇAMBIQUE, SA	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DHC	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
YAAFICO INDUSTRIAL, Lda	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
MIDAL CABLES(Expansion)		3.0	3.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
GAMMA CEMENT INTERNATIONAL			1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
MAQBUL IBRAIM ADEM	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
ARA-SUL			1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
PUMA ENERGY MOÇAMBIQUE		1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
GIMTL		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
ACADEMIA AGA KHAN			3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
AURECON				1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
FIPAG				2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
CIMENTO NACIONAL, LDA		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
BELEZA MOÇAMBIQUE				0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Arcellor Mittal				15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Cimco Pipes Pty				15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Monte Binga, SA				5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Titanium Smelting Plant				50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
DHT Holding Africa Pty				80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
CIF Moz				20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Mozal											950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0	950.0
Future increase after 2021						63.6	127.1	190.7	254.2	317.8	381.4	444.9	508.5	572.0	635.6	699.2	762.7	826.3	889.8	953.4	1,017.0	1,080.5	1,144.1	1,207.6	1,271.2	1,334.8	1,398.3
Total (Employing ratio: 30%)	4.8	11.2	24.0	91.7	96.3	115.3	134.4	153.5	172.5	191.6	1,160.7	1,179.7	1,198.8	1,217.9	1,236.9	1,256.0	1,275.1	1,294.1	1,313.2	1,332.3	1,351.3	1,370.4	1,389.5	1,408.5	1,427.6	1,446.7	1,465.7

Source: JICA Study Team

Table 3.5-14 Special Customer List of Maputo City (Energy consumption)

Maputo City (GWh)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<Existing Customer>																											
MCM	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
<New Customer>																											
Banco de Moçambique		49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3
JAT Constroi		37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6
CONSTELLATION					112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7
Empresa GTO	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Empresa Olimpico Imobiliaria, SA	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Radisson Hotel	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
Empresa Cognis	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
DDS					117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4	117.4
CC Joaquim Chissano	18.8	18.8	18.8	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.7
Cidadela da Matola					70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4	70.4
Cervejas de Moçambique		6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Escola Americana	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
MASA		11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7
Emen Building			4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Inalca	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Deco Construçoes	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Maputo Bay	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Euromoc	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Instituto National de Saude		7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Maputo Shopping Mall				16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
Mozambique Holdings LDA	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1
Gespetro	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
ISSM			5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Layout	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
Chiango Gardens	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6	37.6
GOLDEN ALLIANCE GROUP AND CONSTRUCTION, LDA	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Future increase after 2021						134.4	268.7	403.1	537.5	671.8	806.2	940.6	1,074.9	1,209.3	1,343.7	1,478.0	1,612.4	1,746.8	1,881.1	2,015.5	2,149.9	2,284.2	2,418.6	2,553.0	2,687.3	2,821.7	2,956.1
Total (Employing ratio: 30%)	60.8	94.7	97.9	114.9	205.1	245.4	285.7	326.0	366.3	406.6	446.9	487.2	527.6	567.9	608.2	648.5	688.8	729.1	769.4	809.7	850.0	890.4	930.7	971.0	1,011.3	1,051.6	1,091.9

Source: JICA Study Team

Table 3.5-15 Special Customer List of Maputo City (Maximum power)

Maputo City (MW)

	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
<Existing Customer>																											
MCM	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
<New Customer>																											
Banco de Moçambique		8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
JAT Constroi		6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
CONSTELLATION					19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
Empresa GTO	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Empresa Olimpico Imobiliaria, SA	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Radisson Hotel	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Empresa Cognis	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
DDS					20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
CC Joaquim Chissano	3.2	3.2	3.2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Cidadela da Matola					12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Cervejas de Moçambique		1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Escola Americana	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
MASA		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Emen Building			0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Inalca	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Deco Construçoes	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Maputo Bay	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Euromoc	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Instituto National de Saude		1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Maputo Shopping Mall				2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Mozambique Holdings LDA	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Gespetro	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
ISSM			1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Layout	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Chiango Gardens	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
GOLDEN ALLIANCE GROUP AND CONSTRUCTION, LDA	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Future increase after 2021						22.9	45.8	68.7	91.6	114.5	137.4	160.3	183.1	206.0	228.9	251.8	274.7	297.6	320.5	343.4	366.3	389.2	412.1	435.0	457.9	480.8	503.7
Total (Employing ratio: 30%)	10.4	16.1	16.7	19.6	34.9	41.8	48.7	55.5	62.4	69.3	76.1	83.0	89.9	96.7	103.6	110.5	117.4	124.2	131.1	138.0	144.8	151.7	158.6	165.4	172.3	179.2	186.0

Source: JICA Study Team

3.5.4 Demand Forecast

Table 3.5-16 shows the demand forecast of energy consumption by provinces on base case. Total of provinces is different from national level by about 8% at maximum. One of the reasons is considered that provincial level GDP and population is used. In the next step, national level result is reallocated to each province using each province’s share. On the other hand, maximum demand is calculated with coincidence factor for 11 provinces consolidation described in 2.2.5. Result after reallocation of energy consumption and maximum power are shown in Table 3.5-17, Table 3.5-18, Figure 3.5-1, and Figure 3.5-2.

Table 3.5-16 Energy Consumption at the Receiving End

(GWh)

	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	Total	Difference Ratio
2015	99.3	55.7	476.6	148.6	147.1	351.5	375.3	117.0	267.2	855.3	1,049.1	3,942.7	
2016	170.8	67.5	592.9	176.7	159.8	372.7	427.9	132.2	252.3	941.6	1,185.1	4,479.6	−1.95%
2017	199.2	80.1	657.9	202.7	193.2	403.8	460.7	146.8	295.1	1,053.9	1,301.2	4,994.6	−2.43%
2018	230.9	116.1	947.6	221.7	228.9	428.6	832.6	162.2	321.3	1,197.2	1,391.5	6,078.5	−2.74%
2019	291.8	130.9	1,008.0	322.9	245.6	473.4	943.9	178.3	348.8	1,659.3	1,500.6	7,103.4	−3.03%
2020	339.0	138.8	1,066.9	366.9	263.2	501.1	981.0	204.5	377.4	1,758.2	1,688.2	7,685.1	−3.48%
2021	386.7	155.5	1,182.2	411.6	289.9	535.6	1,102.4	224.3	410.9	1,943.1	1,831.6	8,473.8	−3.81%
2022	436.0	172.7	1,300.3	457.3	317.5	571.9	1,225.4	244.9	445.8	2,130.4	1,981.2	9,283.5	−4.12%
2023	486.8	190.3	1,421.6	504.2	346.2	610.0	1,350.3	266.5	482.2	2,320.2	2,137.2	10,115.5	−4.41%
2024	539.3	208.5	1,546.1	552.4	376.0	650.2	1,477.1	289.1	520.0	2,512.4	2,299.9	10,971.0	−4.69%
2025	593.7	227.3	1,673.9	601.8	406.9	692.5	1,606.0	312.8	559.4	2,707.4	2,469.8	11,851.5	−4.96%
2026	649.9	246.6	1,805.4	652.7	439.1	737.1	1,737.0	337.7	600.6	2,905.4	2,647.4	12,758.8	−5.23%
2027	708.3	266.5	1,940.7	705.0	472.7	784.1	1,870.4	363.8	643.5	3,106.5	2,833.2	13,694.7	−5.48%
2028	768.8	287.0	2,080.1	759.0	507.7	833.8	2,006.4	391.2	688.5	3,311.0	3,027.7	14,661.1	−5.73%
2029	831.8	308.2	2,223.8	814.6	544.3	886.4	2,145.0	420.0	735.5	3,519.1	3,231.3	15,659.9	−5.97%
2030	897.3	330.1	2,372.1	872.1	582.4	942.0	2,286.5	450.4	784.6	3,731.0	3,444.9	16,693.3	−6.21%
2031	965.5	352.7	2,524.9	931.3	622.1	1,000.6	2,430.9	482.4	836.0	3,948.1	3,668.9	17,763.3	−6.44%
2032	1,036.4	375.8	2,682.4	992.2	662.9	1,061.8	2,578.4	515.9	889.6	4,171.9	3,904.4	18,871.8	−6.65%
2033	1,110.2	399.7	2,844.8	1,054.9	705.0	1,126.0	2,729.1	551.1	945.7	4,402.7	4,152.0	20,021.0	−6.84%
2034	1,187.1	424.2	3,012.3	1,119.6	748.5	1,193.2	2,883.2	588.1	1,004.3	4,640.6	4,412.6	21,213.6	−7.01%
2035	1,267.3	449.5	3,185.6	1,186.2	793.5	1,263.6	3,041.0	627.1	1,065.6	4,886.0	4,687.0	22,452.5	−7.17%
2036	1,351.2	475.6	3,364.8	1,255.1	840.0	1,337.5	3,202.6	668.1	1,129.9	5,139.2	4,976.3	23,740.4	−7.32%
2037	1,439.0	502.6	3,550.3	1,326.2	888.1	1,415.2	3,368.4	711.4	1,197.4	5,400.6	5,281.5	25,080.6	−7.46%
2038	1,530.9	530.4	3,742.5	1,399.9	935.8	1,496.7	3,538.6	757.2	1,268.1	5,670.5	5,603.6	26,474.2	−7.59%
2039	1,627.4	559.2	3,942.0	1,476.2	989.8	1,582.4	3,713.4	805.4	1,342.4	5,949.5	5,943.8	27,931.5	−7.71%
2040	1,728.7	589.1	4,149.1	1,555.3	1,043.6	1,672.6	3,893.2	856.4	1,420.6	6,237.8	6,303.3	29,449.7	−7.83%
2041	1,834.7	617.6	4,365.8	1,635.3	1,096.8	1,764.4	4,072.4	910.7	1,499.6	6,556.6	6,675.0	31,028.9	−7.78%
2042	1,946.2	648.2	4,590.1	1,719.1	1,153.3	1,862.2	4,259.2	967.8	1,583.9	6,876.0	7,071.6	32,677.6	−7.81%

Source: JICA Study Team

Table 3.5-17 Energy Consumption at the Receiving End (After Reallocation)

(GWh)

	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	Total
2015	99.3	55.7	476.6	148.6	147.1	351.5	375.3	117.0	267.2	855.3	1,049.1	3,942.7
2016	174.2	68.9	604.7	180.2	162.9	380.1	436.5	134.8	257.4	960.4	1,208.6	4,568.7
2017	204.2	82.1	674.3	207.8	198.0	413.9	472.1	150.5	302.4	1,080.1	1,333.6	5,118.9
2018	237.4	119.4	974.3	227.9	235.3	440.6	856.0	166.7	330.4	1,230.9	1,430.6	6,249.5
2019	300.9	135.0	1,039.5	333.0	253.3	488.2	973.4	183.9	359.7	1,711.1	1,547.5	7,325.4
2020	351.2	143.8	1,105.3	380.1	272.7	519.1	1,016.3	211.9	391.0	1,821.5	1,749.0	7,962.0
2021	402.0	161.7	1,229.0	427.9	301.3	556.9	1,146.0	233.1	427.2	2,020.2	1,904.2	8,809.6
2022	454.7	180.1	1,356.2	477.0	331.2	596.5	1,278.1	255.4	465.0	2,222.0	2,066.4	9,682.6
2023	509.3	199.1	1,487.3	527.5	362.2	638.2	1,412.7	278.8	504.4	2,427.3	2,235.9	10,582.6
2024	565.9	218.8	1,622.2	579.6	394.5	682.2	1,549.9	303.3	545.6	2,636.2	2,413.2	11,511.4
2025	624.7	239.1	1,761.4	633.3	428.2	728.7	1,689.9	329.1	588.6	2,848.9	2,598.8	12,470.6
2026	685.8	260.2	1,905.0	688.7	463.4	777.7	1,832.8	356.3	633.7	3,065.6	2,793.3	13,462.2
2027	749.3	281.9	2,053.2	745.9	500.1	829.5	1,978.8	384.8	680.8	3,286.6	2,997.4	14,488.5
2028	815.5	304.4	2,206.5	805.1	538.6	884.4	2,128.2	414.9	730.3	3,512.2	3,211.6	15,551.8
2029	884.6	327.8	2,365.1	866.3	578.8	942.7	2,281.2	446.7	782.2	3,742.6	3,436.6	16,654.6
2030	956.8	352.0	2,529.2	929.9	621.0	1,004.4	2,438.0	480.3	836.6	3,978.2	3,673.1	17,799.5
2031	1,032.0	376.9	2,698.8	995.4	664.9	1,069.5	2,598.3	515.6	893.6	4,220.1	3,921.6	18,986.7
2032	1,110.2	402.6	2,873.5	1,062.9	710.1	1,137.5	2,762.1	552.6	953.0	4,469.2	4,182.5	20,216.2
2033	1,191.6	429.0	3,053.6	1,132.4	756.8	1,208.6	2,929.4	591.5	1,015.1	4,725.8	4,456.7	21,490.7
2034	1,276.6	456.2	3,239.4	1,204.0	805.0	1,283.1	3,100.6	632.4	1,080.0	4,990.5	4,745.3	22,813.2
2035	1,365.2	484.2	3,431.7	1,277.9	854.8	1,361.2	3,275.9	675.5	1,148.0	5,263.4	5,049.1	24,186.8
2036	1,457.9	513.2	3,630.5	1,354.2	906.3	1,443.2	3,455.5	720.9	1,219.2	5,545.0	5,369.3	25,615.0
2037	1,554.9	543.1	3,836.3	1,433.1	959.7	1,529.2	3,639.8	768.8	1,293.8	5,835.7	5,707.1	27,101.5
2038	1,656.7	574.0	4,050.1	1,514.9	1,012.7	1,619.7	3,829.4	819.4	1,372.3	6,136.6	6,064.1	28,650.0
2039	1,763.3	606.0	4,271.3	1,599.5	1,072.5	1,714.6	4,023.6	872.7	1,454.6	6,446.5	6,440.3	30,264.8
2040	1,875.5	639.1	4,501.4	1,687.3	1,132.2	1,814.7	4,223.7	929.1	1,541.2	6,767.5	6,838.5	31,950.4
2041	1,989.5	669.7	4,734.1	1,773.2	1,189.3	1,913.3	4,416.0	987.6	1,626.2	7,109.7	7,238.1	33,646.8
2042	2,110.9	703.1	4,978.7	1,864.6	1,251.0	2,019.8	4,619.8	1,049.8	1,718.0	7,458.1	7,670.2	35,444.0
AAGR	12.58%	10.11%	9.33%	10.07%	8.31%	6.70%	10.41%	8.49%	7.18%	8.52%	7.67%	

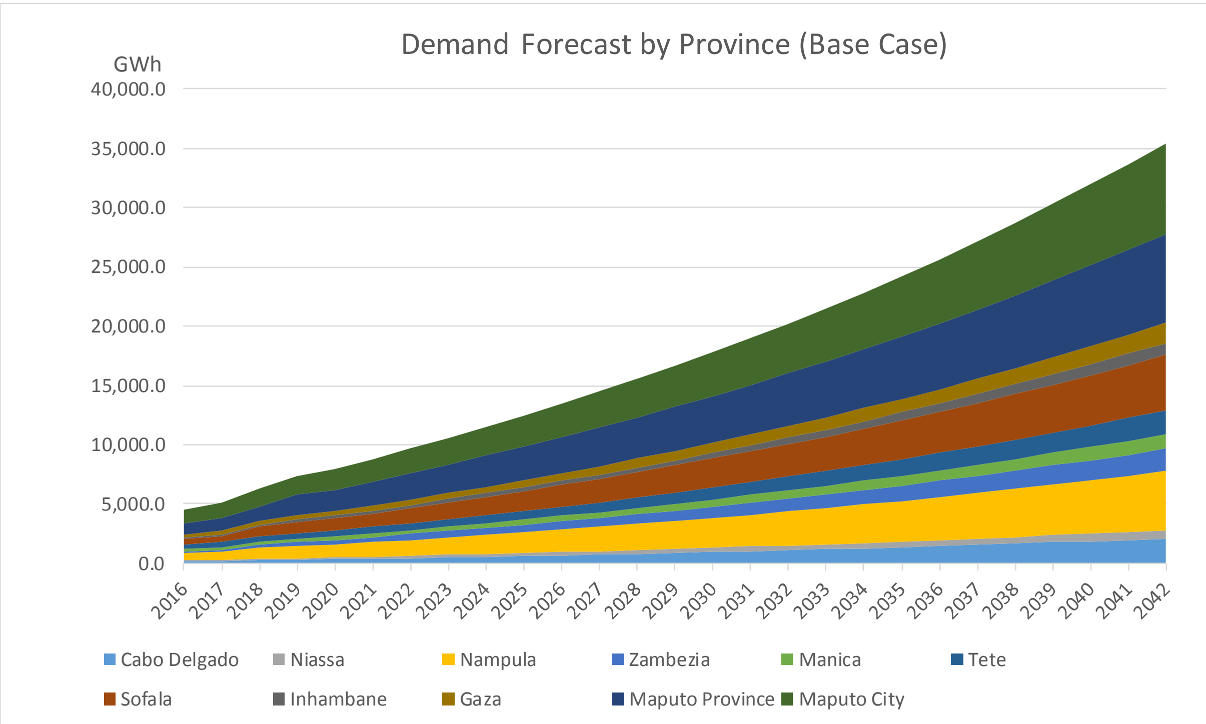
Source: JICA Study Team

Table 3.5-18 Maximum Demand at the Receiving End (After Reallocation)

(MW)

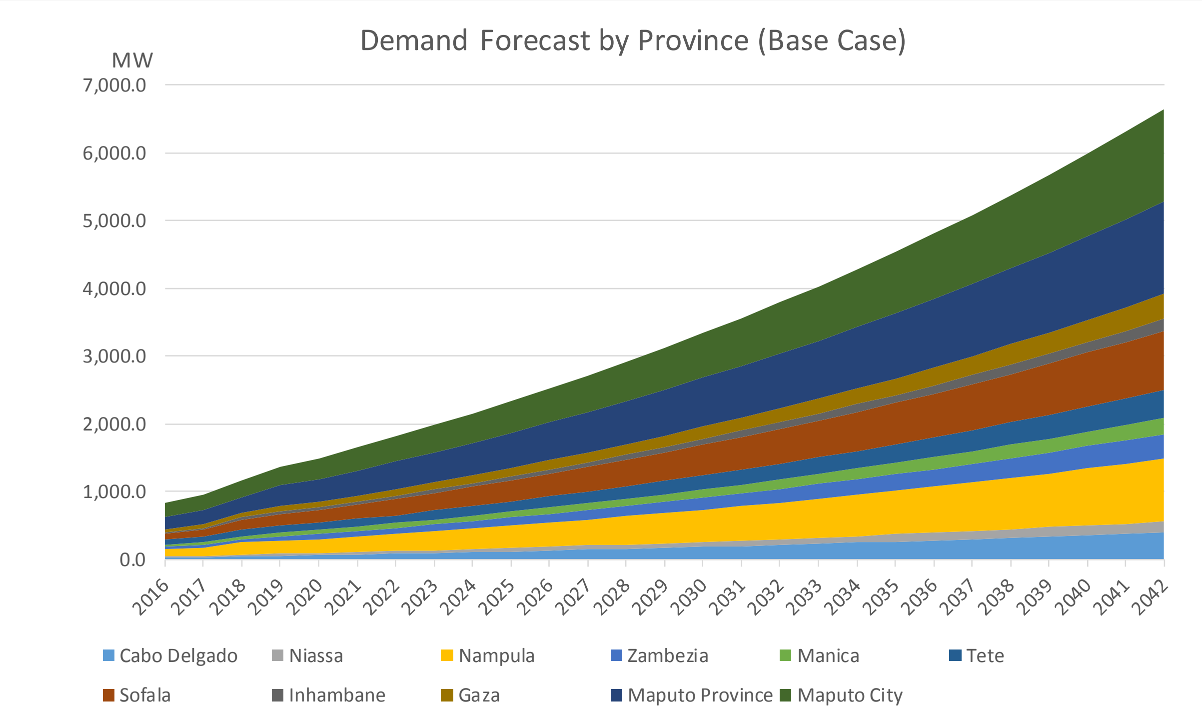
	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	Total
2015	21.4	12.5	94.3	33.9	26.6	73.0	73.9	18.0	43.3	160.1	164.1	721.0
2016	32.6	14.5	109.8	33.2	30.5	74.9	79.2	22.4	53.4	169.1	209.6	829.3
2017	39.5	17.9	126.5	39.6	38.3	84.2	88.6	25.8	64.8	196.4	238.9	960.6
2018	45.9	26.0	182.6	43.4	45.5	89.6	160.4	28.6	70.8	223.7	256.1	1,172.7
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	1,816.9
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	2,340.1
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	2,718.7
2028	158.0	66.5	414.1	153.5	104.3	180.0	399.4	71.2	156.6	639.1	575.7	2,918.3
2029	171.3	71.6	443.8	165.1	112.1	191.9	428.0	76.6	167.7	681.0	616.0	3,125.2
2030	185.3	76.8	474.6	177.2	120.3	204.4	457.4	82.4	179.4	723.8	658.3	3,340.1
2031	199.9	82.3	506.4	189.7	128.8	217.7	487.5	88.4	191.6	767.8	702.8	3,562.8
2032	215.0	87.9	539.1	202.6	137.5	231.5	518.2	94.8	204.3	813.1	749.6	3,793.5
2033	230.8	93.7	572.9	215.8	146.6	246.0	549.6	101.5	217.6	859.7	798.7	4,032.7
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	4,538.6
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	5,085.6
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	5,376.1
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	5,679.1
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	6,313.8
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	6,651.0
AAGR	11.88%	10.00%	9.08%	9.35%	8.60%	6.62%	10.21%	8.95%	8.33%	8.41%	8.27%	

Source: JICA Study Team



Source: JICA Study Team

Figure 3.5-1 Energy Consumption at the Receiving End (After Reallocation)



Source: JICA Study Team

Figure 3.5-2 Maximum Demand at the Receiving End (After Reallocation)

Energy consumption at receiving end on base case, there are 5 provinces that AAGR is exceeding national level AAGR 8.58%. The biggest province is Cabo Delgado (12.58%) followed by Sofala (10.41%), Niassa (10.11%), Zambezia (10.07%), and Nampula (9.38%). These provinces' shares are increasing, especially share of Cabo Delgado is expected to increase to 6% significantly from 2.5%.

Table 3.5-19 Share by Provinces at Receiving end on Base Case (After Reallocation)

	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City
2015	2.5%	1.4%	12.1%	3.8%	3.7%	8.9%	9.5%	3.0%	6.8%	21.7%	26.6%
2020	4.4%	1.8%	13.9%	4.8%	3.4%	6.5%	12.8%	2.7%	4.9%	22.9%	22.0%
2030	5.4%	2.0%	14.2%	5.2%	3.5%	5.6%	13.7%	2.7%	4.7%	22.4%	20.6%
2040	5.9%	2.0%	14.1%	5.3%	3.5%	5.7%	13.2%	2.9%	4.8%	21.2%	21.4%
2042	6.0%	2.0%	14.0%	5.3%	3.5%	5.7%	13.0%	3.0%	4.8%	21.0%	21.6%

Source: JICA Study Team

3.5.5 Demand Forecast (with Mozal)

To confirm the influence of Mozal, case with Mozal was studied in a similar manner with national level.

Result after reallocation of energy consumption and maximum power at a receiving end are shown in Table 3.5-20, Table 3.5-21, Figure 3.5-3, and Figure 3.5-4.

Table 3.5-20 Energy Consumption at the Receiving End (After Reallocation)

(GWh)

	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	Total
2015	99.3	55.7	476.6	148.6	147.1	351.5	375.3	117.0	267.2	855.3	1,049.1	3,942.7
2016	174.2	68.9	604.7	180.2	162.9	380.1	436.5	134.8	257.4	960.4	1,208.6	4,568.7
2017	204.2	82.1	674.3	207.8	198.0	413.9	472.1	150.5	302.4	1,080.1	1,333.6	5,118.9
2018	237.4	119.4	974.3	227.9	235.3	440.6	856.0	166.7	330.4	1,230.9	1,430.6	6,249.5
2019	300.9	135.0	1,039.5	333.0	253.3	488.2	973.4	183.9	359.7	1,711.1	1,547.5	7,325.4
2020	351.2	143.8	1,105.3	380.1	272.7	519.1	1,016.3	211.9	391.0	1,821.5	1,749.0	7,962.0
2021	402.0	161.7	1,229.0	427.9	301.3	556.9	1,146.0	233.1	427.2	2,020.2	1,904.2	8,809.6
2022	454.7	180.1	1,356.2	477.0	331.2	596.5	1,278.1	255.4	465.0	2,222.0	2,066.4	9,682.6
2023	509.3	199.1	1,487.3	527.5	362.2	638.2	1,412.7	278.8	504.4	2,427.3	2,235.9	10,582.6
2024	565.9	218.8	1,622.2	579.6	394.5	682.2	1,549.9	303.3	545.6	2,636.2	2,413.2	11,511.4
2025	624.7	239.1	1,761.4	633.3	428.2	728.7	1,689.9	329.1	588.6	2,848.9	2,598.8	12,470.6
2026	671.7	254.8	1,865.9	674.5	453.9	761.8	1,795.2	349.0	620.7	11,517.5	2,736.1	21,701.0
2027	733.9	276.1	2,011.0	730.5	489.8	812.5	1,938.1	376.9	666.8	11,755.9	2,935.7	22,727.3
2028	798.7	298.2	2,161.0	788.5	527.5	866.2	2,084.4	406.4	715.3	11,999.0	3,145.4	23,790.6
2029	866.4	321.0	2,316.4	848.5	566.9	923.2	2,234.2	437.5	766.1	12,247.2	3,365.8	24,893.3
2030	937.1	344.7	2,477.3	910.8	608.3	983.8	2,387.9	470.4	819.4	12,500.8	3,597.7	26,038.3
2031	1,010.9	369.3	2,643.7	975.1	651.3	1,047.6	2,545.3	505.1	875.3	12,760.3	3,841.6	27,225.5
2032	1,087.8	394.5	2,815.4	1,041.4	695.8	1,114.5	2,706.2	541.5	933.8	13,026.2	4,098.0	28,455.0
2033	1,167.9	420.5	2,992.7	1,109.8	741.7	1,184.5	2,871.0	579.7	994.9	13,298.9	4,367.9	29,729.5
2034	1,251.5	447.3	3,175.9	1,180.4	789.2	1,258.0	3,039.8	620.0	1,058.8	13,578.8	4,652.2	31,051.9
2035	1,338.9	474.9	3,365.7	1,253.3	838.3	1,335.0	3,212.8	662.5	1,125.9	13,866.4	4,951.9	32,425.6
2036	1,430.4	503.5	3,562.0	1,328.6	889.2	1,415.9	3,390.4	707.3	1,196.2	14,162.2	5,268.1	33,853.8
2037	1,526.2	533.0	3,765.6	1,406.7	942.0	1,501.0	3,572.7	754.6	1,270.0	14,466.6	5,601.8	35,340.3
2038	1,626.9	563.7	3,977.1	1,487.6	994.4	1,590.5	3,760.4	804.6	1,347.6	14,781.2	5,954.8	36,888.8
2039	1,732.3	595.3	4,196.2	1,571.4	1,053.7	1,684.5	3,952.9	857.4	1,429.0	15,103.5	6,327.2	38,503.5
2040	1,843.4	628.2	4,424.4	1,658.5	1,112.9	1,783.6	4,151.5	913.3	1,514.8	15,437.1	6,721.5	40,189.1
2041	1,957.0	658.8	4,656.8	1,744.3	1,169.9	1,882.0	4,343.9	971.5	1,599.6	15,781.7	7,120.0	41,885.6
2042	2,077.8	692.0	4,900.4	1,835.3	1,231.3	1,988.1	4,547.2	1,033.3	1,691.0	16,136.7	7,549.7	43,682.8

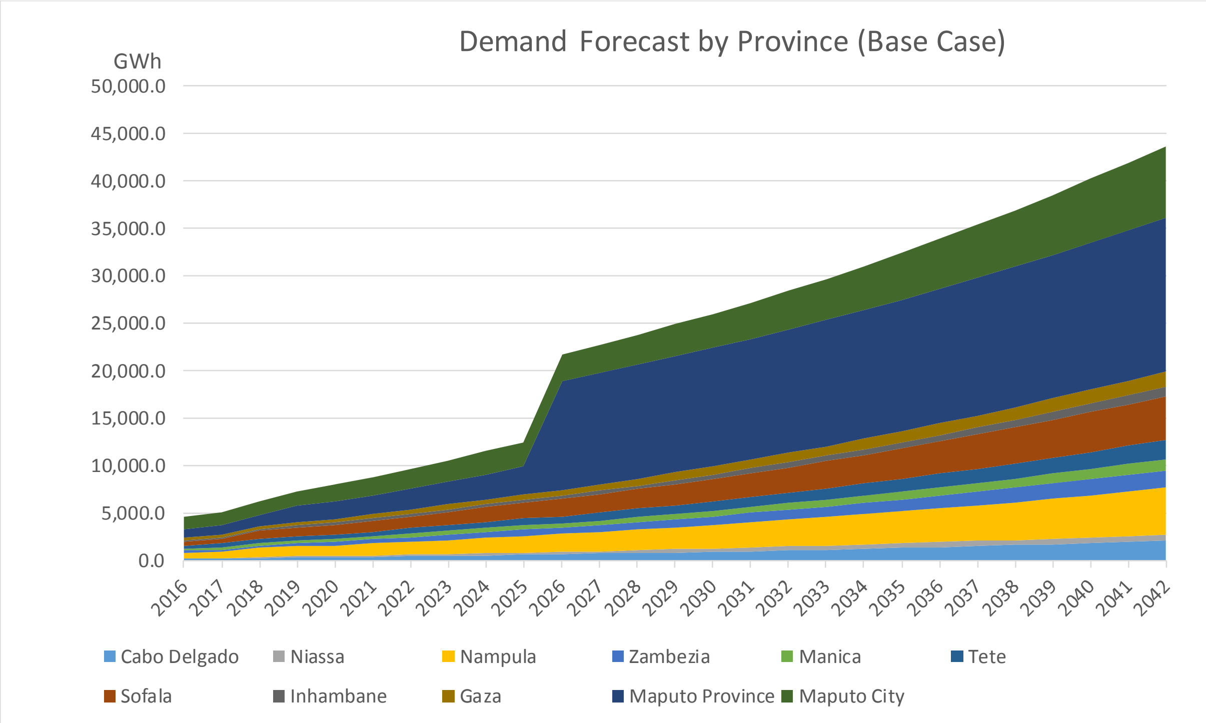
Source: JICA Study Team

Table 3.5-21 Maximum Demand at the Receiving End (After Reallocation)

(MW)

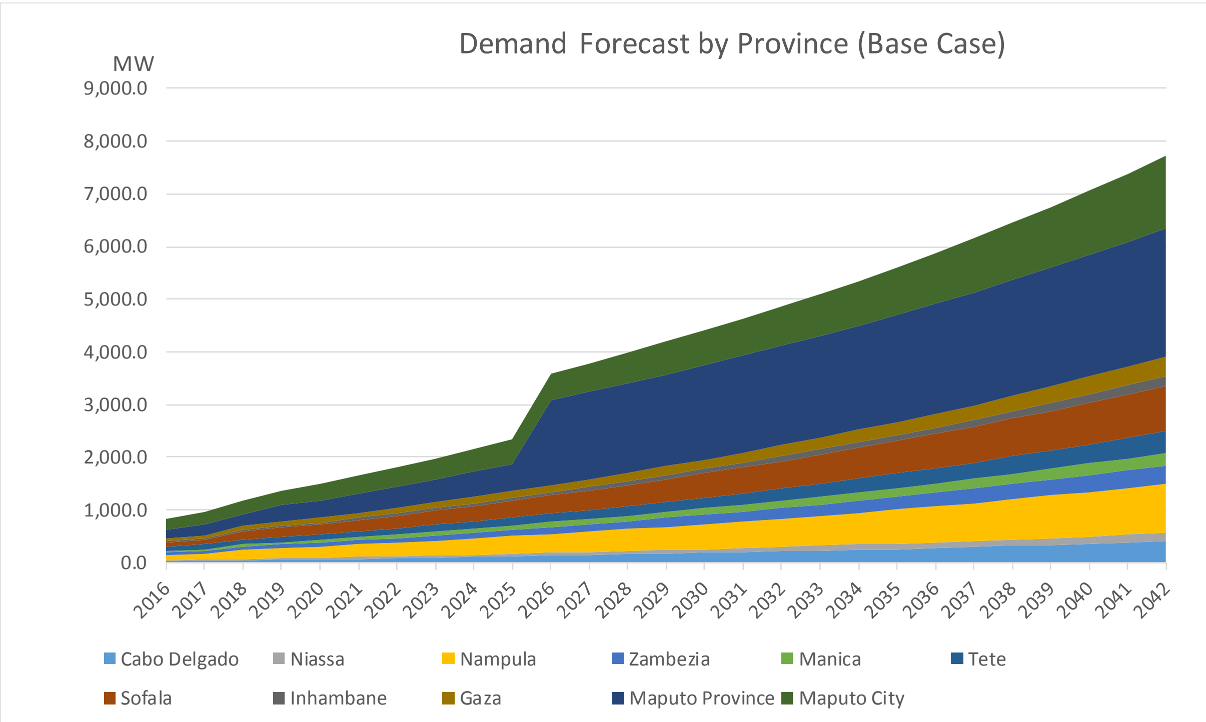
	Cabo Delgado	Niassa	Nampula	Zambezia	Manica	Tete	Sofala	Inhambane	Gaza	Maputo Province	Maputo City	Total
2015	21.4	12.5	94.3	33.9	26.6	73.0	73.9	18.0	43.3	160.1	164.1	721.0
2016	32.6	14.5	109.8	33.2	30.5	74.9	79.2	22.4	53.4	169.1	209.6	829.3
2017	39.5	17.9	126.5	39.6	38.3	84.2	88.6	25.8	64.8	196.4	238.9	960.6
2018	45.9	26.0	182.6	43.4	45.5	89.6	160.4	28.6	70.8	223.7	256.1	1,172.7
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	1,816.9
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	2,340.1
2026	133.1	56.9	358.2	131.6	89.9	158.6	344.7	61.3	136.2	1,615.8	501.8	3,588.1
2027	145.3	61.6	385.8	142.4	97.0	169.1	371.8	66.1	146.2	1,657.5	537.9	3,780.6
2028	158.0	66.5	414.2	153.5	104.4	180.1	399.5	71.2	156.7	1,700.0	575.9	3,980.2
2029	171.3	71.5	443.7	165.1	112.1	191.8	427.9	76.6	167.7	1,743.5	615.8	4,187.1
2030	185.2	76.8	474.2	177.1	120.2	204.3	457.1	82.3	179.3	1,787.9	657.8	4,401.9
2031	199.6	82.2	505.7	189.5	128.6	217.4	486.8	88.3	191.3	1,833.4	701.9	4,624.7
2032	214.6	87.7	538.2	202.2	137.3	231.1	517.3	94.6	204.0	1,880.2	748.2	4,855.4
2033	230.3	93.5	571.7	215.4	146.3	245.4	548.4	101.3	217.2	1,928.2	797.0	5,094.6
2034	246.6	99.4	606.3	228.9	155.5	260.5	580.3	108.2	231.0	1,977.7	848.3	5,342.8
2035	263.7	105.4	642.1	242.9	165.1	276.3	613.0	115.6	245.5	2,028.6	902.4	5,600.5
2036	281.5	111.7	679.2	257.4	175.0	292.9	646.4	123.3	260.7	2,081.0	959.5	5,868.5
2037	300.2	118.2	717.6	272.3	185.3	310.3	680.8	131.5	276.6	2,135.0	1,019.7	6,147.5
2038	319.8	124.9	757.5	287.8	195.5	328.6	716.2	140.1	293.3	2,190.9	1,083.4	6,438.0
2039	340.4	131.9	798.8	303.9	207.0	347.8	752.5	149.2	310.9	2,248.3	1,150.5	6,741.0
2040	362.0	139.1	841.8	320.5	218.6	368.1	789.8	158.9	329.4	2,307.7	1,221.5	7,057.3
2041	384.1	145.8	885.5	336.9	229.6	388.2	826.0	168.9	347.6	2,369.8	1,293.2	7,375.7
2042	407.6	153.0	931.3	354.3	241.6	409.9	864.2	179.5	367.3	2,433.5	1,370.6	7,712.9

Source: JICA Study Team



Source: JICA Study Team

Figure 3.5-3 Energy Consumption at the Receiving End (After Reallocation)



Source: JICA Study Team

Figure 3.5-4 Maximum Demand at the Receiving End (After Reallocation)

3.5.6 Demand Forecast of Substation

Table 3.5-22～Table 3.5-32 show maximum demand of existing substations (Base Case) by province. They were forecasted utilizing annual growth rate of each province and 2016 data as starting year. Two provinces are exception. In Maputo and Maputo city, 2015 data was employed as starting year because there was big transformer problem at Matola substation and abnormal system configuration had been continued and load shedding had been conducted for a long time. To define the 2016 substation maximum demand, demand of mobile transformer was integrated with substation demand because it was part of substation demand, in addition, regarding substations which have more than two transformers, maximum demand was investigated carefully not adopting sum of each transformer's maximum demand. Finally, 0.8 was hired considering past trend.

Table 3.5-22 Maximum Demand of Substation (Cabo Delgado)

Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	46.14	53.18	60.92	75.53	86.85	98.25	109.94	122.32	135.43	149.01	163.10	177.73	192.94	208.79	225.30	242.51	260.43	279.11	298.61	318.99	340.32	362.66	386.10	410.73	436.63	463.74	492.31
MW	36.91	42.54	48.74	60.42	69.48	78.60	87.95	97.85	108.34	119.21	130.48	142.19	154.36	167.03	180.24	194.01	208.35	223.29	238.89	255.19	272.25	290.13	308.88	328.58	349.30	370.99	393.85
MVR	27.68	31.91	36.55	45.32	52.11	58.95	65.96	73.39	81.26	89.41	97.86	106.64	115.77	125.27	135.18	145.51	156.26	167.47	179.17	191.39	204.19	217.60	231.66	246.44	261.98	278.25	295.39
PF																											

Pemba	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	29.45	33.94	38.89	48.21	55.44	62.71	70.18	78.08	86.45	95.12	104.11	113.45	123.16	133.27	143.81	154.80	166.24	178.16	190.61	203.62	217.23	231.49	246.45	262.17	278.70	296.01	314.25
MW	23.56	27.15	31.11	38.57	44.35	50.17	56.14	62.46	69.16	76.09	83.29	90.76	98.53	106.62	115.05	123.84	132.99	142.53	152.49	162.89	173.78	185.19	197.16	209.74	222.96	236.81	251.40
MVR	17.67	20.37	23.33	28.93	33.26	37.63	42.11	46.85	51.87	57.07	62.47	68.07	73.90	79.96	86.29	92.88	99.74	106.90	114.36	122.17	130.34	138.89	147.87	157.30	167.22	177.61	188.55
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Macomia	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	1.71	1.97	2.26	2.80	3.22	3.65	4.08	4.54	5.03	5.53	6.05	6.60	7.16	7.75	8.36	9.00	9.67	10.36	11.08	11.84	12.63	13.46	14.33	15.25	16.21	17.21	18.27
MW	1.37	1.58	1.81	2.24	2.58	2.92	3.26	3.63	4.02	4.42	4.84	5.28	5.73	6.20	6.69	7.20	7.73	8.29	8.87	9.47	10.11	10.77	11.46	12.20	12.97	13.77	14.62
MVR	1.03	1.18	1.36	1.68	1.93	2.19	2.45	2.72	3.02	3.32	3.63	3.96	4.30	4.65	5.02	5.40	5.80	6.22	6.65	7.10	7.58	8.08	8.60	9.15	9.72	10.33	10.96
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Metoro	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
MVA(MW+MVR)	9.75	11.24	12.87	15.96	18.35	20.76	23.23	25.85	28.62	31.49	34.47	37.56	40.77	44.12	47.61	51.25	55.04	58.98	63.10	67.41	71.92	76.64	81.59	86.80	92.27	98.00	104.04
MW	7.80	8.99	10.30	12.77	14.68	16.61	18.59	20.68	22.90	25.19	27.57	30.05	32.62	35.30	38.09	41.00	44.03	47.19	50.48	53.93	57.53	61.31	65.27	69.44	73.82	78.40	83.23
MVR	5.85	6.74	7.72	9.58	11.01	12.46	13.94	15.51	17.17	18.89	20.68	22.54	24.46	26.47	28.57	30.75	33.02	35.39	37.86	40.45	43.15	45.98	48.96	52.08	55.36	58.80	62.42
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Auasse	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	5.23	6.02	6.90	8.55	9.84	11.13	12.45	13.85	15.34	16.88	18.47	20.13	21.85	23.64	25.52	27.46	29.49	31.61	33.82	36.13	38.54	41.07	43.73	46.51	49.45	52.52	55.75
MW	4.18	4.82	5.52	6.84	7.87	8.90	9.96	11.08	12.27	13.50	14.78	16.10	17.48	18.92	20.41	21.97	23.59	25.29	27.05	28.90	30.83	32.86	34.98	37.21	39.56	42.01	44.60
MVR	3.14	3.61	4.14	5.13	5.90	6.68	7.47	8.31	9.20	10.13	11.08	12.08	13.11	14.19	15.31	16.48	17.70	18.97	20.29	21.68	23.12	24.64	26.24	27.91	29.67	31.51	33.45
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-23 Maximum Demand of Substation (Niassa)

Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	30.88	35.89	49.59	55.39	58.63	65.14	71.79	78.61	85.61	92.79	100.15	107.72	115.49	123.49	131.71	140.14	149.11	158.60	168.37	178.46	188.87	199.63	210.77	222.32	234.29	245.71	257.97
MW	24.70	28.71	39.68	44.31	46.91	52.11	57.43	62.89	68.49	74.23	80.12	86.18	92.39	98.79	105.37	112.11	119.29	126.88	134.70	142.77	151.10	159.71	168.62	177.85	187.43	196.57	206.38
MVR	18.53	21.53	29.76	33.23	35.18	39.08	43.07	47.17	51.37	55.67	60.09	64.63	69.30	74.09	79.03	84.09	89.47	95.16	101.02	107.07	113.32	119.78	126.46	133.39	140.58	147.42	154.78
PF																											

Cuamba	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	8.18	9.50	13.13	14.67	15.53	17.25	19.01	20.81	22.67	24.57	26.52	28.52	30.58	32.70	34.87	37.11	39.48	41.99	44.58	47.25	50.01	52.86	55.81	58.86	62.04	65.06	68.30
MW	6.54	7.60	10.51	11.73	12.42	13.80	15.21	16.65	18.13	19.65	21.21	22.82	24.46	26.16	27.90	29.69	31.58	33.59	35.67	37.80	40.01	42.29	44.65	47.09	49.63	52.05	54.64
MVR	4.91	5.70	7.88	8.80	9.32	10.35	11.41	12.49	13.60	14.74	15.91	17.11	18.35	19.62	20.92	22.26	23.69	25.20	26.75	28.35	30.01	31.72	33.48	35.32	37.22	39.03	40.98
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Lichinga	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	22.70	26.38	36.46	40.72	43.11	47.89	52.78	57.80	62.94	68.22	73.64	79.20	84.91	90.79	96.84	103.04	109.63	116.60	123.79	131.21	138.86	146.78	154.97	163.45	172.26	180.65	189.67
MW	18.16	21.11	29.17	32.58	34.49	38.31	42.23	46.24	50.35	54.58	58.91	63.36	67.93	72.63	77.47	82.43	87.70	93.28	99.03	104.96	111.09	117.42	123.97	130.76	137.81	144.52	151.73
MVR	13.62	15.83	21.88	24.43	25.87	28.73	31.67	34.68	37.77	40.93	44.18	47.52	50.95	54.47	58.10	61.82	65.78	69.96	74.27	78.72	83.32	88.07	92.98	98.07	103.35	108.39	113.80
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-24 Maximum Demand of Substation (Nampula)

Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	319.93	353.81	491.77	523.63	554.87	612.28	671.10	731.41	793.28	856.79	922.02	989.11	1,058.15	1,129.24	1,202.51	1,277.95	1,355.56	1,435.46	1,517.73	1,602.75	1,690.46	1,781.12	1,874.91	1,972.04	2,072.74	2,177.93	2,286.56
MW	255.94	283.05	393.41	418.91	443.89	489.83	536.88	585.13	634.63	685.43	737.62	791.29	846.52	903.39	962.01	1,022.36	1,084.45	1,148.37	1,214.18	1,282.20	1,352.37	1,424.89	1,499.93	1,577.63	1,658.19	1,742.35	1,829.25
MVR	191.96	212.29	295.06	314.18	332.92	367.37	402.66	438.85	475.97	514.07	553.21	593.47	634.89	677.54	721.51	766.77	813.33	861.28	910.64	961.65	1,014.28	1,068.67	1,124.95	1,183.22	1,243.64	1,306.76	1,371.94
PF																											

Nampula Centra	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
MVA(MW+MVR)	35.26	39.00	54.20	57.72	61.16	67.49	73.97	80.62	87.44	94.44	101.63	109.02	116.63	124.47	132.54	140.86	149.41	158.22	167.29	176.66	186.32	196.32	206.65	217.36	228.46	240.05	252.03
MW	28.21	31.20	43.36	46.17	48.93	53.99	59.18	64.49	69.95	75.55	81.30	87.22	93.30	99.57	106.03	112.69	119.53	126.57	133.83	141.33	149.06	157.05	165.32	173.89	182.77	192.04	201.62
MVR	21.16	23.40	32.52	34.63	36.69	40.49	44.38	48.37	52.46	56.66	60.98	65.41	69.98	74.68	79.53	84.51	89.65	94.93	100.37	105.99	111.79	117.79	123.99	130.42	137.08	144.03	151.22
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Nampula 220	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
MVA(MW+MVR)	205.69	227.48	316.17	336.66	356.74	393.65	431.47	470.24	510.02	550.85	592.79	635.92	680.31	726.01	773.12	821.63	871.52	922.89	975.79	1,030.45	1,086.84	1,145.12	1,205.42	1,267.87	1,332.61	1,400.25	1,470.08
MW	164.55	181.98	252.93	269.32	285.39	314.92	345.17	376.19	408.02	440.68	474.23	508.74	544.25	580.81	618.50	657.30	697.22	738.31	780.63	824.36	869.47	916.10	964.34	1,014.30	1,066.09	1,120.20	1,176.07
MVR	123.41	136.49	189.70	201.99	214.04	236.19	258.88	282.15	306.01	330.51	355.68	381.55	408.19	435.61	463.87	492.98	522.91	553.73	585.47	618.27	652.10	687.07	723.25	760.72	799.57	840.15	882.05
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Moma	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
MVA(MW+MVR)	19.75	21.84	30.36	32.33	34.25	37.80	41.43	45.15	48.97	52.89	56.92	61.06	65.32	69.71	74.23	78.89	83.68	88.62	93.69	98.94	104.36	109.95	115.74	121.74	127.96	134.45	141.16
MW	15.80	17.47	24.29	25.86	27.40	30.24	33.14	36.12	39.18	42.31	45.54	48.85	52.26	55.77	59.39	63.11	66.95	70.89	74.96	79.15	83.49	87.96	92.60	97.39	102.37	107.56	112.93
MVR	11.85	13.11	18.21	19.40	20.55	22.68	24.86	27.09	29.38	31.74	34.15	36.64	39.19	41.83	44.54	47.34	50.21	53.17	56.22	59.37	62.61	65.97	69.45	73.04	76.77	80.67	84.69
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Monapo	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	15.88	17.56	24.40	25.98	27.53	30.38	33.30	36.29	39.36	42.51	45.75	49.08	52.51	56.03	59.67	63.41	67.26	71.23	75.31	79.53	83.88	88.38	93.03	97.85	102.85	108.07	113.46
MW	12.70	14.05	19.52	20.79	22.03	24.31	26.64	29.03	31.49	34.01	36.60	39.26	42.01	44.83	47.74	50.73	53.81	56.98	60.25	63.62	67.11	70.70	74.43	78.28	82.28	86.46	90.77
MVR	9.53	10.53	14.64	15.59	16.52	18.23	19.98	21.78	23.62	25.51	27.45	29.45	31.50	33.62	35.80	38.05	40.36	42.74	45.19	47.72	50.33	53.03	55.82	58.71	61.71	64.84	68.08
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Nacala	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
MVA(MW+MVR)	35.18	38.90	54.07	57.57	61.01	67.32	73.79	80.42	87.22	94.20	101.37	108.75	116.34	124.16	132.21	140.51	149.04	157.83	166.87	176.22	185.86	195.83	206.14	216.82	227.89	239.46	251.40
MW	28.14	31.12	43.25	46.06	48.81	53.86	59.03	64.33	69.78	75.36	81.10	87.00	93.07	99.33	105.77	112.41	119.23	126.26	133.50	140.97	148.69	156.66	164.91	173.46	182.31	191.57	201.12
MVR	21.11	23.34	32.44	34.54	36.60	40.39	44.27	48.25	52.33	56.52	60.82	65.25	69.80	74.49	79.33	84.30	89.42	94.70	100.12	105.73	111.52	117.50	123.69	130.09	136.74	143.68	150.84
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Same as Nacala Velha-Vale

Vale Tr1	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
MVA(MW+MVR)	8	9	13	13	14	16	17	19	20	22	24	25	27	29	31	33	35	37	39	41	43	46	48	50	53	56	58
MW	6.54	7.23	10.05	10.70	11.34	12.52	13.72	14.95	16.22	17.51	18.85	20.22	21.63	23.08	24.58	26.12	27.71	29.34	31.03	32.76	34.56	36.41	38.33	40.31	42.37	44.52	46.74
MVR	4.91	5.42	7.54	8.03	8.51	9.39	10.29	11.21	12.16	13.14	14.14	15.16	16.22	17.31	18.44	19.59	20.78	22.01	23.27	24.57	25.92	27.31	28.75	30.23	31.78	33.39	35.06
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-25 Maximum Demand of Substation (Zambezia)

Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	55.88	62.81	67.77	94.75	106.27	118.15	131.03	144.25	157.85	171.83	186.24	201.08	216.41	232.24	248.61	265.51	282.91	300.85	319.36	338.47	358.24	378.70	399.90	421.88	444.70	467.80	492.03
MW	44.70	50.25	54.22	75.80	85.02	94.52	104.82	115.40	126.28	137.47	148.99	160.87	173.12	185.79	198.89	212.41	226.33	240.68	255.49	270.78	286.59	302.96	319.92	337.50	355.76	374.24	393.62
MVR	33.53	37.69	40.66	56.85	63.76	70.89	78.62	86.55	94.71	103.10	111.74	120.65	129.84	139.34	149.17	159.30	169.75	180.51	191.61	203.08	214.95	227.22	239.94	253.13	266.82	280.68	295.22
PF																											
Molocue	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	2.30	2.59	2.79	3.90	4.37	4.86	5.39	5.94	6.50	7.07	7.67	8.28	8.91	9.56	10.23	10.93	11.65	12.38	13.15	13.93	14.75	15.59	16.46	17.37	18.31	19.26	20.25
MW	1.84	2.07	2.23	3.12	3.50	3.89	4.31	4.75	5.20	5.66	6.13	6.62	7.13	7.65	8.19	8.74	9.32	9.91	10.52	11.15	11.80	12.47	13.17	13.89	14.64	15.40	16.20
MVR	1.38	1.55	1.67	2.34	2.62	2.92	3.24	3.56	3.90	4.24	4.60	4.97	5.34	5.74	6.14	6.56	6.99	7.43	7.89	8.36	8.85	9.35	9.88	10.42	10.98	11.55	12.15
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mocuba	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
MVA(MW+MVR)	11.50	12.93	13.95	19.50	21.87	24.32	26.97	29.69	32.49	35.37	38.33	41.39	44.54	47.80	51.17	54.65	58.23	61.92	65.73	69.66	73.73	77.94	82.31	86.83	91.53	96.28	101.27
MW	9.20	10.34	11.16	15.60	17.50	19.45	21.57	23.75	25.99	28.29	30.66	33.11	35.63	38.24	40.93	43.72	46.58	49.54	52.58	55.73	58.99	62.35	65.84	69.46	73.22	77.02	81.01
MVR	6.90	7.76	8.37	11.70	13.12	14.59	16.18	17.81	19.49	21.22	23.00	24.83	26.72	28.68	30.70	32.79	34.94	37.15	39.44	41.80	44.24	46.77	49.38	52.10	54.92	57.77	60.76
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Gurue	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	5.75	6.46	6.97	9.75	10.94	12.16	13.48	14.84	16.24	17.68	19.17	20.69	22.27	23.90	25.58	27.32	29.11	30.96	32.86	34.83	36.87	38.97	41.15	43.41	45.76	48.14	50.63
MW	4.60	5.17	5.58	7.80	8.75	9.73	10.79	11.88	13.00	14.15	15.33	16.55	17.82	19.12	20.47	21.86	23.29	24.77	26.29	27.87	29.49	31.18	32.92	34.73	36.61	38.51	40.51
MVR	3.45	3.88	4.18	5.85	6.56	7.30	8.09	8.91	9.75	10.61	11.50	12.42	13.36	14.34	15.35	16.39	17.47	18.58	19.72	20.90	22.12	23.38	24.69	26.05	27.46	28.88	30.38
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Ceramica	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
MVA(MW+MVR)	28.56	32.11	34.64	48.44	54.32	60.40	66.98	73.74	80.69	87.84	95.20	102.79	110.62	118.72	127.09	135.72	144.62	153.79	163.25	173.02	183.13	193.59	204.42	215.66	227.33	239.13	251.52
MW	22.85	25.69	27.71	38.75	43.46	48.32	53.58	58.99	64.55	70.27	76.16	82.23	88.50	94.97	101.67	108.58	115.70	123.03	130.60	138.42	146.50	154.87	163.54	172.53	181.86	191.31	201.21
MVR	17.14	19.26	20.79	29.06	32.59	36.24	40.19	44.24	48.41	52.70	57.12	61.67	66.37	71.23	76.25	81.43	86.77	92.27	97.95	103.81	109.88	116.15	122.65	129.40	136.40	143.48	150.91
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Chimuara	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	6.76	7.60	8.20	11.47	12.86	14.30	15.86	17.46	19.10	20.80	22.54	24.34	26.19	28.11	30.09	32.13	34.24	36.41	38.65	40.97	43.36	45.83	48.40	51.06	53.82	56.62	59.55
MW	5.41	6.08	6.56	9.17	10.29	11.44	12.69	13.97	15.28	16.64	18.03	19.47	20.95	22.49	24.07	25.71	27.39	29.13	30.92	32.77	34.69	36.67	38.72	40.85	43.06	45.29	47.64
MVR	4.06	4.56	4.92	6.88	7.72	8.58	9.51	10.48	11.46	12.48	13.52	14.60	15.71	16.86	18.05	19.28	20.54	21.85	23.19	24.58	26.01	27.50	29.04	30.64	32.29	33.97	35.73
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Uape	2,016	2,017	2,018	2,019	2,020	2,021	2,022	2,023	2,024	2,025	2,026	2,027	2,028	2,029	2,030	2,031	2,032	2,033	2,034	2,035	2,036	2,037	2,038	2,039	2,040	2,041	2,042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	1.00	1.12	1.21	1.70	1.90	2.11	2.35	2.58	2.83	3.08	3.33	3.60	3.87	4.16	4.45	4.75	5.06	5.38	5.72	6.06	6.41	6.78	7.16	7.55	7.96	8.37	8.81
MW	0.80	0.90	0.97	1.36	1.52	1.69	1.88	2.07	2.26	2.46	2.67	2.88	3.10	3.33	3.56	3.80	4.05	4.31	4.57	4.85	5.13	5.42	5.73	6.04	6.37	6.70	7.04
MVR	0.60	0.67	0.73	1.02	1.14	1.27	1.41	1.55	1.70	1.85	2.00	2.16	2.32	2.49	2.67	2.85	3.04	3.23	3.43	3.63	3.85	4.07	4.29	4.53	4.78	5.02	5.28
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-26 Maximum Demand of Substation (Manica)

Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	181.60	215.76	252.08	269.62	287.90	315.07	343.07	372.42	404.18	437.23	471.67	507.57	545.06	584.24	625.22	667.77	711.66	756.95	803.74	852.14	902.23	954.14	1,005.50	1,063.86	1,121.94	1,179.35	1,240.47
MW	145.28	172.61	201.67	215.70	230.32	252.06	274.46	297.93	323.34	349.79	377.33	406.06	436.05	467.39	500.17	534.22	569.33	605.56	642.99	681.71	721.79	763.31	804.40	851.09	897.55	943.48	992.38
MVR	108.96	129.45	151.25	161.77	172.74	189.04	205.84	223.45	242.51	262.34	283.00	304.54	327.04	350.54	375.13	400.66	426.99	454.17	482.25	511.28	541.34	572.48	603.30	638.31	673.16	707.61	744.28
PF																											
Chimoio 1	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
MVA(MW+MVR)	9.75	11.58	13.53	14.48	15.46	16.92	18.42	19.99	21.70	23.47	25.32	27.25	29.26	31.37	33.57	35.85	38.21	40.64	43.15	45.75	48.44	51.23	53.98	57.12	60.24	63.32	66.60
MW	7.80	9.27	10.83	11.58	12.37	13.53	14.74	16.00	17.36	18.78	20.26	21.80	23.41	25.09	26.85	28.68	30.57	32.51	34.52	36.60	38.75	40.98	43.19	45.69	48.19	50.66	53.28
MVR	5.85	6.95	8.12	8.69	9.27	10.15	11.05	12.00	13.02	14.08	15.19	16.35	17.56	18.82	20.14	21.51	22.93	24.38	25.89	27.45	29.06	30.74	32.39	34.27	36.14	37.99	39.96
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Chimoio 2	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
MVA(MW+MVR)	27.75	32.97	38.52	41.20	43.99	48.15	52.42	56.91	61.76	66.81	72.07	77.56	83.29	89.28	95.54	102.04	108.75	115.67	122.82	130.21	137.87	145.80	153.65	162.57	171.44	180.22	189.55
MW	22.20	26.38	30.82	32.96	35.19	38.52	41.94	45.53	49.41	53.45	57.66	62.05	66.63	71.42	76.43	81.63	87.00	92.53	98.25	104.17	110.29	116.64	122.92	130.05	137.15	144.17	151.64
MVR	16.65	19.78	23.11	24.72	26.40	28.89	31.45	34.15	37.06	40.09	43.24	46.54	49.97	53.57	57.32	61.22	65.25	69.40	73.69	78.13	82.72	87.48	92.19	97.54	102.87	108.13	113.73
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Manica	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.30
MVA(MW+MVR)	5.78	6.86	8.02	8.57	9.16	10.02	10.91	11.84	12.85	13.90	15.00	16.14	17.33	18.58	19.88	21.24	22.63	24.07	25.56	27.10	28.69	30.34	31.98	33.83	35.68	37.50	39.45
MW	4.62	5.49	6.41	6.86	7.32	8.02	8.73	9.47	10.28	11.12	12.00	12.91	13.87	14.86	15.91	16.99	18.10	19.26	20.45	21.68	22.95	24.27	25.58	27.07	28.54	30.00	31.56
MVR	3.47	4.12	4.81	5.14	5.49	6.01	6.55	7.11	7.71	8.34	9.00	9.68	10.40	11.15	11.93	12.74	13.58	14.44	15.34	16.26	17.21	18.21	19.19	20.30	21.41	22.50	23.67
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Mavita	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
MVA(MW+MVR)	3.30	3.92	4.58	4.90	5.23	5.73	6.23	6.77	7.34	7.95	8.57	9.22	9.90	10.62	11.36	12.13	12.93	13.76	14.61	15.48	16.40	17.34	18.27	19.33	20.39	21.43	22.54
MW	2.64	3.14	3.66	3.92	4.19	4.58	4.99	5.41	5.88	6.36	6.86	7.38	7.92	8.49	9.09	9.71	10.35	11.00	11.68	12.39	13.12	13.87	14.62	15.47	16.31	17.14	18.03
MVR	1.98	2.35	2.75	2.94	3.14	3.44	3.74	4.06	4.41	4.77	5.14	5.53	5.94	6.37	6.82	7.28	7.76	8.25	8.76	9.29	9.84	10.40	10.96	11.60	12.23	12.86	13.52
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Messica	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
MVA(MW+MVR)	2.35	2.79	3.26	3.49	3.73	4.08	4.44	4.82	5.23	5.66	6.10	6.57	7.05	7.56	8.09	8.64	9.21	9.80	10.40	11.03	11.68	12.35	13.01	13.77	14.52	15.26	16.05
MW	1.88	2.23	2.61	2.79	2.98	3.26	3.55	3.86	4.18	4.53	4.88	5.25	5.64	6.05	6.47	6.91	7.37	7.84	8.32	8.82	9.34	9.88	10.41	11.01	11.61	12.21	12.84
MVR	1.41	1.68	1.96	2.09	2.24	2.45	2.66	2.89	3.14	3.39	3.66	3.94	4.23	4.54	4.85	5.18	5.53	5.88	6.24	6.62	7.01	7.41	7.81	8.26	8.71	9.16	9.63
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Gondola	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
MVA(MW+MVR)	2.28	2.70	3.16	3.38	3.61	3.95	4.30	4.67	5.06	5.48	5.91	6.36	6.83	7.32	7.83	8.37	8.92	9.48	10.07	10.68	11.30	11.95	12.60	13.33	14.06	14.77	15.54
MW	1.82	2.16	2.53	2.70	2.89	3.16	3.44	3.73	4.05	4.38	4.73	5.09	5.46	5.86	6.27	6.69	7.13	7.59	8.06	8.54	9.04	9.56	10.08	10.66	11.24	11.82	12.43
MVR	1.37	1.62	1.89	2.03	2.16	2.37	2.58	2.80	3.04	3.29	3.55	3.82	4.10	4.39	4.70	5.02	5.35	5.69	6.04	6.41	6.78	7.17	7.56	8.00	8.43	8.86	9.32
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Inchope	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
MVA(MW+MVR)	1.950	2.317	2.707	2.895	3.091	3.383	3.684	3.999	4.340	4.695	5.065	5.450	5.853	6.273	6.714	7.170	7.642	8.128	8.631	9.150	9.688	10.245	10.797	11.424	12.047	12.664	13.320
MW	1.560	1.853	2.165	2.316	2.473	2.707	2.947	3.199	3.472	3.756	4.052	4.360	4.682	5.019	5.371	5.736	6.113	6.502	6.904	7.320	7.750	8.196	8.638	9.139	9.638	10.131	10.656
MVR	1.170	1.390	1.624	1.737	1.855	2.030	2.210	2.399	2.604	2.817	3.039	3.270	3.512	3.764	4.028	4.302	4.585	4.877	5.178	5.490	5.813	6.147	6.478	6.854	7.228	7.598	7.992
PF	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
Catandica	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
MVA(MW+MVR)	3.45	4.10	4.79	5.12	5.47	5.99	6.52	7.08	7.68	8.31	8.96	9.64	10.36	11.10	11.88	12.69	13.52	14.38	15.27	16.19	17.14	18.13	19.10	20.21	21.31	22.41	23.57
MW	2.76	3.28	3.83	4.10	4.38	4.79	5.21	5.66	6.14	6.65	7.17	7.71	8.28	8.88	9.50	10.15	10.82	11.50	12.22	12.95	13.71	14.50	15.28	16.17	17.05	17.92	18.85
MVR	2.07	2.46	2.87	3.07	3.28	3.59	3.91	4.25	4.61	4.98	5.38	5.79	6.21	6.66	7.13	7.61	8.11	8.63	9.16	9.71	10.28	10.88	11.46	12.13	12.79	13.44	14.14
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Chibata	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00	168.00
MVA(MW+MVR)	125.00	148.51	173.51	185.59	198.17	216.87	236.15	256.34	278.21	300.96	324.66	349.38	375.18	402.15	430.35	459.65	489.85	521.03	553.24	586.55	621.03	656.76	692.11	732.28	772.26	811.78	853.85
MW	100.00	118.81	138.81	148.47	158.54	173.50	188.92	205.08	222.57	240.77	259.73	279.50	300.15	321.72	344.28	367.72	391.88	416.82	442.59	469.24	496.82	525.41	553.69	585.82	617.81	649.42	683.08
MVR	75.00	89.11	104.11	111.35	118.90	130.12	141.69	153.81	166.92	180.58	194.80	209.63	225.11	241.29	258.21	275.79	293.91	312.62	331.94	351.93	372.62	394.06	415.27	439.37	463.36	487.07	512.31
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-27 Maximum Demand of Substation (Tete)

Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	121.65	131.26	138.92	152.32	160.64	170.86	181.45	192.46	203.93	217.17	231.43	246.49	262.40	279.25	297.09	315.88	335.54	356.13	377.71	400.35	424.11	449.06	475.28	502.87	531.89	561.44	592.92
MW	97.32	105.01	111.13	121.86	128.52	136.69	145.16	153.97	163.15	173.73	185.14	197.19	209.92	223.40	237.67	252.70	268.43	284.90	302.17	320.28	339.29	359.25	380.23	402.29	425.52	449.15	474.33
MVR	72.99	78.75	83.35	91.39	96.39	102.51	108.87	115.48	122.36	130.30	138.86	147.89	157.44	167.55	178.25	189.53	201.32	213.68	226.63	240.21	254.46	269.44	285.17	301.72	319.14	336.86	355.75
PF																											

Matambo	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
MVA(MW+MVR)	12.91	13.93	14.75	16.17	17.05	18.14	19.26	20.43	21.65	23.05	24.57	26.16	27.85	29.64	31.54	33.53	35.62	37.80	40.09	42.50	45.02	47.67	50.45	53.38	56.46	59.60	62.94
MW	10.33	11.15	11.80	12.94	13.64	14.51	15.41	16.34	17.32	18.44	19.65	20.93	22.28	23.71	25.23	26.82	28.49	30.24	32.08	34.00	36.01	38.13	40.36	42.70	45.17	47.68	50.35
MVR	7.75	8.36	8.85	9.70	10.23	10.88	11.56	12.26	12.99	13.83	14.74	15.70	16.71	17.79	18.92	20.12	21.37	22.68	24.06	25.50	27.01	28.60	30.27	32.03	33.88	35.76	37.76
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Tete	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
MVA(MW+MVR)	39.45	42.57	45.05	49.40	52.10	55.41	58.84	62.41	66.13	70.43	75.05	79.93	85.09	90.56	96.34	102.44	108.81	115.49	122.49	129.83	137.53	145.63	154.13	163.07	172.49	182.07	192.28
MW	31.56	34.05	36.04	39.52	41.68	44.33	47.07	49.93	52.91	56.34	60.04	63.95	68.07	72.45	77.07	81.95	87.05	92.39	97.99	103.86	110.03	116.50	123.30	130.46	137.99	145.65	153.82
MVR	23.67	25.54	27.03	29.64	31.26	33.24	35.31	37.45	39.68	42.26	45.03	47.96	51.06	54.33	57.81	61.46	65.29	69.29	73.49	77.90	82.52	87.38	92.48	97.84	103.49	109.24	115.37
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Manje	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
MVA(MW+MVR)	9.75	10.52	11.13	12.21	12.88	13.69	14.54	15.43	16.34	17.41	18.55	19.76	21.03	22.38	23.81	25.32	26.89	28.54	30.27	32.09	33.99	35.99	38.09	40.30	42.63	45.00	47.52
MW	7.80	8.42	8.91	9.77	10.30	10.96	11.63	12.34	13.08	13.92	14.84	15.80	16.82	17.90	19.05	20.25	21.51	22.83	24.22	25.67	27.19	28.79	30.47	32.24	34.10	36.00	38.02
MVR	5.85	6.31	6.68	7.32	7.73	8.22	8.73	9.26	9.81	10.44	11.13	11.85	12.62	13.43	14.29	15.19	16.14	17.13	18.16	19.25	20.39	21.59	22.86	24.18	25.58	27.00	28.51
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-28 Maximum Demand of Substation (Sofala)

Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	158.36	169.88	287.48	323.53	336.35	375.52	415.18	455.39	496.17	537.57	579.62	622.37	665.89	710.21	755.39	801.45	848.41	896.32	946.86	998.84	1,052.16	1,106.91	1,163.19	1,221.08	1,280.69	1,340.13	1,402.19
MW	126.69	135.90	229.99	258.83	269.08	300.41	332.14	364.31	396.94	430.06	463.70	497.90	532.71	568.16	604.31	641.16	678.73	717.06	757.49	799.07	841.73	885.53	930.55	976.86	1,024.55	1,072.10	1,121.75
MVR	95.02	101.93	172.49	194.12	201.81	225.31	249.11	273.23	297.70	322.54	347.77	373.42	399.53	426.12	453.23	480.87	509.05	537.79	568.12	599.30	631.29	664.15	697.91	732.65	768.42	804.08	841.32
PF																											

Lamego	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
MVA(MW+MVR)	6.34	6.80	11.50	12.95	13.46	15.03	16.62	18.22	19.86	21.51	23.20	24.91	26.65	28.42	30.23	32.07	33.95	35.87	37.89	39.97	42.11	44.30	46.55	48.87	51.25	53.63	56.11
MW	5.07	5.44	9.20	10.36	10.77	12.02	13.29	14.58	15.89	17.21	18.56	19.93	21.32	22.74	24.18	25.66	27.16	28.70	30.31	31.98	33.69	35.44	37.24	39.09	41.00	42.90	44.89
MVR	3.80	4.08	6.90	7.77	8.08	9.02	9.97	10.93	11.91	12.91	13.92	14.94	15.99	17.05	18.14	19.24	20.37	21.52	22.74	23.98	25.26	26.58	27.93	29.32	30.75	32.18	33.67
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Mafambisse	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
MVA(MW+MVR)	11.88	12.74	21.56	24.26	25.22	28.16	31.13	34.15	37.21	40.31	43.46	46.67	49.93	53.26	56.64	60.10	63.62	67.21	71.00	74.90	78.90	83.00	87.22	91.56	96.03	100.49	105.15
MW	9.50	10.19	17.25	19.41	20.18	22.53	24.91	27.32	29.76	32.25	34.77	37.34	39.95	42.60	45.31	48.08	50.90	53.77	56.80	59.92	63.12	66.40	69.78	73.25	76.83	80.39	84.12
MVR	7.13	7.64	12.93	14.56	15.13	16.90	18.68	20.49	22.32	24.19	26.08	28.00	29.96	31.95	33.99	36.06	38.17	40.33	42.60	44.94	47.34	49.80	52.33	54.94	57.62	60.29	63.09
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Fipag	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
MVA(MW+MVR)	2.75	2.95	4.99	5.62	5.84	6.52	7.21	7.91	8.62	9.34	10.07	10.81	11.56	12.33	13.12	13.92	14.73	15.56	16.44	17.35	18.27	19.22	20.20	21.20	22.24	23.27	24.35
MW	2.20	2.36	3.99	4.49	4.67	5.22	5.77	6.33	6.89	7.47	8.05	8.65	9.25	9.87	10.49	11.13	11.79	12.45	13.15	13.88	14.62	15.38	16.16	16.96	17.79	18.62	19.48
MVR	1.65	1.77	3.00	3.37	3.50	3.91	4.33	4.74	5.17	5.60	6.04	6.48	6.94	7.40	7.87	8.35	8.84	9.34	9.87	10.41	10.96	11.53	12.12	12.72	13.34	13.96	14.61
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Dondo	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
MVA(MW+MVR)	11.13	11.93	20.20	22.73	23.63	26.38	29.17	31.99	34.86	37.76	40.72	43.72	46.78	49.89	53.07	56.30	59.60	62.97	66.52	70.17	73.91	77.76	81.71	85.78	89.97	94.14	98.50
MW	8.90	9.55	16.16	18.18	18.90	21.10	23.33	25.59	27.88	30.21	32.57	34.98	37.42	39.91	42.45	45.04	47.68	50.37	53.21	56.13	59.13	62.21	65.37	68.62	71.98	75.32	78.80
MVR	6.68	7.16	12.12	13.64	14.18	15.83	17.50	19.19	20.91	22.66	24.43	26.23	28.07	29.94	31.84	33.78	35.76	37.78	39.91	42.10	44.35	46.66	49.03	51.47	53.98	56.49	59.10
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Marromeu	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	9.18	9.84	16.66	18.74	19.49	21.76	24.05	26.38	28.75	31.14	33.58	36.06	38.58	41.15	43.76	46.43	49.15	51.93	54.86	57.87	60.96	64.13	67.39	70.75	74.20	77.64	81.24
MW	7.34	7.87	13.32	15.00	15.59	17.40	19.24	21.11	23.00	24.92	26.86	28.85	30.86	32.92	35.01	37.15	39.32	41.54	43.89	46.30	48.77	51.30	53.91	56.60	59.36	62.11	64.99
MVR	5.51	5.91	9.99	11.25	11.69	13.05	14.43	15.83	17.25	18.69	20.15	21.63	23.15	24.69	26.26	27.86	29.49	31.16	32.91	34.72	36.58	38.48	40.43	42.45	44.52	46.59	48.74
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Guara-Guara	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
MVA(MW+MVR)	2.33	2.49	4.22	4.75	4.94	5.51	6.10	6.69	7.28	7.89	8.51	9.14	9.78	10.43	11.09	11.77	12.46	13.16	13.90	14.66	15.45	16.25	17.08	17.93	18.80	19.68	20.59
MW	1.86	2.00	3.38	3.80	3.95	4.41	4.88	5.35	5.83	6.31	6.81	7.31	7.82	8.34	8.87	9.41	9.96	10.53	11.12	11.73	12.36	13.00	13.66	14.34	15.04	15.74	16.47
MVR	1.40	1.50	2.53	2.85	2.96	3.31	3.66	4.01	4.37	4.74	5.11	5.48	5.87	6.26	6.65	7.06	7.47	7.90	8.34	8.80	9.27	9.75	10.25	10.76	11.28	11.81	12.35
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Munhava	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
MVA(MW+MVR)	109.98	117.97	199.64	224.68	233.58	260.78	288.32	316.25	344.57	373.32	402.52	432.21	462.43	493.20	524.58	556.57	589.18	622.45	657.55	693.64	730.67	768.70	807.78	847.98	889.38	930.65	973.75
MW	87.98	94.38	159.71	179.74	186.87	208.62	230.66	253.00	275.65	298.65	322.01	345.77	369.94	394.56	419.66	445.25	471.34	497.96	526.04	554.91	584.54	614.96	646.22	678.38	711.50	744.52	779.00
MVR	65.99	70.78	119.79	134.81	140.15	156.47	172.99	189.75	206.74	223.99	241.51	259.32	277.46	295.92	314.75	333.94	353.51	373.47	394.53	416.19	438.40	461.22	484.67	508.79	533.63	558.39	584.25
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Cimentos Dondo	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
MVA(MW+MVR)	4.80	5.15	8.71	9.81	10.19	11.38	12.58	13.80	15.04	16.29	17.57	18.86	20.18	21.53	22.90	24.29	25.72	27.17	28.70	30.27	31.89	33.55	35.26	37.01	38.82	40.62	42.50
MW	3.84	4.12	6.97	7.85	8.16	9.11	10.07	11.04	12.03	13.04	14.05	15.09	16.15	17.22	18.32	19.43	20.57	21.73	22.96	24.22	25.51	26.84	28.21	29.61	31.05	32.50	34.00
MVR	2.88	3.09	5.23	5.88	6.12	6.83	7.55	8.28	9.02	9.78	10.54	11.32	12.11	12.92	13.74	14.58	15.43	16.30	17.22	18.16	19.13	20.13	21.15	22.21	23.29	24.37	25.50
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-29 Maximum Demand of Substation (Inhambane)

Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	20.75	22.77	24.87	27.04	30.50	33.07	35.72	38.74	42.02	45.45	49.06	52.85	56.83	61.02	65.44	70.08	74.95	80.07	85.46	91.13	97.10	103.41	110.06	117.09	124.52	132.43	140.75
MW	16.60	18.22	19.90	21.63	24.40	26.45	28.58	30.99	33.61	36.36	39.25	42.28	45.47	48.82	52.35	56.06	59.96	64.06	68.36	72.90	77.68	82.72	88.05	93.67	99.61	105.94	112.60
MVR	12.45	13.66	14.92	16.23	18.30	19.84	21.43	23.24	25.21	27.27	29.44	31.71	34.10	36.61	39.26	42.05	44.97	48.04	51.27	54.68	58.26	62.04	66.04	70.25	74.71	79.46	84.45
PF																											

Lindela	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00
MVA(MW+MVR)	20.75	22.77	24.87	27.04	30.50	33.07	35.72	38.74	42.02	45.45	49.06	52.85	56.83	61.02	65.44	70.08	74.95	80.07	85.46	91.13	97.10	103.41	110.06	117.09	124.52	132.43	140.75
MW	16.60	18.22	19.90	21.63	24.40	26.45	28.58	30.99	33.61	36.36	39.25	42.28	45.47	48.82	52.35	56.06	59.96	64.06	68.36	72.90	77.68	82.72	88.05	93.67	99.61	105.94	112.60
MVR	12.45	13.66	14.92	16.23	18.30	19.84	21.43	23.24	25.21	27.27	29.44	31.71	34.10	36.61	39.26	42.05	44.97	48.04	51.27	54.68	58.26	62.04	66.04	70.25	74.71	79.46	84.45
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-30 Maximum Demand of Substation (Gaza)

Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	74.39	85.62	92.59	99.80	107.24	115.84	125.01	135.15	145.72	156.74	168.24	180.26	192.83	205.98	219.74	234.13	249.16	264.86	281.28	298.48	316.51	335.42	355.28	376.13	398.06	420.26	443.92
MW	59.51	68.49	74.07	79.84	85.79	92.67	100.01	108.12	116.58	125.39	134.59	144.21	154.27	164.78	175.80	187.31	199.33	211.89	225.03	238.79	253.21	268.34	284.22	300.91	318.45	336.21	355.13
MVR	44.63	51.37	55.55	59.88	64.35	69.50	75.01	81.09	87.43	94.04	100.95	108.16	115.70	123.59	131.85	140.48	149.49	158.91	168.77	179.09	189.91	201.25	213.17	225.68	238.84	252.16	266.35
PF																											

Lionde	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
MVA(MW+MVR)	12.73	14.65	15.84	17.07	18.35	19.82	21.38	23.12	24.93	26.81	28.78	30.84	32.99	35.24	37.59	40.05	42.62	45.31	48.12	51.06	54.14	57.38	60.77	64.34	68.09	71.89	75.94
MW	10.18	11.72	12.67	13.66	14.68	15.85	17.11	18.50	19.94	21.45	23.02	24.67	26.39	28.19	30.07	32.04	34.10	36.25	38.49	40.85	43.32	45.90	48.62	51.47	54.47	57.51	60.75
MVR	7.64	8.79	9.50	10.24	11.01	11.89	12.83	13.87	14.96	16.09	17.27	18.50	19.79	21.14	22.55	24.03	25.57	27.18	28.87	30.64	32.49	34.43	36.46	38.61	40.86	43.13	45.56
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Macia	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
MVA(MW+MVR)	14.78	17.01	18.39	19.82	21.30	23.01	24.83	26.84	28.94	31.13	33.42	35.80	38.30	40.91	43.65	46.50	49.49	52.61	55.87	59.29	62.87	66.62	70.57	74.71	79.06	83.47	88.17
MW	11.82	13.60	14.71	15.86	17.04	18.41	19.86	21.48	23.15	24.91	26.73	28.64	30.64	32.73	34.92	37.20	39.59	42.09	44.70	47.43	50.29	53.30	56.45	59.77	63.25	66.78	70.54
MVR	8.87	10.20	11.03	11.89	12.78	13.81	14.90	16.11	17.37	18.68	20.05	21.48	22.98	24.55	26.19	27.90	29.69	31.56	33.52	35.57	37.72	39.97	42.34	44.83	47.44	50.08	52.90
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Xinavne	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
MVA(MW+MVR)	16.79	19.32	20.90	22.52	24.20	26.14	28.21	30.50	32.89	35.37	37.97	40.68	43.52	46.48	49.59	52.84	56.23	59.77	63.48	67.36	71.43	75.70	80.18	84.88	89.83	94.84	100.18
MW	13.43	15.46	16.72	18.02	19.36	20.91	22.57	24.40	26.31	28.30	30.37	32.54	34.81	37.19	39.67	42.27	44.98	47.82	50.78	53.89	57.14	60.56	64.14	67.91	71.87	75.87	80.15
MVR	10.07	11.59	12.54	13.51	14.52	15.69	16.93	18.30	19.73	21.22	22.78	24.41	26.11	27.89	29.75	31.70	33.74	35.86	38.09	40.42	42.86	45.42	48.11	50.93	53.90	56.91	60.11
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Chicumbane	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
MVA(MW+MVR)	30.10	34.64	37.47	40.38	43.39	46.87	50.58	54.69	58.96	63.42	68.08	72.94	78.03	83.35	88.92	94.74	100.82	107.17	113.82	120.78	128.07	135.72	143.76	152.20	161.07	170.05	179.63
MW	24.08	27.71	29.97	32.30	34.72	37.50	40.47	43.75	47.17	50.74	54.46	58.35	62.42	66.68	71.13	75.79	80.65	85.74	91.05	96.62	102.46	108.58	115.01	121.76	128.86	136.04	143.70
MVR	18.06	20.79	22.48	24.23	26.04	28.12	30.35	32.81	35.38	38.05	40.85	43.76	46.82	50.01	53.35	56.84	60.49	64.30	68.29	72.47	76.84	81.43	86.25	91.32	96.64	102.03	107.78
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-31 Maximum Demand of Substation (Maputo)

Total	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	913.49	908.07	1,005.73	1,124.99	1,484.53	1,570.13	1,720.59	1,872.83	2,026.89	2,182.86	2,340.91	2,501.22	2,664.00	2,829.38	2,997.51	3,168.61	3,343.98	3,524.86	3,711.42	3,903.86	4,102.40	4,307.29	4,518.79	4,737.16	4,962.72	5,195.78	5,455.03	5,713.73
MW	730.79	726.46	804.59	899.99	1,187.62	1,256.10	1,376.47	1,498.26	1,621.51	1,746.29	1,872.72	2,000.97	2,131.20	2,263.50	2,398.01	2,534.89	2,675.18	2,819.89	2,969.14	3,123.09	3,281.92	3,445.83	3,615.03	3,789.73	3,970.18	4,156.62	4,364.02	4,570.99
MVR	548.09	544.84	603.44	674.99	890.72	942.08	1,032.35	1,123.70	1,216.14	1,309.71	1,404.54	1,500.73	1,598.40	1,697.63	1,798.50	1,901.17	2,006.39	2,114.92	2,226.85	2,342.32	2,461.44	2,584.37	2,711.27	2,842.30	2,977.63	3,117.47	3,273.02	3,428.24
PF																												

Infulene	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00	540.00
MVA(MW+MVR)	536.40	533.22	590.57	660.60	871.72	921.98	1,010.33	1,099.72	1,190.19	1,281.77	1,374.58	1,468.72	1,564.30	1,661.41	1,760.14	1,860.61	1,963.59	2,069.80	2,179.35	2,292.35	2,408.93	2,529.24	2,653.43	2,781.66	2,914.11	3,050.96	3,203.19	3,355.11
MW	429.12	426.58	472.45	528.48	697.37	737.58	808.27	879.78	952.15	1,025.42	1,099.66	1,174.97	1,251.44	1,329.13	1,408.11	1,488.49	1,570.87	1,655.84	1,743.48	1,833.88	1,927.14	2,023.39	2,122.75	2,225.33	2,331.29	2,440.77	2,562.56	2,684.08
MVR	321.84	319.93	354.34	396.36	523.03	553.19	606.20	659.83	714.11	769.06	824.75	881.23	938.58	996.85	1,056.08	1,116.36	1,178.15	1,241.88	1,307.61	1,375.41	1,445.36	1,517.55	1,592.06	1,669.00	1,748.47	1,830.58	1,921.92	2,013.06
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Kongolote	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
MVA(MW+MVR)	3.20	3.18	3.52	3.94	5.20	5.50	6.03	6.56	7.10	7.65	8.20	8.76	9.33	9.91	10.50	11.10	11.71	12.35	13.00	13.68	14.37	15.09	15.83	16.59	17.38	18.20	19.11	20.02
MW	2.56	2.54	2.82	3.15	4.16	4.40	4.82	5.25	5.68	6.12	6.56	7.01	7.47	7.93	8.40	8.88	9.37	9.88	10.40	10.94	11.50	12.07	12.66	13.28	13.91	14.56	15.29	16.01
MVR	1.92	1.91	2.11	2.36	3.12	3.30	3.62	3.94	4.26	4.59	4.92	5.26	5.60	5.95	6.30	6.66	7.03	7.41	7.80	8.21	8.62	9.05	9.50	9.96	10.43	10.92	11.47	12.01
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Beluluane	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	20.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
MVA(MW+MVR)	3.00	2.98	3.30	3.69	4.88	5.16	5.65	6.15	6.66	7.17	7.69	8.21	8.75	9.29	9.84	10.41	10.98	11.58	12.19	12.82	13.47	14.15	14.84	15.56	16.30	17.06	17.91	18.76
MW	2.40	2.39	2.64	2.96	3.90	4.13	4.52	4.92	5.33	5.74	6.15	6.57	7.00	7.43	7.88	8.32	8.79	9.26	9.75	10.26	10.78	11.32	11.87	12.45	13.04	13.65	14.33	15.01
MVR	1.80	1.79	1.98	2.22	2.93	3.09	3.39	3.69	3.99	4.30	4.61	4.93	5.25	5.58	5.91	6.24	6.59	6.95	7.31	7.69	8.08	8.49	8.90	9.33	9.78	10.24	10.75	11.26
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Boane	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
MVA(MW+MVR)	27.63	27.46	30.41	34.02	44.89	47.48	52.03	56.64	61.30	66.01	70.79	75.64	80.56	85.56	90.65	95.82	101.13	106.60	112.24	118.06	124.06	130.26	136.65	143.26	150.08	157.13	164.97	172.79
MW	22.10	21.97	24.33	27.22	35.92	37.99	41.63	45.31	49.04	52.81	56.63	60.51	64.45	68.45	72.52	76.66	80.90	85.28	89.79	94.45	99.25	104.21	109.32	114.61	120.06	125.70	131.97	138.23
MVR	16.58	16.48	18.25	20.41	26.94	28.49	31.22	33.98	36.78	39.61	42.48	45.38	48.34	51.34	54.39	57.49	60.68	63.96	67.34	70.83	74.44	78.15	81.99	85.95	90.05	94.28	98.98	103.67
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Manhica	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
MVA(MW+MVR)	13.45	13.37	14.81	16.56	21.86	23.12	25.33	27.58	29.84	32.14	34.47	36.83	39.22	41.66	44.13	46.65	49.24	51.90	54.65	57.48	60.40	63.42	66.53	69.75	73.07	76.50	80.32	84.13
MW	10.76	10.70	11.85	13.25	17.49	18.49	20.27	22.06	23.87	25.71	27.57	29.46	31.38	33.33	35.31	37.32	39.39	41.52	43.72	45.98	48.32	50.74	53.23	55.80	58.46	61.20	64.25	67.30
MVR	8.07	8.02	8.88	9.94	13.11	13.87	15.20	16.55	17.91	19.28	20.68	22.10	23.53	25.00	26.48	27.99	29.54	31.14	32.79	34.49	36.24	38.05	39.92	41.85	43.84	45.90	48.19	50.48
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Machava	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000
MVA(MW+MVR)	65.125	64.739	71.702	80.204	105.836	111.939	122.666	133.519	144.503	155.622	166.890	178.319	189.924	201.714	213.700	225.899	238.401	251.297	264.597	278.317	292.471	307.078	322.157	337.725	353.806	370.421	388.904	407.348
MW	52.100	51.791	57.361	64.163	84.669	89.551	98.132	106.815	115.602	124.497	133.512	142.655	151.939	161.371	170.960	180.719	190.721	201.037	211.678	222.653	233.977	245.663	257.725	270.180	283.045	296.337	311.123	325.878
MVR	39.075	38.843	43.021	48.122	63.502	67.163	73.599	80.111	86.702	93.373	100.134	106.991	113.954	121.029	128.220	135.539	143.041	150.778	158.758	166.990	175.483	184.247	193.294	202.635	212.283	222.253	233.342	244.409
PF	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800

Salamanga	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
MVA(MW+MVR)	12.55	12.48	13.82	15.46	20.40	21.57	23.64	25.73	27.85	29.99	32.16	34.36	36.60	38.87	41.18	43.53	45.94	48.43	50.99	53.63	56.36	59.18	62.08	65.08	68.18	71.38	74.94	78.50
MW	10.04	9.98	11.05	12.36	16.32	17.26	18.91	20.58	22.28	23.99	25.73	27.49	29.28	31.10	32.95	34.83	36.75	38.74	40.79	42.91	45.09	47.34	49.67	52.07	54.54	57.11	59.96	62.80
MVR	7.53	7.49	8.29	9.27	12.24	12.94	14.18	15.44	16.71	17.99	19.30	20.62	21.96	23.32	24.71	26.12	27.56	29.06	30.59	32.18	33.82	35.51	37.25	39.05	40.91	42.83	44.97	47.10
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Matola Rio	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
MVA(MW+MVR)	24.74	24.59	27.24	30.47	40.20	42.52	46.59	50.72	54.89	59.11	63.39	67.73	72.14	76.62	81.17	85.81	90.56	95.45	100.51	105.72	111.09	116.64	122.37	128.28	134.39	140.70	147.72	154.73
MW	19.79	19.67	21.79	24.37	32.16	34.02	37.28	40.57	43.91	47.29	50.71	54.19	57.71	61.30	64.94	68.65	72.44	76.36	80.41	84.57	88.88	93.31	97.90	102.63	107.51	112.56	118.18	123.78
MVR	14.84	14.75	16.34	18.28	24.12	25.51	27.96	30.43	32.93	35.47	38.04	40.64	43.29	45.97	48.70	51.48	54.33	57.27	60.30	63.43	66.66	69.99	73.42	76.97	80.64	84.42	88.63	92.84
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Matola Gare	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
MVA(MW+MVR)	32.58	32.38	35.86	40.12	52.94	55.99	61.36	66.79	72.28	77.84	83.48	89.19	95.00	100.90	106.89	112.99	119.25	125.70	132.35	139.21	146.29	153.60	161.14	168.93	176.97	185.28	194.53	203.75
MW	26.06	25.91	28.69	32.09	42.35	44.79	49.09	53.43	57.82	62.27	66.78	71.35	76.00	80.72	85.51	90.39	95.40	100.56	105.88	111.37	117.03	122.88	128.91	135.14	141.58	148.23	155.62	163.00
MVR	19.55	19.43	21.52	24.07	31.76	33.59	36.81	40.07	43.37	46.70	50.09	53.52	57.00	60.54	64.13	67.80	71.55	75.42	79.41	83.53	87.78	92.16	96.68	101.36	106.18	111.17	116.72	122.25
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Matola275	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00	320.00
MVA(MW+MVR)	172.50	171.48	189.92	212.44	280.33	296.50	324.91	353.66	382.75	412.20	442.05	472.32	503.06	534.29	566.04	598.35	631.47	665.62	700.85	737.19	774.68	813.37	853.31	894.55	937.14	981.15	1,030.11	1,078.96
MW	138.00	137.18	151.94	169.95	224.27	237.20	259.93	282.93	306.20	329.76	353.64	377.86	402.45	427.43	452.83	478.68	505.17	532.50	560.68	589.75	619.75	650.70	682.65	715.64	749.71	784.92	824.09	863.17
MVR	103.50	102.89	113.95	127.46	168.20	177.90	194.95	212.19	229.65	247.32	265.23	283.39	301.84	320.57	339.62	359.01	378.88	399.37	420.51	442.32	464.81	488.02	511.99	536.73	562.29	588.69	618.07	647.38
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Xinavne	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
MVA(MW+MVR)	22.33	22.19	24.58	27.49	36.28	38.37	42.05	45.77	49.54	53.35	57.21	61.13	65.11	69.15	73.26	77.44	81.72	86.15	90.70	95.41	100.26	105.27	110.44	115.77	121.29	126.98	133.32	139.64
MW	17.86	17.75	19.66	22.00	29.02	30.70	33.64	36.62	39.63	42.68	45.77	48.90	52.09	55.32	58.61	61.95	65.38	68.92	72.56	76.33	80.21	84.21	88.35	92.62	97.03	101.58	106.65	111.71
MVR	13.40	13.32	14.75	16.50	21.77	23.02	25.23	27.46	29.72	32.01	34.33	36.68	39.06	41.49	43.95	46.46	49.03	51.69	54.42	57.24	60.16	63.16	66.26	69.46	72.77	76.19	79.99	83.78
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

Table 3.5-32 Maximum Demand of Substation (Maputo City)

Total	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA	419.98	502.13	546.85	583.18	626.01	695.18	749.90	806.90	866.28	928.15	992.69	1,060.06	1,130.46	1,204.04	1,281.00	1,361.54	1,445.94	1,534.49	1,627.45	1,725.14	1,827.84	1,935.91	2,049.68	2,169.55	2,295.90	2,429.15	2,566.45	2,712.72
MW	335.98	401.70	437.48	466.54	500.81	556.15	599.92	645.52	693.02	742.52	794.15	848.05	904.37	963.24	1,024.80	1,089.23	1,156.75	1,227.59	1,301.96	1,380.11	1,462.27	1,548.72	1,639.75	1,735.64	1,836.72	1,943.32	2,053.16	2,170.17
MVR	251.99	301.28	328.11	349.91	375.60	417.11	449.94	484.14	519.77	556.89	595.61	636.04	678.27	722.43	768.60	816.93	867.57	920.69	976.47	1,035.08	1,096.70	1,161.54	1,229.81	1,301.73	1,377.54	1,457.49	1,539.87	1,627.63
PF																												

CTM	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
MVA(MW+MVR)	36.50	43.64	47.53	50.68	54.41	60.42	65.17	70.13	75.29	80.67	86.27	92.13	98.25	104.64	111.33	118.33	125.67	133.36	141.44	149.93	158.86	168.25	178.14	188.56	199.54	211.12	223.05	235.76
MW	29.20	34.91	38.02	40.55	43.52	48.33	52.14	56.10	60.23	64.53	69.02	73.70	78.60	83.71	89.07	94.67	100.53	106.69	113.15	119.95	127.09	134.60	142.51	150.84	159.63	168.89	178.44	188.61
MVR	21.90	26.18	28.52	30.41	32.64	36.25	39.10	42.08	45.17	48.40	51.76	55.28	58.95	62.79	66.80	71.00	75.40	80.02	84.87	89.96	95.31	100.95	106.88	113.13	119.72	126.67	133.83	141.46
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE 1	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
MVA(MW+MVR)	31.09	37.17	40.48	43.17	46.34	51.46	55.51	59.73	64.12	68.70	73.48	78.47	83.68	89.13	94.82	100.78	107.03	113.59	120.47	127.70	135.30	143.30	151.72	160.59	169.95	179.81	189.97	200.80
MW	24.87	29.73	32.38	34.53	37.07	41.17	44.41	47.78	51.30	54.96	58.78	62.77	66.94	71.30	75.86	80.63	85.63	90.87	96.37	102.16	108.24	114.64	121.38	128.48	135.96	143.85	151.98	160.64
MVR	18.65	22.30	24.29	25.90	27.80	30.88	33.31	35.84	38.47	41.22	44.09	47.08	50.21	53.48	56.89	60.47	64.22	68.15	72.28	76.62	81.18	85.98	91.03	96.36	101.97	107.89	113.98	120.48
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE 2	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
MVA(MW+MVR)	32.00	38.26	41.67	44.44	47.70	52.97	57.14	61.48	66.01	70.72	75.64	80.77	86.14	91.74	97.61	103.74	110.17	116.92	124.00	131.45	139.27	147.51	156.18	165.31	174.94	185.09	195.55	206.70
MW	25.60	30.61	33.33	35.55	38.16	42.38	45.71	49.19	52.80	56.58	60.51	64.62	68.91	73.39	78.08	82.99	88.14	93.54	99.20	105.16	111.42	118.01	124.94	132.25	139.95	148.07	156.44	165.36
MVR	19.20	22.96	25.00	26.66	28.62	31.78	34.28	36.89	39.60	42.43	45.38	48.46	51.68	55.05	58.56	62.25	66.10	70.15	74.40	78.87	83.56	88.50	93.71	99.19	104.96	111.05	117.33	124.02
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE 3	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
MVA(MW+MVR)	52.28	62.50	68.07	72.59	77.92	86.53	93.34	100.44	107.83	115.53	123.56	131.95	140.71	149.87	159.45	169.47	179.98	191.00	202.57	214.73	227.51	240.97	255.13	270.05	285.77	302.36	319.45	337.66
MW	41.82	50.00	54.45	58.07	62.34	69.22	74.67	80.35	86.26	92.42	98.85	105.56	112.57	119.90	127.56	135.58	143.98	152.80	162.06	171.78	182.01	192.77	204.10	216.04	228.62	241.89	255.56	270.13
MVR	31.37	37.50	40.84	43.55	46.75	51.92	56.00	60.26	64.70	69.32	74.14	79.17	84.43	89.92	95.67	101.68	107.99	114.60	121.54	128.84	136.51	144.58	153.08	162.03	171.46	181.42	191.67	202.59
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE 4	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
MVA(MW+MVR)	21.29	25.45	27.72	29.56	31.73	35.24	38.01	40.90	43.91	47.05	50.32	53.73	57.30	61.03	64.93	69.01	73.29	77.78	82.49	87.44	92.65	98.13	103.89	109.97	116.37	123.13	130.09	137.50
MW	17.03	20.36	22.17	23.65	25.38	28.19	30.41	32.72	35.13	37.64	40.25	42.99	45.84	48.82	51.94	55.21	58.63	62.22	65.99	69.95	74.12	78.50	83.11	87.98	93.10	98.50	104.07	110.00
MVR	12.77	15.27	16.63	17.74	19.04	21.14	22.81	24.54	26.35	28.23	30.19	32.24	34.38	36.62	38.96	41.41	43.97	46.67	49.49	52.47	55.59	58.88	62.34	65.98	69.82	73.88	78.05	82.50
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE 5	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
MVA(MW+MVR)	44.78	53.53	58.30	62.17	66.74	74.12	79.95	86.03	92.36	98.95	105.83	113.02	120.52	128.37	136.57	145.16	154.16	163.60	173.51	183.92	194.87	206.39	218.52	231.30	244.77	258.98	273.62	289.21
MW	35.82	42.83	46.64	49.74	53.39	59.29	63.96	68.82	73.89	79.16	84.67	90.41	96.42	102.69	109.26	116.13	123.33	130.88	138.81	147.14	155.90	165.11	174.82	185.04	195.82	207.18	218.89	231.37
MVR	26.87	32.12	34.98	37.30	40.04	44.47	47.97	51.62	55.41	59.37	63.50	67.81	72.31	77.02	81.94	87.10	92.49	98.16	104.11	110.35	116.92	123.84	131.11	138.78	146.86	155.39	164.17	173.53
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE6	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	40.00	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000	40.000
MVA(MW+MVR)	39.925	47.735	51.986	55.440	59.511	66.088	71.290	76.708	82.353	88.235	94.370	100.775	107.467	114.463	121.778	129.435	137.459	145.876	154.714	164.000	173.764	184.037	194.853	206.248	218.260	230.928	243.980	257.885
MW	31.940	38.188	41.589	44.352	47.609	52.870	57.032	61.366	65.882	70.588	75.496	80.620	85.974	91.570	97.423	103.548	109.967	116.701	123.771	131.200	139.011	147.230	155.883	164.999	174.608	184.742	195.184	206.308
MVR	23.955	28.641	31.192	33.264	35.707	39.653	42.774	46.025	49.412	52.941	56.622	60.465	64.480	68.678	73.067	77.661	82.475	87.526	92.829	98.400	104.258	110.422	116.912	123.749	130.956	138.557	146.388	154.731
PF	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800

SE 7	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
MVA(MW+MVR)	34.25	40.95	44.60	47.56	51.05	56.69	61.16	65.80	70.65	75.69	80.96	86.45	92.19	98.19	104.47	111.04	117.92	125.14	132.72	140.69	149.07	157.88	167.16	176.93	187.24	198.10	209.30	221.23
MW	27.40	32.76	35.68	38.05	40.84	45.36	48.93	52.64	56.52	60.55	64.77	69.16	73.75	78.55	83.57	88.83	94.34	100.11	106.18	112.55	119.25	126.30	133.73	141.55	149.79	158.48	167.44	176.98
MVR	20.55	24.57	26.76	28.54	30.63	34.02	36.69	39.48	42.39	45.42	48.57	51.87	55.31	58.92	62.68	66.62	70.75	75.08	79.63	84.41	89.44	94.73	100.29	106.16	112.34	118.86	125.58	132.74
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE 8	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
MVA(MW+MVR)	31.16	37.26	40.58	43.27	46.45	51.58	55.64	59.87	64.28	68.87	73.66	78.66	83.88	89.34	95.05	101.03	107.29	113.86	120.76	128.01	135.63	143.65	152.09	160.98	170.36	180.25	190.43	201.29
MW	24.93	29.81	32.46	34.62	37.16	41.27	44.51	47.90	51.42	55.10	58.93	62.93	67.10	71.47	76.04	80.82	85.83	91.09	96.61	102.41	108.50	114.92	121.67	128.79	136.29	144.20	152.35	161.03
MVR	18.70	22.35	24.35	25.96	27.87	30.95	33.39	35.92	38.57	41.32	44.20	47.19	50.33	53.60	57.03	60.62	64.37	68.32	72.46	76.80	81.38	86.19	91.25	96.59	102.21	108.15	114.26	120.77
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE 9	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
MVA(MW+MVR)	47.88	57.24	62.34	66.48	71.36	79.25	85.48	91.98	98.75	105.80	113.16	120.84	128.87	137.25	146.03	155.21	164.83	174.92	185.52	196.66	208.36	220.68	233.65	247.32	261.72	276.91	292.56	309.24
MW	38.30	45.79	49.87	53.18	57.09	63.40	68.39	73.59	79.00	84.64	90.53	96.67	103.09	109.80	116.82	124.17	131.86	139.94	148.42	157.33	166.69	176.55	186.92	197.85	209.38	221.53	234.05	247.39
MVR	28.73	34.34	37.40	39.89	42.82	47.55	51.29	55.19	59.25	63.48	67.90	72.51	77.32	82.35	87.62	93.13	98.90	104.95	111.31	117.99	125.02	132.41	140.19	148.39	157.03	166.15	175.54	185.54
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Riopele	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
MVA(MW+MVR)	19.75	23.61	25.72	27.42	29.44	32.69	35.27	37.95	40.74	43.65	46.68	49.85	53.16	56.62	60.24	64.03	68.00	72.16	76.53	81.13	85.96	91.04	96.39	102.03	107.97	114.23	120.69	127.57
MW	15.80	18.89	20.57	21.94	23.55	26.15	28.21	30.36	32.59	34.92	37.35	39.88	42.53	45.30	48.19	51.22	54.40	57.73	61.23	64.90	68.77	72.83	77.11	81.62	86.37	91.39	96.55	102.06
MVR	11.85	14.17	15.43	16.45	17.66	19.62	21.16	22.77	24.44	26.19	28.01	29.91	31.90	33.97	36.14	38.42	40.80	43.30	45.92	48.68	51.57	54.62	57.83	61.22	64.78	68.54	72.41	76.54
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE10	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
MVA(MW+MVR)	24.51	29.31	31.92	34.04	36.54	40.58	43.77	47.10	50.56	54.17	57.94	61.87	65.98	70.28	74.77	79.47	84.39	89.56	94.99	100.69	106.68	112.99	119.63	126.63	134.00	141.78	149.79	158.33
MW	19.61	23.45	25.53	27.23	29.23	32.46	35.02	37.68	40.45	43.34	46.35	49.50	52.78	56.22	59.81	63.57	67.52	71.65	75.99	80.55	85.35	90.39	95.71	101.30	107.20	113.43	119.84	126.67
MVR	14.71	17.58	19.15	20.42	21.92	24.35	26.26	28.26	30.34	32.50	34.76	37.12	39.59	42.17	44.86	47.68	50.64	53.74	56.99	60.41	64.01	67.80	71.78	75.98	80.40	85.07	89.88	95.00
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

SE11	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
MVA(Tr Cap)	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
MVA(MW+MVR)	4.58	5.47	5.96	6.35	6.82	7.57	8.17	8.79	9.44	10.11	10.81	11.55	12.31	13.12	13.95	14.83	15.75	16.72	17.73	18.79	19.91	21.09	22.33	23.63	25.01	26.46	27.96	29.55
MW	3.66	4.38	4.77	5.08	5.46	6.06	6.54	7.03	7.55	8.09	8.65	9.24	9.85	10.49	11.16	11.87	12.60	13.37	14.18	15.03	15.93	16.87	17.86	18.91	20.01	21.17	22.37	23.64
MVR	2.75	3.28	3.57	3.81	4.09	4.54	4.90	5.27	5.66	6.07	6.49	6.93	7.39	7.87	8.37	8.90	9.45	10.03	10.64	11.28	11.95	12.65	13.40	14.18	15.01	15.88	16.77	17.73
PF	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80

Source: JICA Study Team

3.6 Demand Forecast of SAPP Countries

Neighboring countries' demand are important for Mozambique with the aim of becoming energy hub country. Table 3.6-1and Table 3.6-2 show the demand forecast up to 2040 of SAPP 11 countries without Mozambique reported in SAPP Regional Generation and Transmission Expansion Plan 2017. These were forecasted by Economic Consulting Associates (EIHP, Energy Exemplar, Norconsult AS, Geo Terra Image) and reported in June 2017. Demand of Malawi and Tanzania will increase significantly in energy base, increase ration are more than 10%. They are followed by Angola.

According to this report, base case[4] predicts that South Africa and Zambia are main power import countries and Mozambique and Zimbabwe are the main power export countries in 2035.

Table 3.6-1 Energy Consumption of SAPP Countries (at Sending End)

(GWh)

	Angola	Botswana	DRC	Lesotho	Malawi	Namibia	S Africa	Swaziland	Tanzania	Zambia	Zimbabwe
2017	9,507	4,203	10,641	706	2,501	4,549	253,510	1,240	9,010	18,314	10,265
2018	10,661	4,479	10,592	740	2,944	4,780	261,014	1,283	10,320	19,117	10,424
2019	11,768	4,669	10,910	774	3,459	4,930	268,738	1,355	11,810	19,944	10,417
2020	12,994	5,406	11,445	819	3,994	5,100	275,336	1,444	13,430	20,721	10,837
2021	14,152	5,609	12,057	864	4,426	5,288	282,508	1,538	14,890	21,185	11,218
2022	15,385	5,996	12,609	914	4,897	5,443	289,804	1,632	16,490	22,021	11,988
2023	16,718	6,180	13,174	962	5,412	5,606	296,696	1,724	18,270	22,894	12,517
2024	18,051	6,370	14,046	1,015	5,973	5,793	302,192	1,803	20,230	23,715	12,982
2025	19,427	6,930	14,684	1,069	6,586	5,991	310,219	1,863	22,440	24,667	13,611
2026	21,089	7,107	15,414	1,124	7,253	6,197	317,280	1,910	24,680	25,549	14,214
2027	22,906	7,408	16,121	1,181	7,981	6,425	323,226	1,952	27,140	26,552	14,825
2028	24,895	7,519	16,960	1,238	8,774	6,655	328,286	1,990	29,830	27,607	15,324
2029	27,073	7,632	17,746	1,297	9,637	6,895	334,678	2,024	32,780	28,715	15,838
2030	29,029	7,790	18,582	1,357	10,627	7,147	340,846	2,054	36,000	29,879	16,370
2031	31,128	7,985	19,765	1,420	11,675	7,405	347,510	2,082	39,540	30,993	17,092
2032	33,379	8,185	20,718	1,486	12,811	7,636	354,210	2,104	43,410	32,149	17,692
2033	35,794	8,344	21,717	1,556	14,044	7,918	360,612	2,126	47,640	33,347	18,176
2034	38,385	8,410	23,094	1,628	15,380	8,181	366,927	2,144	52,270	34,591	18,809
2035	41,164	8,518	24,208	1,703	16,829	8,490	372,727	2,162	57,340	35,880	19,323
2036	44,146	8,696	25,738	1,776	18,400	8,787	378,349	2,184	62,480	37,218	19,992
2037	47,345	8,874	26,979	1,851	20,102	9,095	385,184	2,207	68,060	38,605	20,537
2038	50,778	9,035	28,679	1,929	21,947	9,414	391,780	2,230	74,130	40,045	21,100
2039	54,461	9,203	30,062	2,011	23,945	9,744	397,026	2,253	80,720	41,538	21,676
2040	58,413	9,377	31,511	2,096	26,105	10,085	403,062	2,276	87,880	43,086	22,270
AAGR	7.70%	3.50%	4.50%	4.80%	11.40%	3.90%	2.10%	2.80%	11.10%	3.80%	3.40%

Source: SAPP Regional Generation and Transmission Expansion Plan 2017

[4] Base case is the Component A (Benchmark Case), which considers international transmission lines in coming 3 or 4 years only.

Table 3.6-2 Maximum Demand of SAPP Countries (at Sending End)

(MW)

	Angola	Botswana	DRC	Lesotho	Malawi	Namibia	S Africa	Swaziland	Tanzania	Zambia	Zimbabwe
2017	1,670	641	1,620	166	449	693	38,617	252	1,450	3,063	1,977
2018	1,872	683	1,727	168	529	733	39,757	257	1,680	3,177	2,083
2019	2,067	712	1,832	172	621	758	40,931	265	1,930	3,300	2,130
2020	2,282	824	1,921	178	719	786	41,934	273	2,190	3,432	2,247
2021	2,486	855	2,024	183	795	816	43,024	283	2,430	3,573	2,381
2022	2,702	914	2,117	188	878	842	44,133	294	2,690	3,724	2,601
2023	2,936	942	2,212	196	967	869	45,180	306	2,980	3,886	2,752
2024	3,170	971	2,358	201	1,064	899	46,015	317	3,300	4,060	2,947
2025	3,412	1,057	2,465	204	1,169	931	47,235	329	3,660	4,247	3,077
2026	3,704	1,084	2,588	211	1,282	964	48,327	339	4,030	4,447	3,185
2027	4,023	1,130	2,706	220	1,405	1,001	49,247	349	4,430	4,662	3,352
2028	4,372	1,172	2,847	224	1,538	1,039	49,920	359	4,860	4,893	3,482
2029	4,755	1,187	2,979	235	1,682	1,078	51,029	367	5,340	5,140	3,617
2030	5,098	1,212	3,120	240	1,873	1,119	51,961	374	5,870	5,406	3,757
2031	5,467	1,234	3,270	243	2,063	1,159	52,983	381	6,450	5,616	3,879
2032	5,862	1,261	3,428	247	2,267	1,195	53,898	386	7,080	5,825	4,044
2033	6,286	1,286	3,593	251	2,489	1,239	55,008	390	7,770	6,043	4,175
2034	6,741	1,308	3,766	256	2,728	1,281	55,979	393	8,520	6,268	4,354
2035	7,229	1,325	3,948	261	2,986	1,329	56,865	396	9,350	6,501	4,495
2036	7,753	1,340	4,138	272	3,265	1,376	57,583	401	10,190	6,744	4,666
2037	8,315	1,365	4,338	284	3,566	1,424	58,747	405	11,100	6,995	4,795
2038	8,918	1,390	4,547	296	3,892	1,473	59,752	410	12,090	7,256	4,928
2039	9,565	1,413	4,766	308	4,243	1,525	60,563	415	13,160	7,527	5,064
2040	10,259	1,436	4,996	321	4,620	1,578	61,334	419	14,330	7,807	5,204
AAGR	7.70%	3.50%	5.20%	3.50%	11.10%	4.00%	2.10%	2.30%	11.40%	4.10%	4.40%

Source: SAPP Regional Generation and Transmission Expansion Plan 2017

Chapter 4 Primary Energy Analysis

4.1 Current Situation of Primary Energy

The Republic of Mozambique have not only various kinds of mineral resources such as coal, natural gas, gold, graphite, etc. but also much water resources which come from various rivers including Zambezi River. There is also huge fertile land around downstream basin.

Table 4.1-1 shows current energy balance in Mozambique. The major primary energy resources produced in Mozambique are coal, natural gas, hydro and biofuels. Mozambique is able to procure these resources by themselves except for oil products. It is shown that Mozambique has rich natural resources because large portion of coal and natural gas is exported.

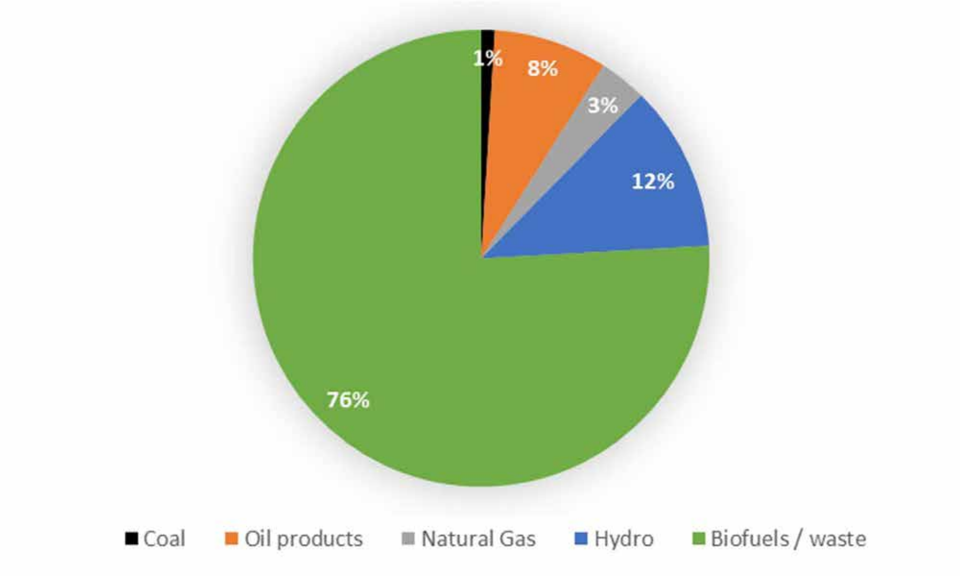
Table 4.1-1 Energy Balance in Mozambique (2014)

[unit: ktoe]

	Coal	Crude oil	Oil products	Natural Gas	Hydro	Biofuels / waste	Electricity	Total
Production	4070	59		3472	1391	8997		17989
Imports			1071				658	1730
Exports	-3071	-59		-3074			-877	-7082
International aviation bunkers			-128					-128
Stock changes	-885		11					-873
TPES	114	0	955	398	1391	8997	-219	11636
Transfers			-1					-1
Statistical differences	-102		-1	-2		-1	9	-97
Electricity plants				-312	-1391		1526	-177
Other transformation						-950		-950
Energy industry own use	-11						-20	-32
Losses							-225	-225
Total final consumption	0	0	953	84	0	8045	1071	10154
Industry			**132**	**81**		**880**	**916**	**2010**
Transport			**723**	**2**				**725**
Other			**98**			**7165**	**155**	**7419**
Residential			59			7151	140	7351
Commercial and public services			28			14	15	58
Agriculture / forestry			10					11

Source: IEA

Figure 4.1-1 shows the balance of primary energy supply in Mozambique. This figure does not include import and export of electricity. The bulk of current energy supply is biofuels / waste. Although they are used as fuel for industry and household, they are not used for generation. It is necessary to facilitate development of coal and natural gas for future growth of industrial field.



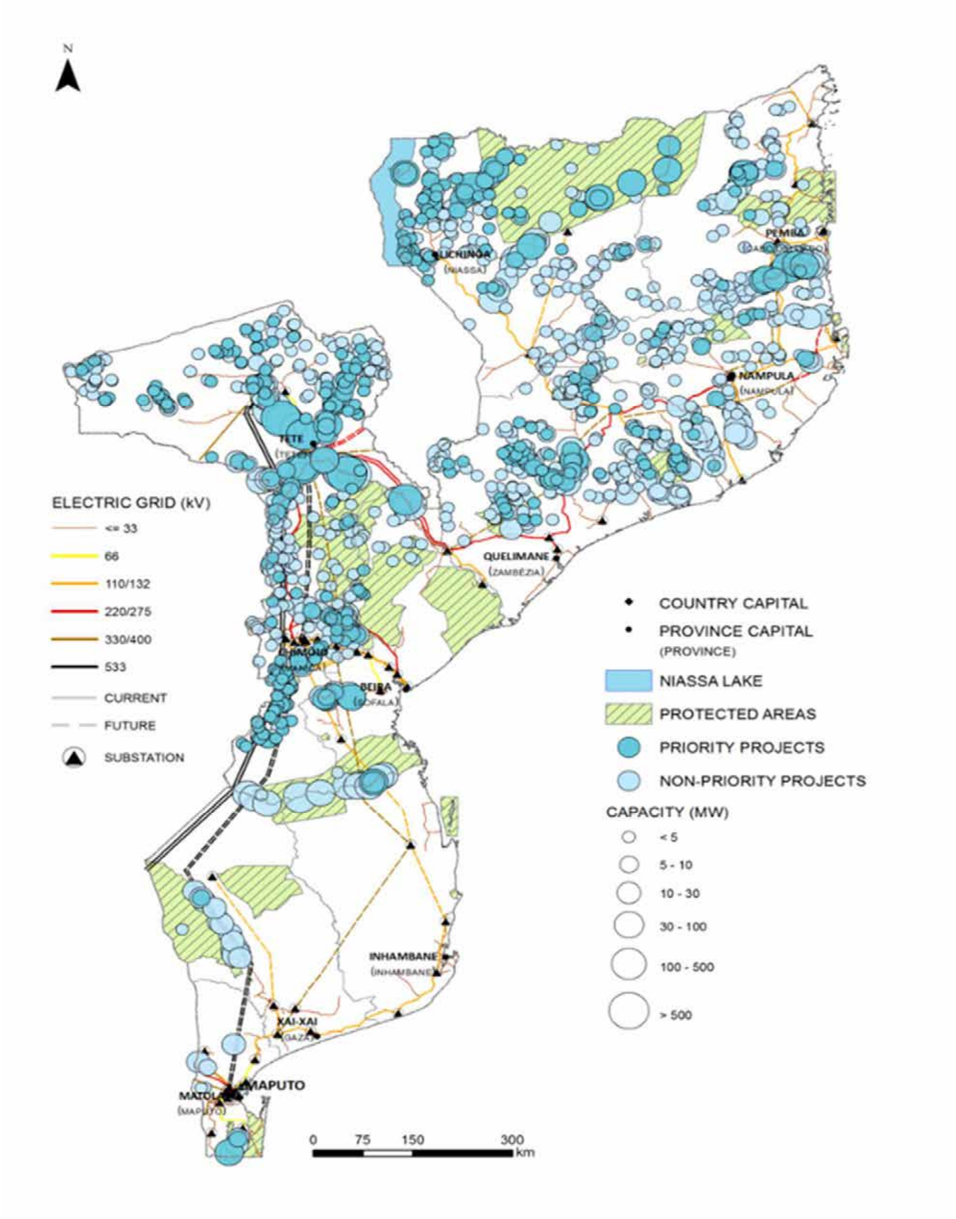
Source: IEA

Figure 4.1-1 Balance of primary energy supply

4.2 Primary Energy Analysis

4.2.1 Hydro

The major hydro potential in Mozambique exists hydrographic basin of Zambezi river which is the 4th longest river in Africa. However, Cahora Bassa Dam is the only one site which is already developed in the river. Therefore, there are much hydro potential to be developed. In addition, there are lots of small and medium sized river except the Zambezi river. Figure 4.2-1 shows hydro potential for electricity in Mozambique.



Source: Renewable Energy Atlas of Mozambique

Figure 4.2-1 Hydro potential for electricity in Mozambique

4.2.2 Coal

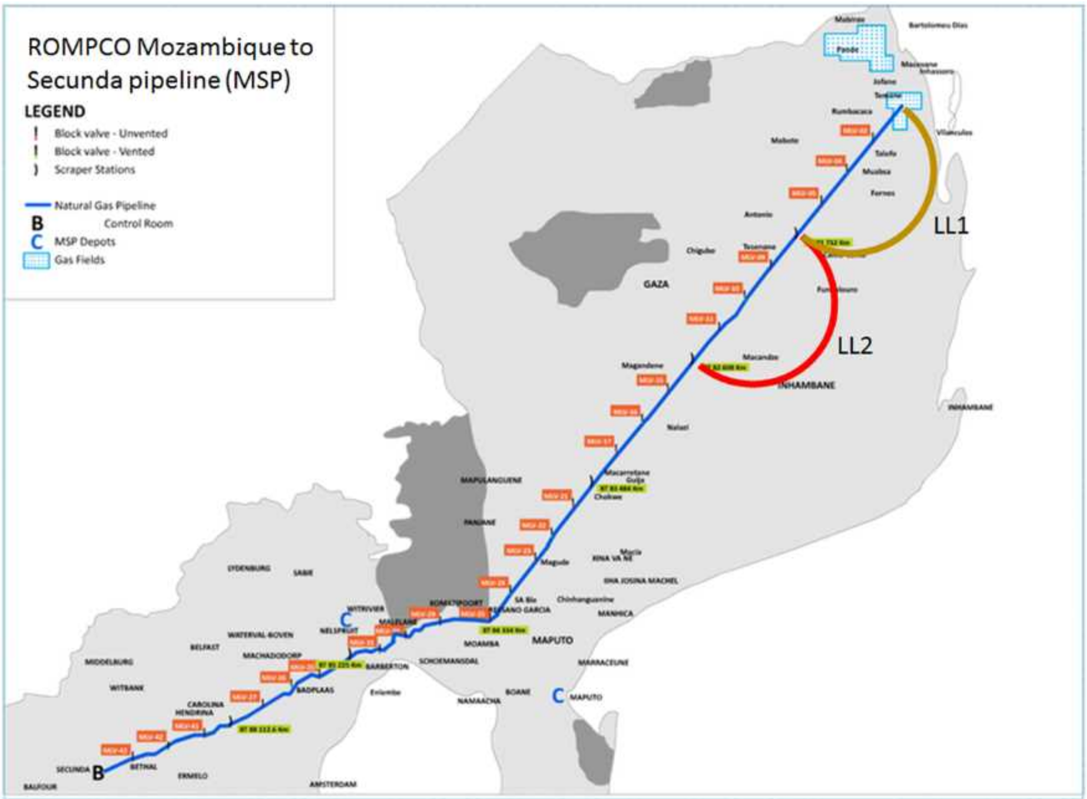
Foreign developers are proceeding coal mine projects at Tete province, north of Mozambique. There are three major coal mines which are Moatize coal mine operated by Vale, Benga coal mine operated by ICVL and Chirodze coal mine operated by JINDAL. Produced coal is relatively rich sulfur and ash. Instead of that, it can be used for both metallurgical coal and thermal coal because its heat value is on a level with that of other famous coal mines. Produced coal is limited for domestic use because almost of it is to export. However, it is expected to use coal for developing domestic industry because the production and exportation of coal is increasing recently and there is enough amount of deposit which is estimated almost 20 billion tons.

4.2.3 Natural gas

There are two natural gas reserves in Mozambique. One is Pande-Temane gas fields located in Inhambane province, southern part of Mozambique. The other is Rovuma offshore gas fields located in Rovuma basin, Cabo Delgado province, northern part of Mozambique. The Natural Gas Master Plan was formulated in 2014 to set up the policy of domestic development of gas sector.

Pande-Temane gas fields has almost 3 TCF amount of deposit. This gas fields has been developed by Sasol, South Africa company. The gas pipeline named Mozambique to Secunda pipeline (hereinafter referred to as MSP) was completed in 2014 which is led to South Africa shown in Figure 4.2-2. Nowadays, over 90% of production in Pande-Temane gas fields export to South Africa via gas pipeline. Branch line is connected to MSP to provide the gas for domestic use at Maputo and Matola cities such as industry and household. In addition, there is a plan to increase provision of the amount of gas by expanding the gas fields production.

However, the capacity of MSP transport has led to maximum amount of design value. Furthermore, amount of domestic use via MSP is limited to existing supply destination including CTM thermal power station which is under construction. Therefore, it is required to use nearby gas fields or build additional pipeline for expanding supply amount to provide domestic industries from this gas fields. Just for the record, there are parallel gas pipeline which is called Loop Line1 and Loop Line 2 for expand the supply amount about 250 km distance from sending point. These Loop Line is constructed parallel of existing pipeline.



Source: ROMPCO

Figure 4.2-2 Gas Pipeline route from Pande-Temane gas fields to South Africa

Rovuma gas fields has almost 185 TCF amount of deposit which is one of the largest gas fields in the world. There are two companies acting as operators of Rovuma gas fields. Anadarko originated in United States is owned in the Area 1, and ENI originated in Italy is owned in the Area 4. These companies make enterprise groups to have own interest respectively. instead of that, they collaborate on developing gas fields. Table 4.2-1 shows constitution of groups. In March 2017, ExxonMobil and ENI signed sale and purchase agreement to acquire a portion of indirect interest in the Area 4. The scheme was approved by government in September, 2017.

Table 4.2-1 Stakeholders of Area 1 and Area 4

Site	Operator	Stakeholders	Condition
Area1	Anadarko	Anadarko（26.5%）, Mitsui（20%）, ONGC Videsh（16%）, Bharat Petroleum（10%）,PTTEP（8.5%）, OIL（4%）, ENH（15%）	Cooperation development of Area1 & Area4 COD in 2022~2023
Area4	ENI East Africa	ENI East Africa（70% : ENI（25%）, ExxonMobil（25%）, CNPC（20%））, Kogas（10%）, Galp Energia（10%）, ENH（10%）	GoM has approved jointing ExxonMobil

Source: JICA Study Team based on Anadarko and ENI Web Site

Although it is written in Gas Master Plan that the production in Area 1 and Area 4 will start in 2018, it seems to commence gas production in 2022 or 2023 according to latest information. Initially it is planned to produce 1,000 mmscf/d from 2 trains of production facilities. Later it seems to produce 2,000 mmscf/d from 4 trains after expanded.

The portion of gas produced in this gas fields is allocated preferentially for domestic use. In August 2016, a public tender for the industrial use from this gas fields was announced. The result was published in January 2017 which is shown in Table 4.2-2.

Table 4.2-2 Results of Rovuma gas industrial allocation bidding

Winner	Shell Mozambique BV	Yara International	GL Energy Africa
Purpose	liquified fuel, generation	fertilize, generation	generation
Allocation	310-330 mmscf/d	80-90 mmscf/d	41.8 mmscf/d
Generation capacity	50-80 MW	80MW	250MW
Production	38 mil barris	1.2-1.3 MTPA	

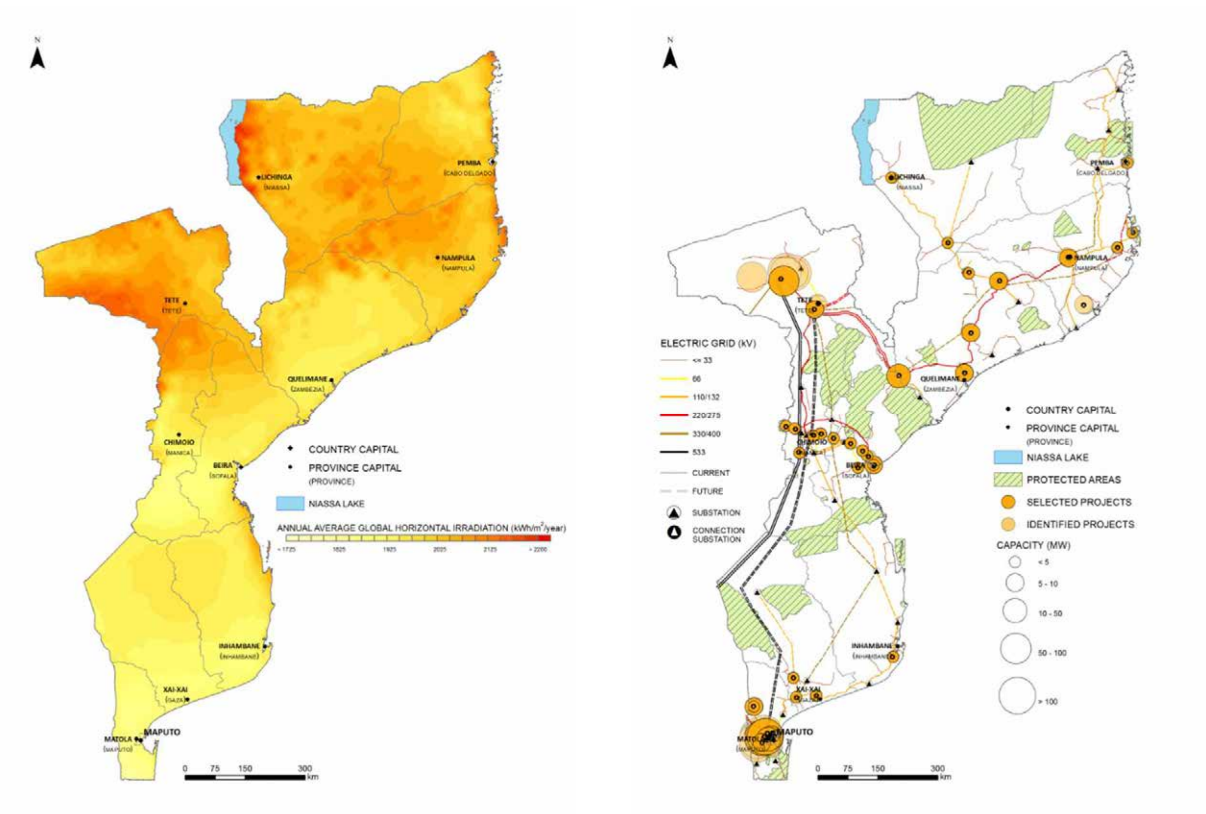
Source: JICA Study Team

4.2.4 Renewable energy

The potential study of renewable energy in Mozambique, which is named Renewable Energy Atlas of Mozambique, was published in 2014. In this study, hydro, solar, wind, biomass, geothermal and waves resources were studied throughout the Mozambique and the potential for production of electrical energy was evaluated about 23,000GW. Especially almost all of that comes from solar resource which is evaluated as 23,000GW, following hydro as 19GW, wind as 5GW, biomass as 2GW. Hydro resource is already written in 4.2.1. Therefore, in this session, solar, wind and biomass are characterized as follows.

(1) Solar

Solar resource potential in Mozambique is quite high because Mozambique has a high global irradiation on the horizontal plane in nationwide. Figure 4.2-3 shows the solar potential atlas and expected solar projects map. There is notably large solar potential in above of Mozambique. However, expected solar projects are considered to locate adjoining area of existing grid so that it is estimated that more than 2.7 GW solar power is able to develop. It is expected to increase the developable capacity of solar by future grid expansion.

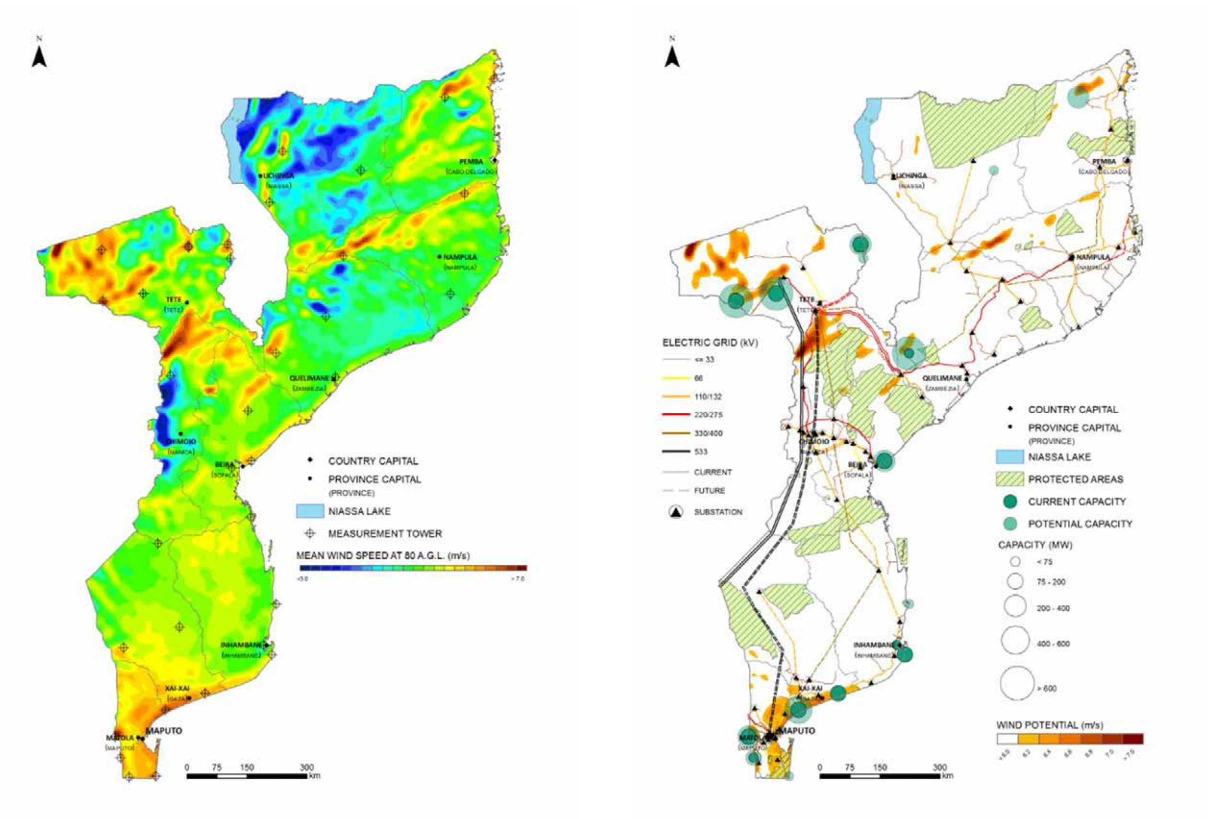


Source: Renewable Energy Atlas of Mozambique

Figure 4.2-3 Solar potential atlas and expected solar projects map

(2) Wind

Figure 4.2-4 shows wind potential atlas and wind projects potential map in Mozambique. It is required for the suitable condition of wind generation that the average wind speed is generally more than 6-8 m/s. According to Figure 4.2-4, the suitable area is eccentrically located in Maputo, Tete, Sofala, Inhambane and Gaza province. Although the estimated capacity of wind power is 4.5GW, the capacity which is able to connect to the existing grid is evaluated as 1.1GW.

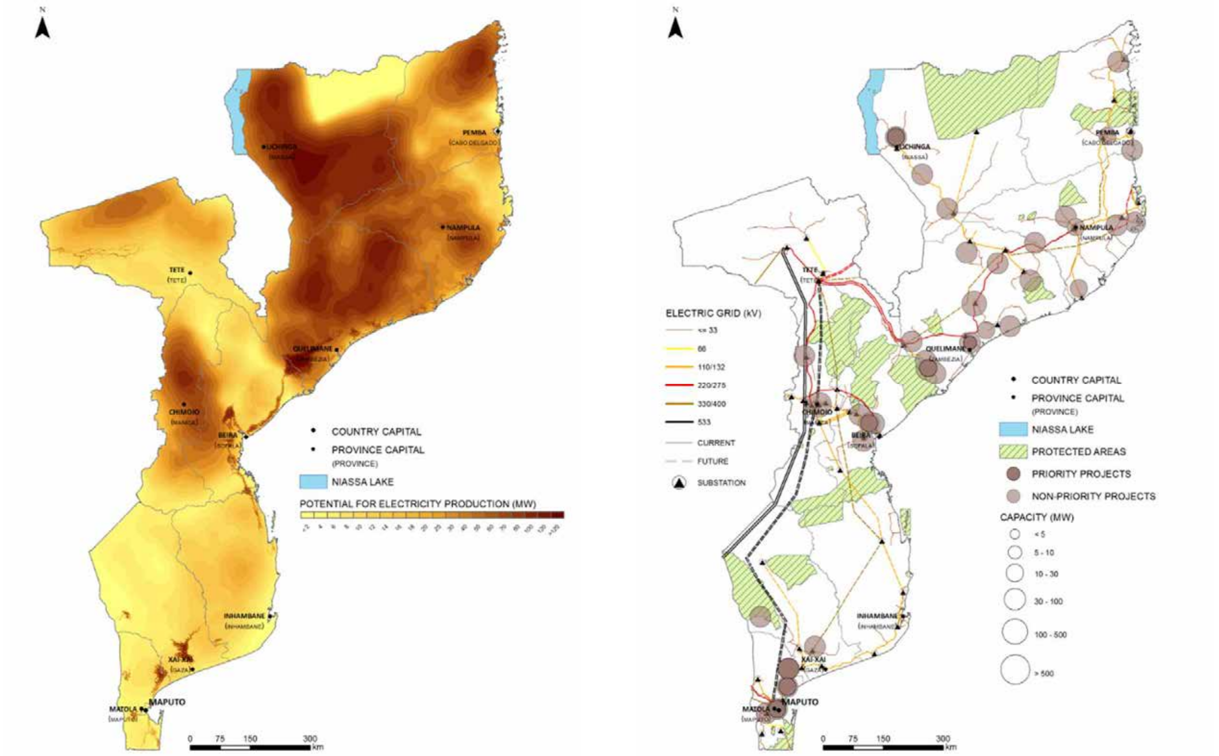


Source: Renewable Energy Atlas of Mozambique

Figure 4.2-4 Wind potential atlas and wind projects potential map

(3) Biomass

Mozambique has different biomass resources such as forest biomass, biomass from industrial and agroindustrial wastes, cogeneration in the pulp industry, sugar industry and so on. Figure 4.2-5 shows the biomass potential atlas and expected biomass projects map. Total potential of biomass is evaluated over 2GW and breakdown of that is estimated as 1GW from forest biomass, 0.8GW from sugar industry and 0.2GW from pulp industry. However, considering procurement of biomass fuel, it is limited 128MW to develop short term for the existing grid.



Source: Renewable Energy Atlas of Mozambique

Figure 4.2-5 Biomass potential atlas and expected biomass projects map

Chapter 5 Generation Development Plan

In formulating a long-term generation development plan, a planner should consider that the plan should show an appropriate plan for the development of generation units by reviewing preconditions such as future demand, supply capacity, required supply reliability and costs. The appropriate plan not only shows a process for improving supply cost and supply reliability in the system, but it must also contribute to a further understanding of the future conditions for the balance between demand and supply in the power system.

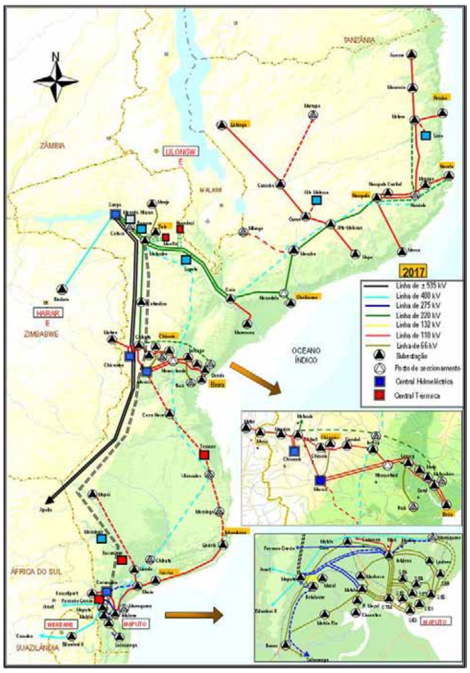
Mozambique is expected for a development of rich primary energy not only water resource but also natural gas and coal material in several regions. Therefore, electric power system in Mozambique has a potential to be developed with diversity of energy resource and system stability taking the place of power concentrated system heavily relied on the existing Cahora Bassa hydropower plant.

This chapter discusses the generation development plan in Mozambique from 2018 to 2042.

5.1 Generation Development Planning Procedure

5.1.1 Target System for the Study

As power system in Mozambique as of 2017 is divided into two systems of southern region and central & northern regions, all on-grid power systems across the country of Mozambique based on base case result of Chapter 3 Demand Forecasts are the target systems for generation development planning. Supply for the Mozal company is assumed to be supplied from Cahora Bassa hydropower in the study period and supply power from existing Cahora Bassa hydropower plant for EDM on-grid system is assumed to be maximum 500MW through the study period as preconditions.



Source: EDM

Figure 5.1-1 Power system in Mozambique

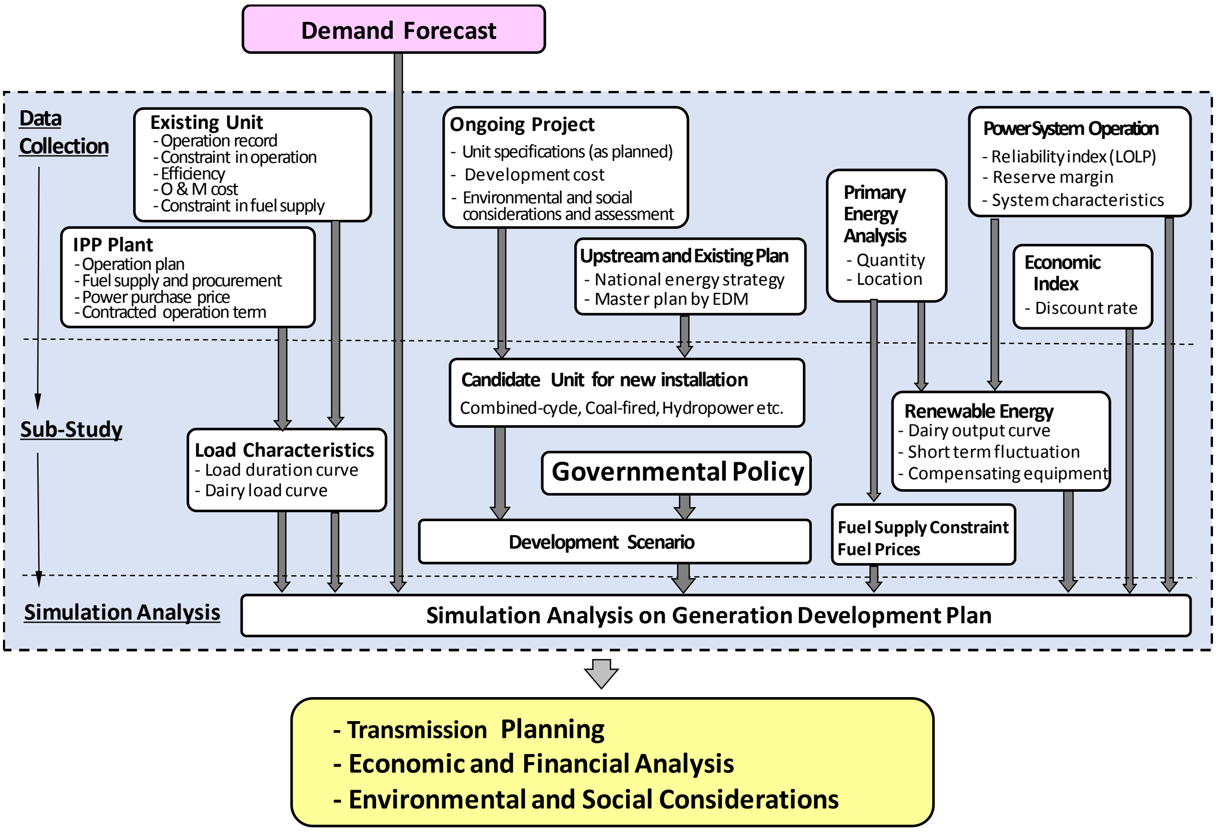
5.1.2 Methodology for the generation development planning

In this study, optimization of generation development plan with the least cost method is used for the following reasons;

- This master plan study is considered up to 2042. Peak demand in 2042 forecasted in the study is expected over 6,500MW and therefore many generation projects will be needed to be developed in the future.
- As Mozambique has a potential for rich primary energy, it is expected to be developed many kinds of generators such as hydropower unit, gas thermal power unit, coal thermal power unit, solar power and wind power unit in the future. Characteristics of generators in the point of not only specifications but also capital cost and operation cost are different each other, therefore optimization of generation development plan will be needed taking into consideration total generation cost, development site and energy mix etc.

5.1.3 Workflow of Generation Development Planning

Figure 5.1-2 shows a workflow for the formulation of a generation development plan in the Study.



Source: JICA Study Team

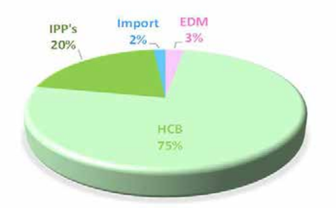
Figure 5.1-2 Workflow for the formulation of a generation development plan

5.2 Trend of Power Generation System

5.2.1 Power supply record (2015)

Power supply record (2015) in Mozambique is shown in Figure 5.2-1 Power Supply Record (2015). It consists of 75% of HCB, 20% of IPP, 3% of EDM and 2% of Import. It forms that hydro power generation (HCB: Cahora Bassa) is mainly sustaining country's electricity demand. Recently, power supply from IPP is becoming the important position to maintain the balance of electricity demand and power supply.

	Energy Producer	2015(GWh)	(Weight)
1	HCB	4,599	(75%)
2	IPP's	1,229	(20%)
3	EDM	158	(3%)
4	Import	98.8	(2%)
	Total	6,085	(100%)



Source: JICA Study Team

Figure 5.2-1 Power Supply Record (2015)

5.2.2 Hydro Power Generation

Cahora Bassa Hydro Power Plant (Capacity: 2,075MW, 500MW is supplied to Mozambique) is the primary power supplier in this country. In addition to that, there are 5 hydro power plants that is the small/middle scale (0.5-57MW). Mphanda Nkuwa hydro power plant (1,500MW) is pushed forward with a target of COD in 2024 as a high prioritized development project.

5.2.3 Thermal Power Generation

Thermal power generation mainly consisted of small scale such as a diesel engine (light oil).

After Temane gas-well was developed, Temane gas engine thermal power plant (11.6MW) started operation step by step from 2006 to 2014. Since the gas engine type is short construction period, three IPP projects of 100MW class were added in Ressano Garcia area in southern region from 2014 through 2016 afterwards. In addition to that, CTM CCGT thermal power plant (110MW) is now under construction in Maputo. Furthermore, Temane gas fired thermal power plant (400MW) is pushed forward with a target of COD in 2022 as a high prioritized development project.

5.2.4 Renewable Energy Generation

Construction of Mocuba solar power generation (40MW) is being pushed forward now with a target of COD in 2018. A challenge of increasing the ratio of renewable energy (such as photovoltaic power generation, wind power generation and biomass generation) is expected to continue in future.

5.3 Existing Power Generation

5.3.1 Power Producers in Mozambique

Major power producers in Mozambique are shown in Table 5.3-1. In addition to EDM, there are several power producers as IPP (Independent Power Producer) and/or PPP (Private Public Partnership).

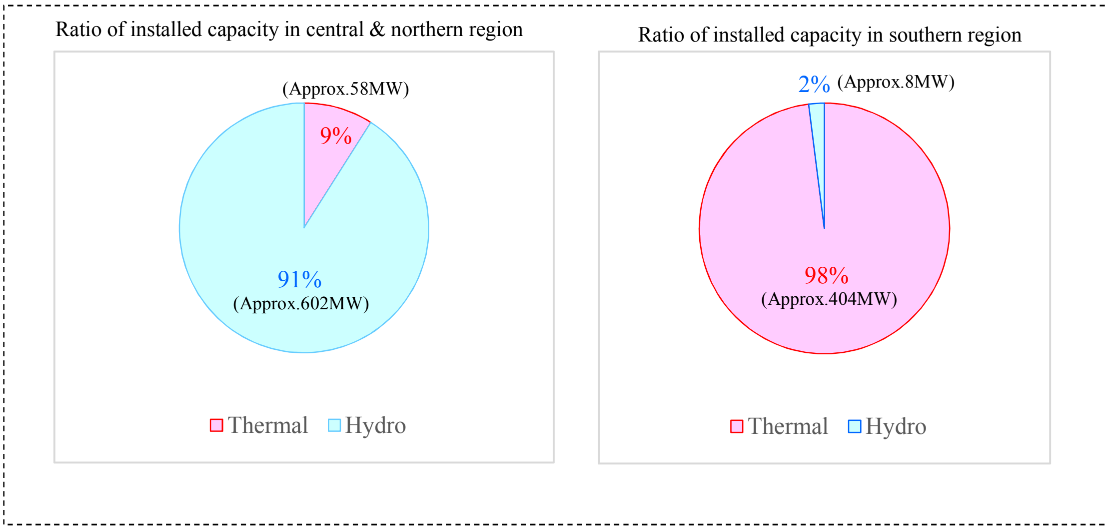
Table 5.3-1 Power Producers in Mozambique

No	Power Producer Name	Description	Business scale/scope
1	EDM (Electricidade de Moçambique)	An electricity public company of the 100% government investment, established in 1977.	Power supply record (2015) is 6,085GWh.
2	HCB (Hidroelectrica de Cahora Bassa)	An IPP company (Mozambique: 92.5% and REN (Portugal): 7.5% investment).	Operating the Cahora Bassa hydro power plant (2,075MW).
3	Sasol	A company of the energy & chemical industry in South Africa. The company is developing natural gas production plant in Temane and IPP business with EDM	Operating the CTRG thermal power plant (175MW) with EDM as PPP project.
4	Gigawatt	An IPP company from Mozambique. (Gigajoule, WBHO, Old Mutual, etc.)	Operating the Gigawatt thermal power plant (121MW).
5	CTRG (Central Termica de Ressano Garcia)	An IPP company (EDM: 51% and Sasol: 49%).	Operating the CTRG thermal power plant (175MW).
6	Aggreko	A supplier of temporary power generation equipment.	Operating two gas engine thermal power plants (154MW/as total).
7	Karpower	An IPP company.	Operating floating type power generation plant (100MW).
8	ZOGOPE/Andrade Guterres	An IPP company.	Constructing Moamba Major hydro power plant.
9	Scatec	A company of solar generation development.	Constructing Mocuba solar power plant (capacity 40MW).
10	Kuvaninga	An IPP company	Recently commissioned thermal power plant (capacity 40 MW)

Source: JICA Study Team

5.3.2 Existing Power Generation

Lists of existing power generation in central & northern region and southern region are shown in Table 5.3-2 and Table 5.3-3. There are 11 power plants in central & northern regions (Supply capacity: approx. 660MW) and 9 power plants in southern area (Supply capacity: approx. 442MW). Installed capacity of hydropower is 91% and that of thermal power is 9% in Central & Northern region. On the other hand, installed capacity of hydropower is 2% and that of thermal power is 98% in Southern region.



Source: JICA Study Team

Figure 5.3-1 Ratio of installed capacity by power sources in central & northern and southern region

Table 5.3-2 Existing power generation equipment (central & northern region)

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015	Remarks
1	Mavuzi (EDM)	Hydro	57MW (6MWx2u) (15MWx3u)	57MW	1955-1957	Base Load	4.6%	Rehabilitation from Feb. to Dec. in 2015
2	Chicamba (EDM)	Hydro	44MW (22MWx2u)	44MW	1968-1969	Peak	14%	-
3	Nampula Emergency (EDM)	Thermal (D/E)	4MW (2MWx2u)	1.5MW	1971	Peak (Emergency)	-	-
4	Cahora Bassa (HCB)	Hydro	2,075MW (415MWx5u)	500MW	1975	Base Load	105%	-
5	Quelimane Emergency (EDM)	Thermal (D/E)	6.88MW (3.44x2u)	2.5MW	1980	Peak (Emergency)	-	
6	Lichinga (EDM)	Hydro	0.73MW	0.5MW	1983	Base Load	19.9%	-
7	Beira GT35 (EDM)	Thermal (OCGT)	14MW	12MW	1988	Peak	2.4%	-

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015	Remarks
8	Cuamba (EDM)	Hydro	1.1MW	0.5MW	1989	Base Load	46.8%	-
9	Pemba Emergency (EDM)	Thermal (D/E)	1.46MW	1MW	2002	Peak (Emergency)	-	-
10	Lichinga Emergency (EDM)	Thermal (D/E)	1.5MW	1.2MW	2003	Peak (Emergency)	-	-
11	Nacala Barcassa -IPP (Karpower)	Thermal (Powership)	102.5MW (17.09MWx6u)	40MW	2016	Base Load	-	-
Sub-total				660.2MW				

D/E: Diesel Engine, OCGT: Open Cycle Gas Turbine Source: JICA Study Team

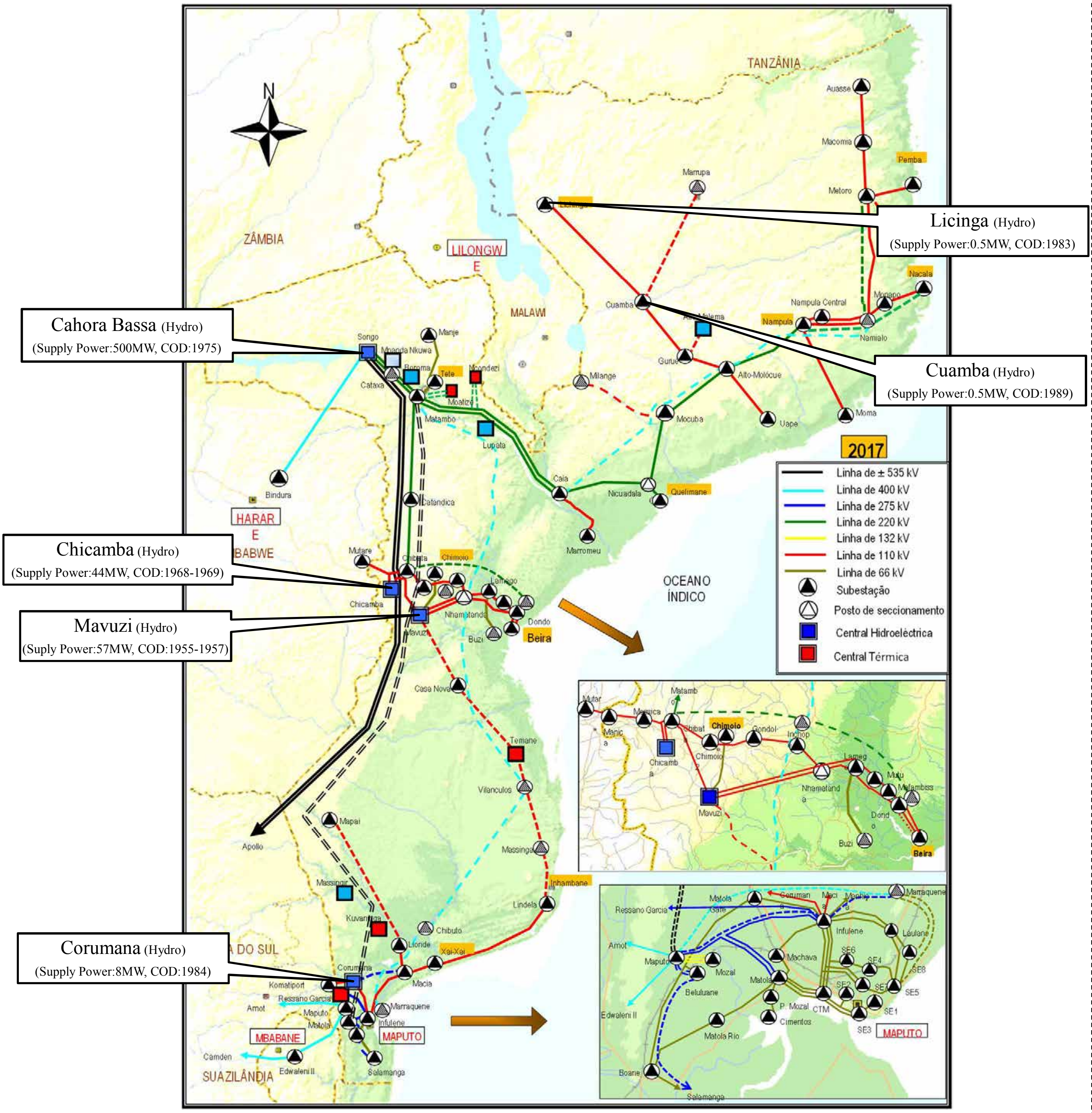
Table 5.3-3 Existing power generation equipment (Southern region)

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015	Remarks
1	Corumana (EDM)	Hydro	16.6MW (8.3MWx2u)	8MW	1984	Base Load	34.1%	-
2	CTM GT (EDM)	Thermal (GT)	24MW	18MW	1991	Peak	-	-
3	Temane (EDM)	Thermal (G/E)	11.6MW (0.95MWx7u) (2.5MWx2u)	10.7MW	2006-2014	Base Load	35.5%	-
4	Xai-Xai (EDM)	Thermal (D/E)	3.6MW (0.9MWx4u)	3MW	2008	Peak (Emergency)	-	-
5	CTRG -PPP (EDM/Sasol)	Thermal (G/E)	175MW (9.72MWx18u)	150MW	2014	Base Load	85.1%	-
6	Inhambane Emergency (EDM)	Thermal (D/E)	4.6MW (2.3MWx2)	1.8MW	2015	Peak (Emergency)	-	-
7	Aggreko Ressano Phase-2 -IPP (Aggreko)	Thermal (G/E)	112MW (1.12MWx100u)	90MW	2016	Base Load	-	Decommission in 2017
8	Aggreko Beluluane-IPP (Aggreko)	Thermal (G/E)	40MW (1MWx40u)	40MW	2016	Base Load	-	Decommission in 2017
9	Gigawatt-IPP (Gigawatt)	Thermal (G/E)	121MW (9.34x13u)	120MW	2016	Base Load		-
10	Kuvaninga-(IPP)	Thermal (G/E)	40MW (4MWx10u)	40MW	2017	Base Load	-	-
Sub-total				481.5MW				

GT: Gas Turbine, D/E: Diesel Engine, G/E: Gas Engine, Source: JICA Study Team

5.3.3 Site Location of Existing Power Generation

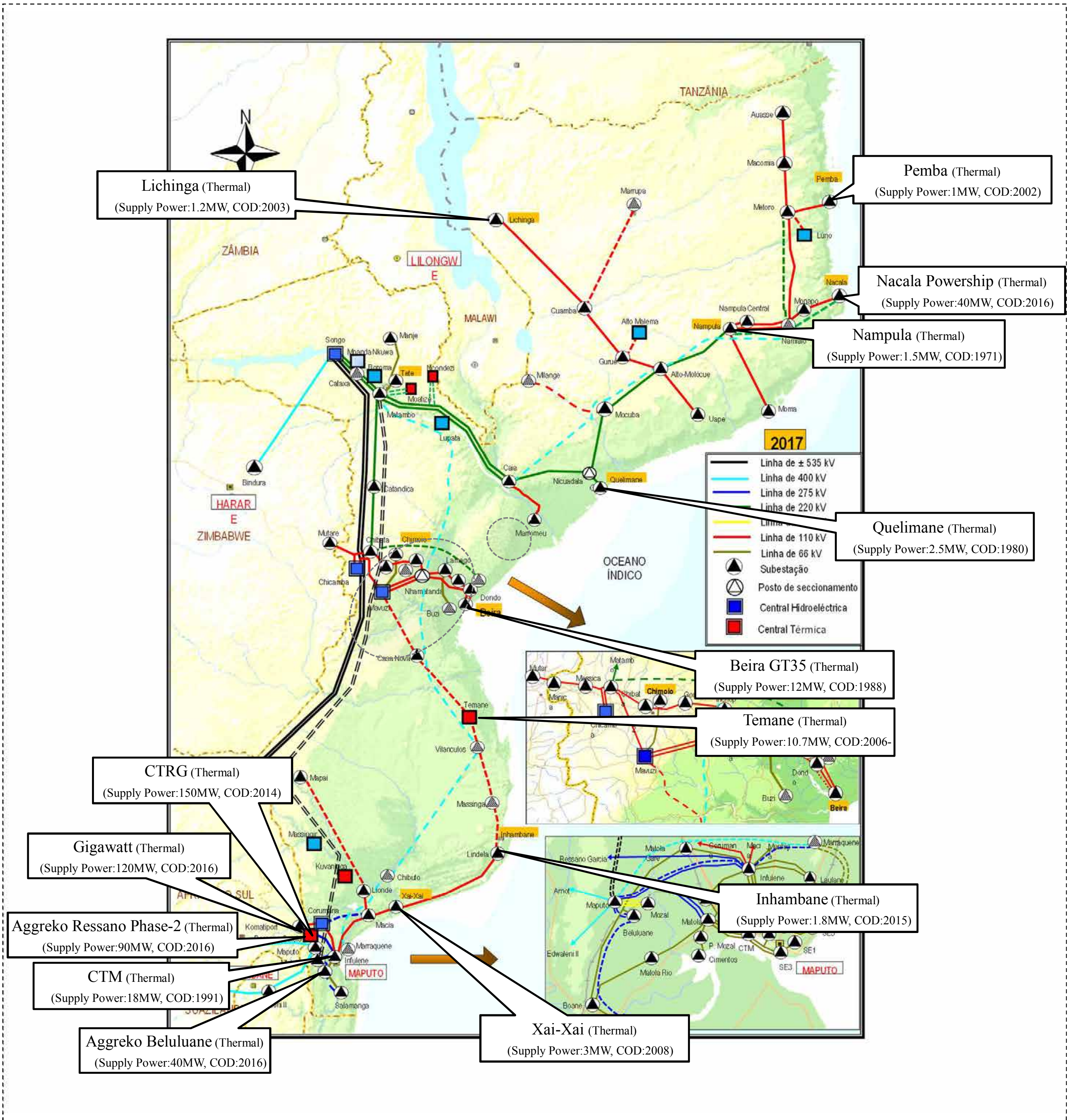
Site locations of existing power generation (Hydropower) are shown in Figure 5.3-2.



Source: JICA Study Team

Figure 5.3-2 Site locations of existing power generation (Hydropower)

Site locations of existing power generation (Thermal power) are shown in Figure 5.3-3.



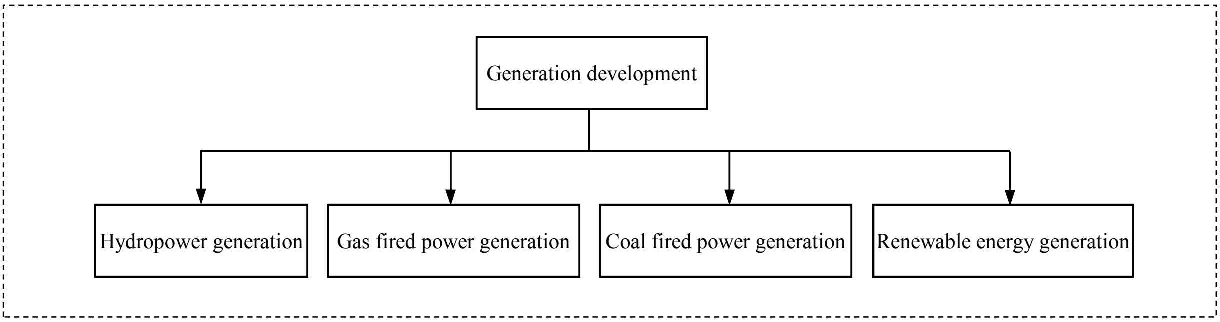
Source: JICA Study Team

Figure 5.3-3 Site locations of existing power generation (Hydropower)

5.4 Generation Development

5.4.1 Outline of Generation Development

There are a lot of variety generation development plans that consists of hydropower generation, gas fired thermal power generation, coal fired thermal power generation and renewable energy generation as candidates of future generation development because Mozambique has abundant primary energy potential. In recent years (until 2024), firstly gas fired thermal power generation will be developed due to a short construction period and less environment impact. In addition to that, large scale hydropower generation and coal fired power generation will be developed after 2024. Renewable energy generation is individually developed depending on increase of the power system (grid) capacity.



Source: JICA Study Team

Figure 5.4-1 Generation Development Plan in Mozambique

5.4.2 Generation Development Plan

Lists of Generation Development Plan (including construction status) are shown in Table 5.4-1 and Table 5.4-2. Total installed capacity is approx. 10,300MW that consists of hydropower generation, gas fired thermal power generation, coal fired thermal power generation and renewable energy generation. The Generation Development Plan consists of; hydropower: 52% (17 projects), thermal power: 46% (25 projects) and renewable energy: 2% (5 projects).

Table 5.4-1 Generation Development Plan (Central & northern Region)

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
1	Quelimane Emergency	Thermal (D/E)	6MW	6MW	2017	Peak (Emergency)	Conceptual
2	Nampula Emergency	Thermal (D/E)	6MW	6MW	2017	Peak (Emergency)	Conceptual
3	Lichinga Emergency	Thermal (D/E)	6MW	6MW	2017	Peak (Emergency)	Conceptual
4	Penba Emergency	Thermal (D/E)	6MW	6MW	2017	Peak (Emergency)	Conceptual
5	Jindal-(IPP)	Thermal (Coal Fired)	150MW	150MW	2023	Base Load	Feasibility Study
6	Mocuba-(PPP)	Solar	40MW	40MW	2018	Day time only	Under Construction
7	Metoro-(IPP)	Solar	30MW	30MW	2019	Day time only	Conceptual

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
8	Nacala GT Emergency	Thermal (OCGT)	40MW	40MW	2019	Peak	Feasibility Study
9	ENRC (Estima)-(IPP)	Thermal (Coal Fired)	300MW	300MW	2020	Base Load	Feasibility Study
10	Tete 1200-(PPP)	Thermal (Coal Fired)	1,200MW	1,200MW (300MWx4u)	2023	Base Load	Pre-Feasibility Study
11	Central Termica da Baobab	Thermal (Coal Fired)	200MW	200MW	2022	Base Load	Feasibility Study
12	Nacala Coal	Thermal (Coal Fired)	200MW	200MW	2022	Base Load	Pre-Feasibility Study
13	Mphanda Nkuwa-(PPP)	Hydro	1,500MW (375x4u)	1,500MW	2024	Base Load	Feasibility Study
14	Moatize	Thermal (Coal Fired)	300MW	300MW	2025	Base Load	Conceptual
15	Ncondezi	Thermal (Coal Fired)	300MW	300MW	2025	Base Load	Conceptual
16	Muenezi	Hydro	21MW	21MW	2025	Base Load	Conceptual
17	Tsate	Hydro	50MW	50MW	2025	Base Load	Feasibility Study
18	Alto Molocue	Hydro	50MW	50MW	2025	Base Load	Conceptual
19	Mutelete	Hydro	40MW	40MW	2025	Base Load	Conceptual
20	Mugeba	Hydro	50MW	50MW	2025	Base Load	Conceptual
21	Alto Malema	Hydro	60MW	60MW	2025	Base Load	Conceptual
22	Messalo	Hydro	50MW	50MW	2025	Base Load	Conceptual
23	Lugenga	Hydro	50MW	50MW	2025	Base Load	Conceptual
24	Lurio I	Hydro	120MW	120W		Base Load	Conceptual
25	Lurio II	Hydro	120MW	120W	2025	Base Load	Conceptual
26	Lurio III	Hydro	60MW	60W		Base Load	Conceptual
27	Cahora Bassa North–(IPP)	Hydro	1,245MW (415MWx3u)	1,245MW	2026		Feasibility Study
28	ENI-(IPP)	Thermal (Gas Fired)	75MW	75MW	2027	Base Load	Conceptual
29	Shell-(IPP)	Thermal (Gas Fired)	80MW	80MW	2027	Base Load	Conceptual
30	Nacala Thermal Power	Thermal (Coal Fired)	400MW	400MW			Conceptual
31	Buzi-(IPP)	Thermal (Gas Fired)	260MW	260MW			Conceptual
32	Benga-(IPP)	Thermal (Coal Fired)	300MW	300MW			Conceptual
33	Lupata	Hydro	650MW	650MW		Base Load	Feasibility Study
34	Boroma	Hydro	200MW	200MW		Base Load	Feasibility Study
35	Mphanda Nkuwa Phase-2- (PPP)	Hydro	1,125MW (375x3u)	1,125MW			Conceptual
36	Central Hidrica de Pavue-(IPP)	Hydro	120MW	120W			Conceptual
37	Chemba 1	Hydro	600MW	600MW		Base Load	Conceptual
38	Chemba 1	Hydro	400MW	400MW		Base Load	Conceptual
39	Cuamba	Thermal (Coal Fired)					

D/E: Diesel Engine, OCGT: Open Cycle Gas Turbine   Source: JICA Study Team

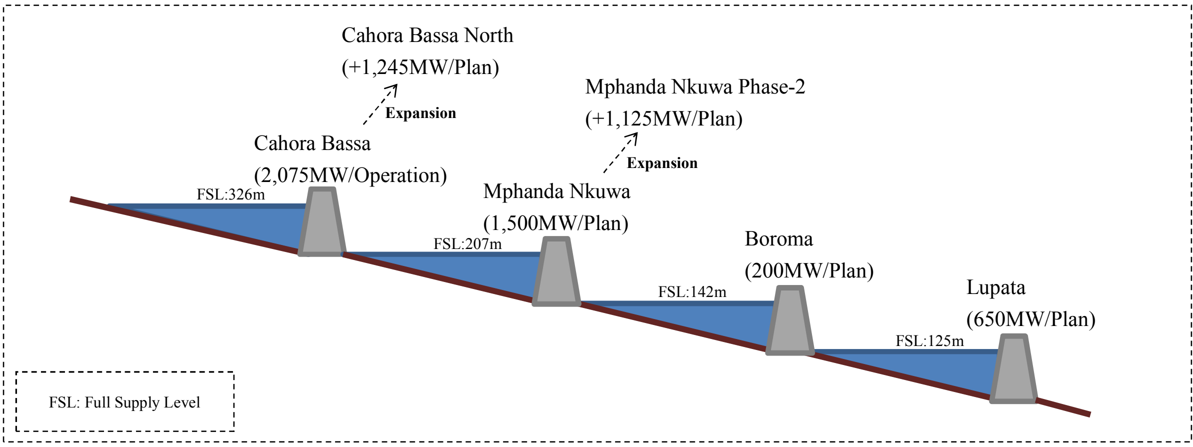
Table 5.4-2 Generation Development Plan (Southern Region)

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
1	CTM CCGT	Thermal (CCGT)	110MW	110MW	2018	Base Load	Under Construction
2	Trino-(IPP)	Thermal (Gas Fired)	100MW	100MW	2019	Base Load	Conceptual
3	Moamba Major-(IPP)	Hydro	15MW	15MW	2020	Base Load	Under Construction
4	Electrotec CCGT-(IPP)	Thermal (CCGT)	40-80MW	40MW	2020	Base Load	Conceptual
5	Central Termica Engco-(IPP)	Thermal (Gas Fired)	120MW	120MW	2020	Base Load	Conceptual
6	Temane MGTP-(PPP)	Thermal (CCGT)	400MW (100MWx4u)	400MW	2022	Base Load	Feasibility Study
7	Temane CCGT	Thermal (CCGT)	100MW	100MW	2023	Base Load	Feasibility Study
8	CGMassinga	Thermal (CCGT)	30MW	30MW			Conceptual
9	MOVE ENERGY	Thermal (CCGT)	78MW	78MW			Conceptual
10	CMEL	Thermal (CCGT					Conceptual
11	Tofo Windpower	Wind	30MW	30MW	2023		Conceptual
12	Massingir	Hydro	27MW	27MW	2025	Base Load	Conceptual
13	Biomassa Salamanga-(IPP)	Biomass	30MW	30MW			Conceptual
14	Biomassa Moamba-(IPP)	Biomass	30MW	30MW			Conceptual

G/E: Gas Engine, CCGT: Combined Cycle Gas Turbine, GT: Gas Turbine, D/E: Diesel Engine Source: JICA Study Team

5.4.3 Development Plan of Hydropower Generation

There are 16 development plans of hydropower generation including conceptual status. Particularly, Mphanda Nkuwa hydropower generation project (1,500MW) that utilizes Zambezi river has an abundant water quantity and is being pushed forward as an important power generation to support future demand increase. Mphanda Nkuwa hydropower generation locates at downstream of Cahora Bassa hydropower plant that started operation in 1975 (2,075MW). Furthermore, there are development plans of Boroma hydropower generation (200MW) and Lupata hydropower generation (650MW) at downstream of Mphanda Nkuwa hydropower plant. Development plans are utilizing Zambezi water system effectively. In addition to those plans, there are expansion plans of Cahora Bassa North (1,245MW) and Mphanda Nkuwa Phase-2 (1,125MW). Hydropower development plans in Zambezi river system is shown in Figure 5.4-2.



Source: JICA Study Team

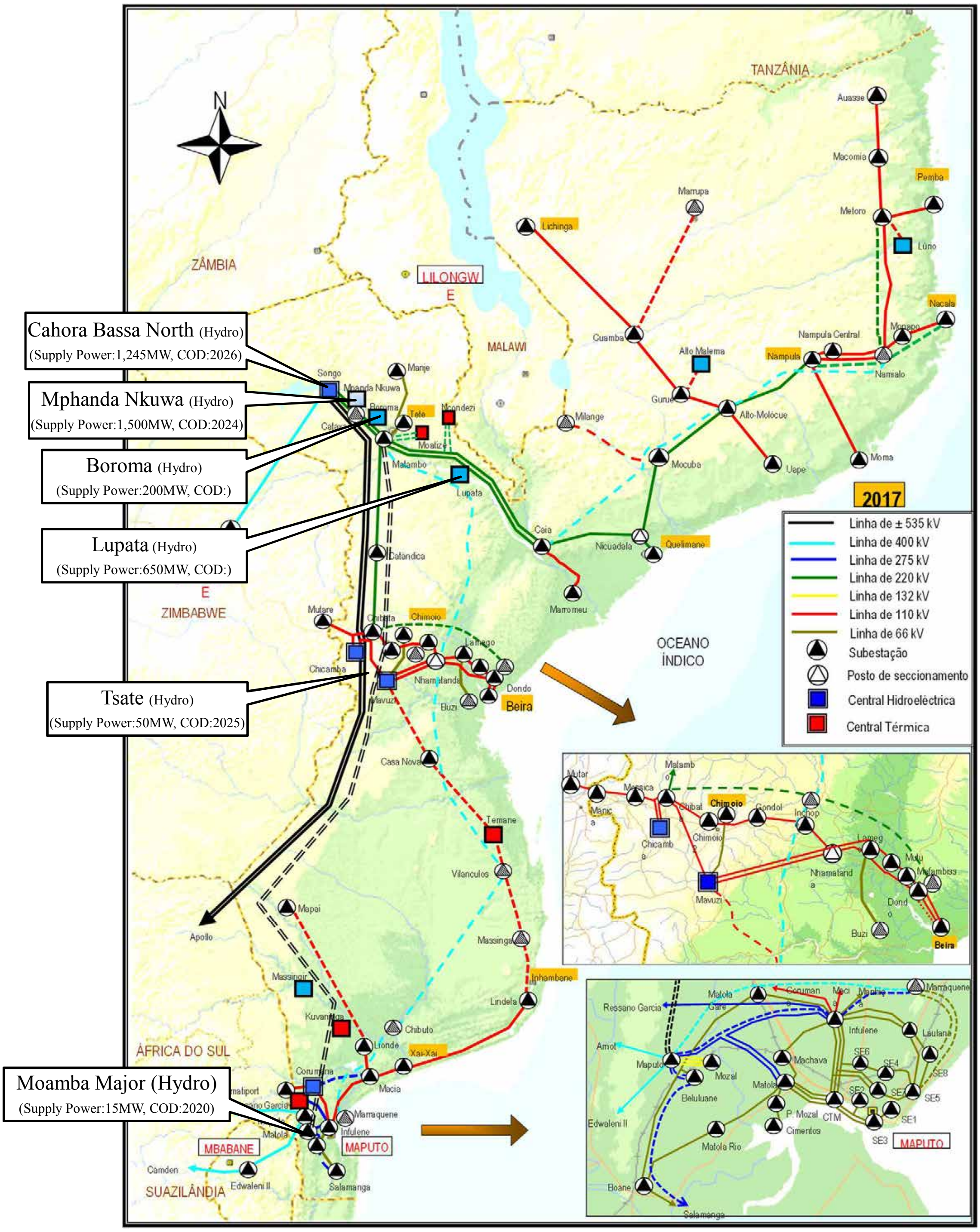
Figure 5.4-2 Hydropower development plans under Zambezi river system

Hydropower development plans status under (construction or completed feasibility study) are shown in Table 5.4-3 and its locations are shown in Figure 5.4-3.

Table 5.4-3 Hydropower development plans of the status of under construction or completed feasibility study

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
-1	Moamba Major-(IPP)	Hydro	15MW	15MW	2020	Base Load	Under Construction
2	Mphanda Nkuwa-(PPP)	Hydro	1,500MW (375x4u)	1,500MW	2024	Base Load	Feasibility Study
3	Tsate	Hydro	50MW	50MW	2025	Base Load	Feasibility Study
4	Cahora Bassa North (IPP)	Hydro	1,245MW (415MWx3u)	1,245MW	2026		Feasibility Study
5	Lupata	Hydro	650MW	650MW		Base Load	Feasibility Study
6	Boroma	Hydro	200MW	200MW		Base Load	Feasibility Study

Source: JICA Study Team



Source: JICA Study Team

Figure 5.4-3 Site locations and development plans status of hydropower (under construction or completed feasibility study)

5.4.4 Development Plan of Thermal Power Generation

There are 24 development plans of thermal power generation including conceptual status. They are mainly gas fired thermal power plants and coal fired thermal power plants. The locations of gas fired thermal power development plans are a neighborhood of Temane natural gas well and an area along gas supply pipeline from natural gas well to South Africa because a gas supply network is required.

And a neighborhood of Rovuma natural gas well in northern region (now under development) and Nacala area by utilizing a pipeline from Rovuma are expected as locations of future's thermal power development. The locations of coal fired thermal power development plans are Tete area with coal mine and Nacala area that is the major port of materials transportation including coal fuel because those areas are advantageous of viewpoint of fuel procurement.

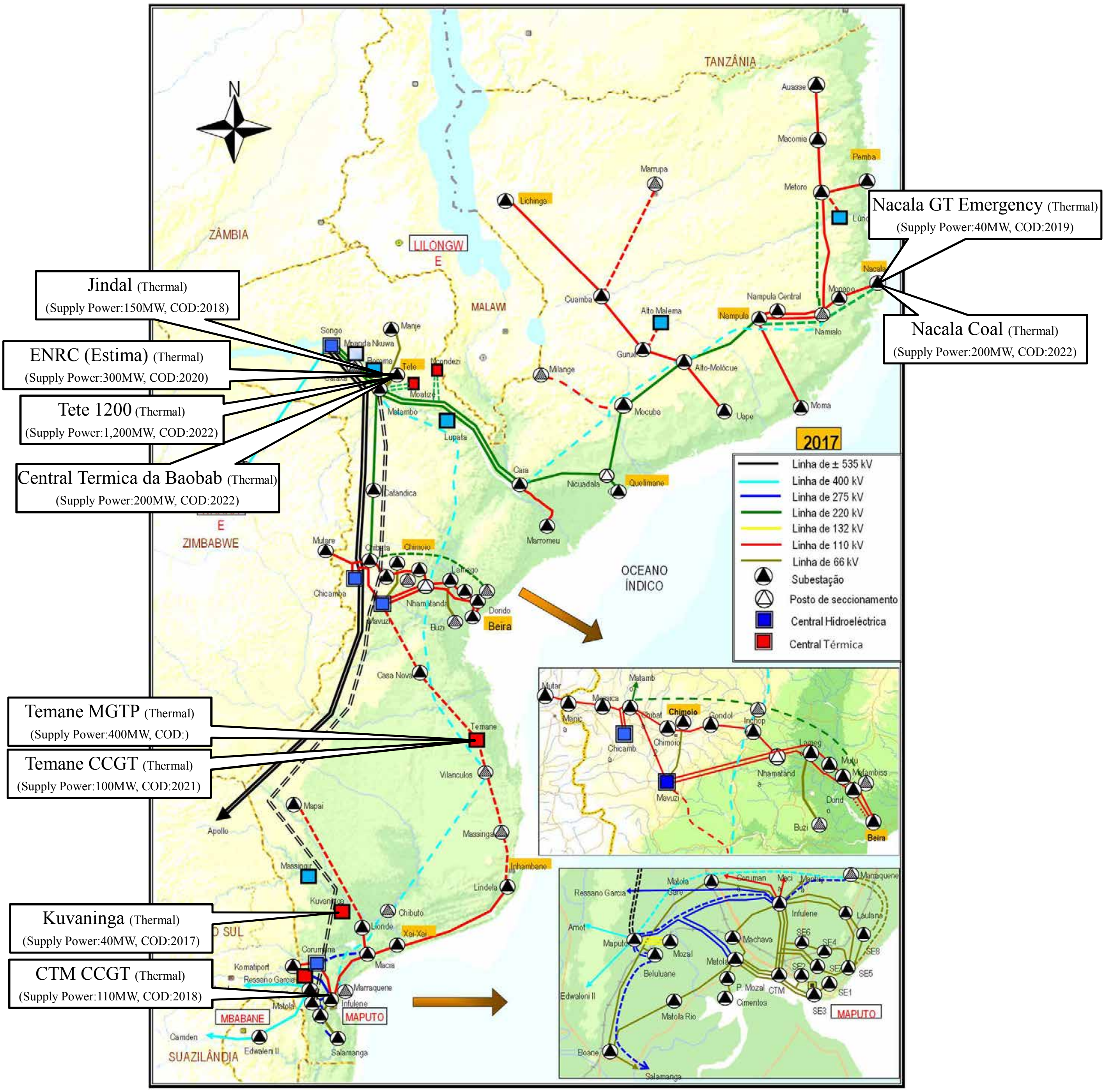
Thermal power development plans on the status of under construction or completed feasibility study are shown in Table 5.4-4 and its locations are shown in Figure 5.4-4.

In addition, as of May 2017, Cuamba coal-fired power plant in Niassa state (200MW) is planning to develop with Chinese invester. This project is just a conceptual stage.

Table 5.4-4 Thermal power development plans of the status of under construction or completed feasibility study

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
1	CTM CCGT	Thermal (CCGT)	110MW	110MW	2018	Base Load	Under Construction
2	Jindal-(IPP)	Thermal (Coal Fired)	150MW	150MW	2023	Base Load	Feasibility Study
3	Nacala GT Emergency	Thermal (OCGT)	40MW	40MW	2019	Peak	Feasibility Study
4	ENRC (Estima)-(IPP)	Thermal (Coal Fired)	300MW	300MW	2020	Base Load	Feasibility Study
5	Temane MGTP-(PPP)	Thermal (Gas Fired)	400MW (100MWx4u)	400MW	2022	Base Load	Feasibility Study
6	Temane CCGT	Thermal (CCGT)	100MW	100MW	2023	Base Load	Feasibility Study
7	Tete 1200-(PPP)	Thermal (Coal Fired)	1,200MW	1,200MW (300MWx4u)	2023	Base Load	Pre-Feasibility Study
8	Central Termica da Baobab	Thermal (Coal Fired)	200MW	200MW	2022	Base Load	Feasibility Study
9	Nacala Coal	Thermal (Coal Fired)	200MW	200MW	2022	Base Load	Pre-Feasiblility Study

Source: JICA Study Team

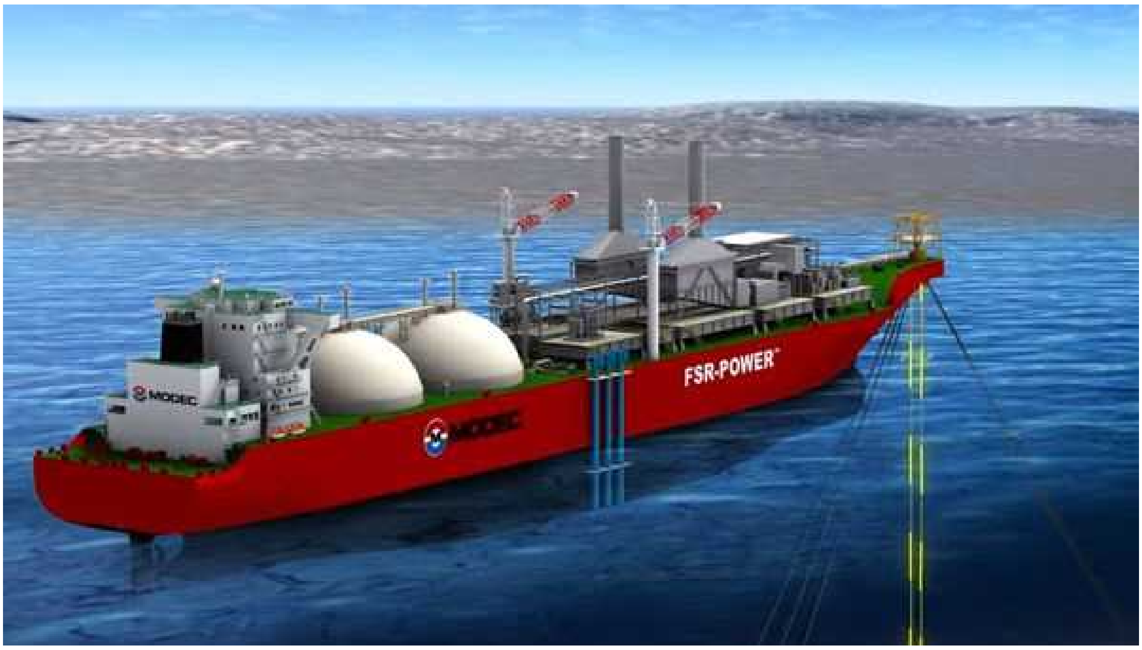


Source: JICA Study Team

Figure 5.4-4 Site locations of thermal power development plans of status of under construction or completed feasibility study

Tips 1　Ship Based LNG Power Generation

Offshore gas reserve in northern Rovuma Basin is leading with utilizing floating LNG facilities. There is a concept to utilize from gas reserve through nationwide gas pipeline in the future. However, it should be supply LNG for nationwide demand area before completion of gas pipeline except northern area where is neighboring onshore gas production facilities. Therefore, ship based LNG power generation is considerable to utilize northern gas in the short to medium term. Ship based LNG power generation is a combined ship with LNG storage, regasification, and gas-fired power generator. It has benefits that it is not necessary to construct onshore power station and fuel receiving terminal, thus construction period is shorter.



Source: MODEC

Figure 5.4-5　image of ship based LNG power genertaion

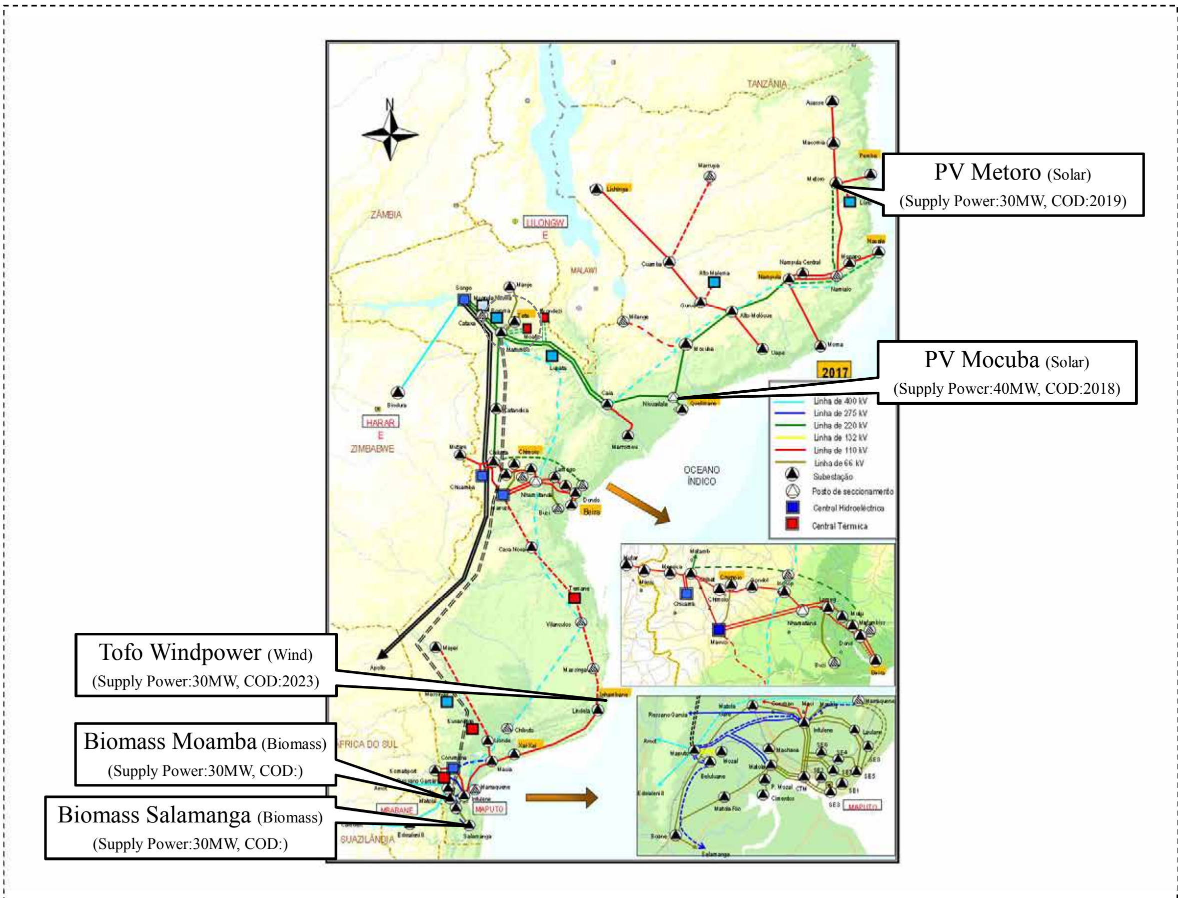
5.4.5 Development Plan of Renewable Energy Generation

There are 5 development plans of renewable energy generation including conceptual status. It consists of 2 solar power generation projects, 1 wind power generation project and 2 biomass power generation projects. Mocuba solar power generation is now under construction as a target of starting operation in 2018. Renewable energy development plans are shown in Table 5.4-5 and its locations are shown in Figure 5.4-6.

Table 5.4-5 Renewable energy development plans

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
1	Mocuba-(PPP)	Solar	40MW	40MW	2018	Day time only	Under Construction
2	Metoro-(IPP)	Solar	30MW	30MW	2019	Day time only	Conceptual
3	Tofo	Wind	30MW	30MW	2023		Conceptual
4	Salamanga-(IPP)	Biomass	30MW	30MW			Conceptual
5	Moamba-(IPP)	Biomass	30MW	30MW			Conceptual

Source: JICA Study Team



Source: JICA Study Team

Figure 5.4-6 Site locations of renewable energy development plans

Tips 2 Floating solar photovoltaic power plant

The most potential of renewable energy in Mozambique is based on solar resource, thus more and more photovoltaic power plants are expected to be introduced. Although solar photovoltaic power plants are rapidly prevailing in the world, it is necessary to prepare land area in case of large capacity solar photovoltaic power plant because photovoltaic module is low efficiency and low energy density.

Floating solar photovoltaic power plant is considered due to limitation of land use. The positive points of this are no needs to land preparation, less degradation of efficiency due to heating loss, etc. This system can be installed in water bodies like lakes, reservoir, oceans etc. In addition, existing dam reservoir with hydropower plants are profitable location to install this system because it is easy to access substation facilities.

Source: Kyocera Corp.

Figure 5.4-7 Image of floating solar photovoltaic power plant

5.5 Nacala Emergency Generation

Outline of Nacala emergency generation is described below.

No	Plant Name	Type	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
1	Nacala GT Emergency	Thermal (OCGT)	40MW	40MW	2019	Peak	Feasibility Study

Source: JICA Study Team

The development plan with two phases (the first stage and the second stage) is suggested in JICA study report (2016) "Nacala Corridor Transmission & Distribution Network Reinforcement Project". At the first stage, OCGT is planned to construct with the fuel of light oil and/or kerosene which is available for procurement at Nacala area to achieve an early startup. And at the second stage, OCGT is converted to CCGT when natural gas to be available at Nacala area from Rovuma natural gas well (northern region) through a gas pipeline.

- The first stage: one OCGT is installed as emergency generation (40MW)
- The second stage: one more OCGT is installed and converted to CCGT (110MW)

The specifications of main equipment of EPP (Aero derivative type gas turbine) are summarized below.

1. Outline of generation system

a. Gas turbine (at ambient temperature 15˚C)

Rererence: Sectional schematic of Gas turbine

(a) Type: Aero Derivative Type
(b) Type of cycle: Open Cycle 2 Shaft Gas Turbine Type
(c) Number: One (1) set
(d) Firing Temperature: 854˚C
(e) Fuel: Diesel Oil
(f) Output: 40MW class
(g) Generation Efficiency: 40%
(h) Compressor: 5 stage low pressure compressor & 14 stage high pressure compressor
(i) Combustor: Annular Type
(j) Gas turbine: 2 stage high pressure turbine & 5 stage low pressure turbine
(k) Exhaust Gas Temperature: 450 to 460˚C
(l) Exhaust Gas Flow: 473.6 ton/h
(m) Measures for Reducing NOx: Low NOx Combustor or Water Injection Equipment
(n) Starter: Electro-Hydraulic Type Motor
(o) Lubrication Oil System: Forced Lubrication System

b. Generator

(a) Type: Horizontally mounted salient pole of one forging rotor, rotating field, brushless synchronous generator with closed air water cooled

(b) Number: One (1) set

(c) Rated Capacity: 56.5MVA

(d) Power Factor: 0.85

(e) Rated Voltage: 11 kV

(f) Frequency: 50 Hz

(g) Pole: 4

(h) Rotating Speed: 1,500 rpm

(i) Exciter: Brushless

c. Generator Main Circuit

(a) Non IPB: One (1) set

(b) Circuit Breaker: One (1) set (including meter transformer and surge absorber)

(c) Neutralization earthing: One (1) set

d. Step-up Transformer

(a) Rated Capacity: 5.5MVA, One (1) set

(b) Rated Voltage: 11 kV / 33kV

(c) Cooling Method: Air Cooled

(d) Connection: Primary side: Connection to generator with cable or non IPB

Secondary side: Connection to Switchyard equipment with underground cable

e. Switchyard

(a) Circuit: One (1)

(b) Rated Voltage: 33kV

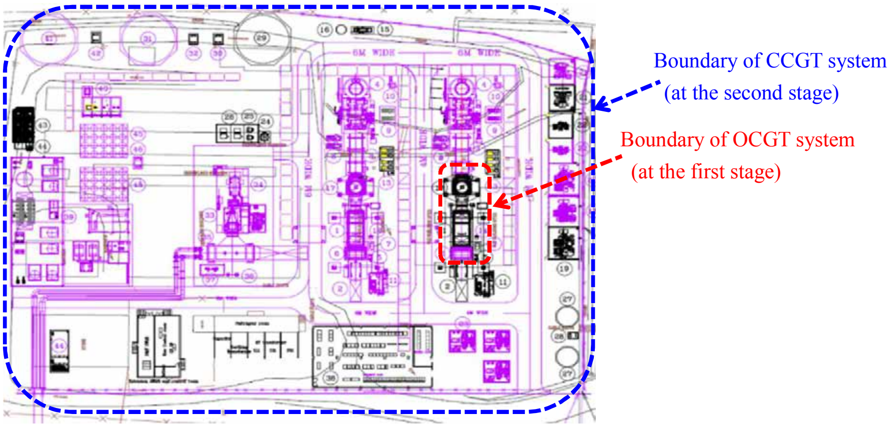
(c) Control & Protection Panel: One (1) set

2. Estimated construction cost

Item	Foreign currency	Local currency	Sum total
	millionUD$	millionUD$	millionUD$
Lot1: Emergency power plant construction	36.1	12.1	48.2
Consulting services	6.3	3.4	9.7
Price escalation	3.3	5.8	9.1
Physical contingency	2.3	1.1	3.4
Total	48.0	22.4	70.4

Constructon cost for one OCGT at the first stage

3. Site Layout



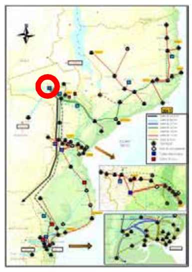
Source: JICA study report "Nacala Corridor Transmission & Distribution Network Reinforcement Project"

Figure 5.5-1 Outline of Nacala emergency generation

5.6 Power Generation Data Sheet

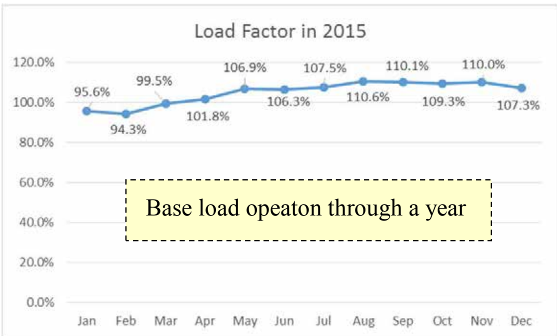
5.6.1 Power Generation Data Sheet (Existing Units)

No	Descriptions
1	**Cahora Bassa / Cahora Bassa North (Hydro)**



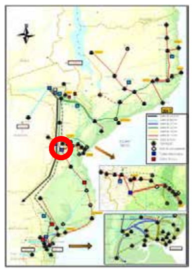
Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015
Cahora Bassa (HCB)	2,075MW (415MWx5u)	500MW	1975	Base Load	105%

<Key descriptions>
A generation that supports the provision of electricity in Mozambique as a main power supplier. It was developed by HCB and started operation in 1975. The ratio of power supply from Cahora Bassa hydropower generation is approx. 75% of electricity demand in Mozambique. There is an expansion plan to install another 3 units by utilizing same dam (as Cahora Bassa North/415MWx3u).



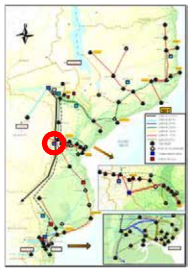
	Design Data	
1	Dam design	Concrete arch
2	Height of wall	163m
3	Width of wall	303m
4	Generating capacity	2,075MW,
5	Surface area	2,665km2
6	Live storage volume	51,704Mm3
7	Full supply level	326m
8	Power output per reservoir area	1.4MW/km2
9	Storage to flow volume ratio	0.69
10	No. of Turbines	5
11	Sluice gate	8 + crest gate
12	Maximum discharge capacity	16,260m3/s

No	Descriptions
2	Mavuzi (Hydro)



Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015
Mavusi (EDM)	57MW (6MWx2u) (15MWx3u)	57MW	1955-1957	Base Load	4.6%

No	Descriptions
3	Chicamba (Hydro)



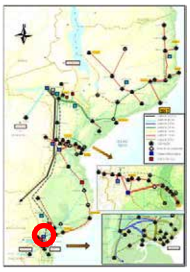
Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015
Chicamba (EDM)	44MW (22MWx2u)	44MW	1968-1969	Peak	14%

No	Descriptions

4 Corumana (Hydro)

Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015
Corumana (EDM)	16.6MW (8.3MWx2u)	8MW	1984	Base Load	34.1%

5 CTM GT (Thermal)

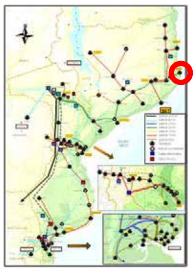


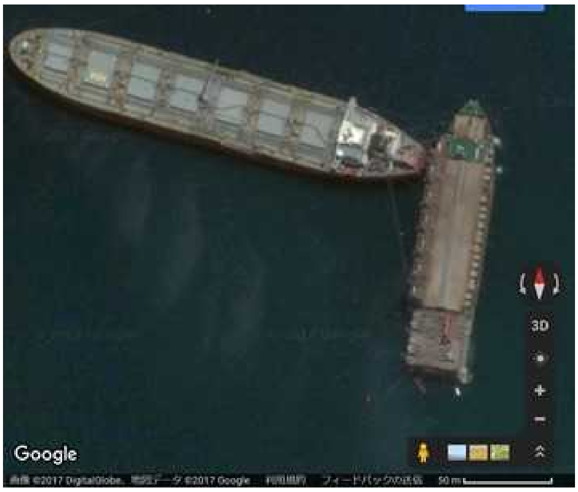
Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015
CTM GT (EDM)	24MW	18MW	1991	Peak	-

No	Descriptions

6 Nacala Barcassa (Thermal)

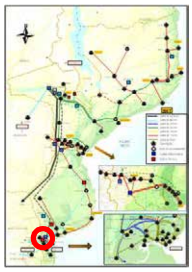
Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015
Nacala Barcassa -IPP (Karpower)	102.5MW (17.09MWx6u)	40MW	2016	Base Load	-

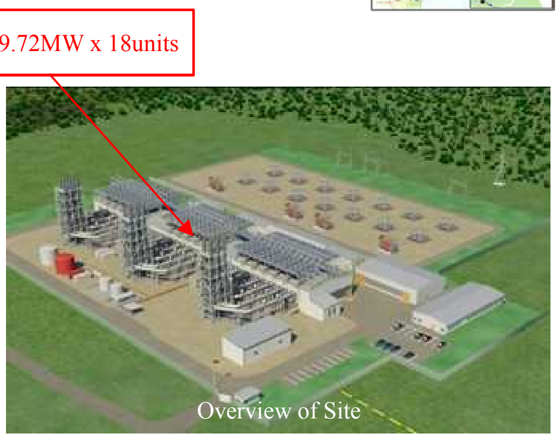




7 CTRG (Thermal)

Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015
CTRG -PPP (EDM/Sasol)	175MW (9.72MWx18u)	150MW	2014	Base Load	85.1%

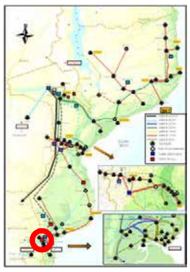




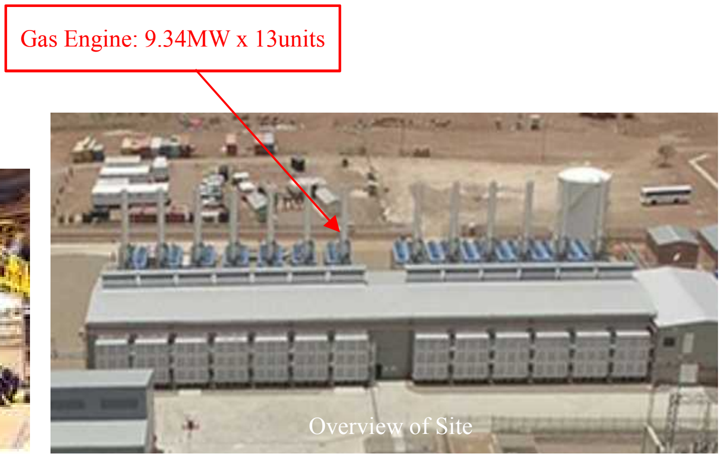
Source: CTRG HP

No	Descriptions

8 Gigawatt (Thermal)

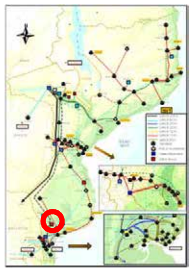


Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Load Factor in 2015
Gigawatt-IPP (Gigawatt)	121MW (9.34x13u)	120MW	2016	Base Load	



Source: Gigawatt HP

9 Kuvaninga (Thermal)



Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
Kuvaninga-(IPP)	40MW (4MWx10u)	40MW	2017	Base Load	Under Construction

Source: Kuvaninga HP

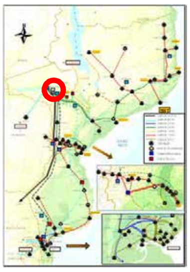
Source: JICA Study Team

Figure 5.6-1 Power generation data sheet (Existing units)

5.6.2 Power Generation Data Sheet (Development Plan)

No	Descriptions
1	**Mphanda Nkuwa (Hydro)**

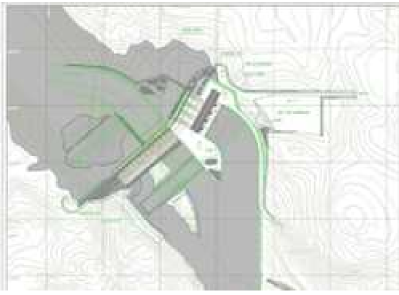
Plant Name	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
Mphanda Nkuwa-(PPP)	1,500MW	2024	Base Load	Feasibility Study



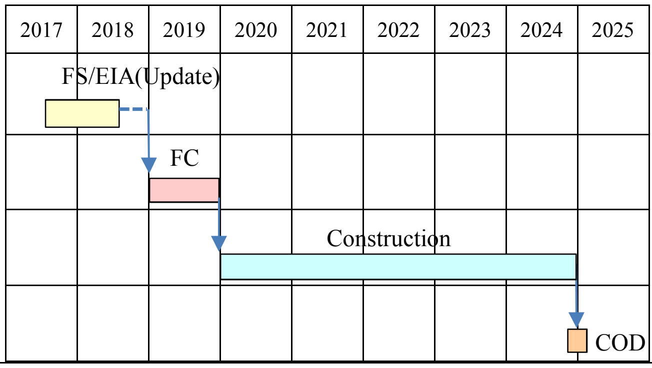
<Key Descriptions>

It is a large-scale hydropower project under Zambezi river has an abundant water quantity and is being pushed forward as an important power generation to support future demand increase. A target of starting operation is 2024. It was developed as the IPP project at the beginning stage, but currently it is being developed by EDM and HCB as the PPP project.

	UTIP	Projeto Revisado
Potência instalada	1.300 MW (4x325)	1.500 MW (4x375)
N.A. Máx.	207,00 m	207,00 m
Crista	211,00 m	211,00 m
Altura Máxima sobre a Fundação	86,00 m	86,00 m
Volume de Concreto Rolado	1.061.000 m³	763.000 m³
Volume de Concreto Convencional	925.000 m³	611.000 m³
Volume de Escavação em Solo	1.011.000 m³	1.463.000 m³
Volume de Escavação em Rocha	4.615.000 m³	6.609.000 m³
nº de Vertedouros	13 vãos (14,90x19,50 m)	13 vãos (14,90x19,50 m)
nº de Adufas	6 adufas (10,00x4,50 m)	10 adufas (12,00x5,95 m)
Vazão Máxima – Decamilenar	33.000 m³/s	33.000 m³/s
Volume do Reservatório	2.510 x 10⁶ m³	2.510 x 10⁶ m³
Superficie do Reservatório	96,50 Km²	96,50 Km²



Source: Feasibility Study Report (2003)



Expected Development Schedule

No	Descriptions

The result of interview at Mphanda Nkuwa Project Office

(Date: April 21,2017 / June 15, 2017)

Development Schedule (plan)

-Nov. 2017 - Dec. 2018 : FS/EIA update

-Sep. 2019 : Financial close (FC)

-Oct. 2019 - Oct. 2024 : Construction

-Oct. 2024 : COD

Project Cost (estimation)

-Total construction cost : approx. 2,200MUSD （based on FS result in 2010）

Project Structure (plan)

-EDM, HCB, 3rd Party (PPP-scheme）

Financing (plan)

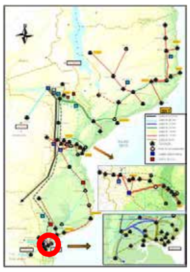
-WB, AfDB, IFC, others

Off Taker (plan)

-EDM, Export

2 CTM CCGT (Thermal)

Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
CTM CCGT	110MW	110MW	2018	Base Load	Under Construction



Plant configuration :2GTG +1STG

No	Descriptions
3	Tete 1200 (Thermal)

Plant Name	Installed Capacity (MW)	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
Tete 1200-(PPP)	1,200MW	1,200MW (300MWx4u)	2023	Base Load	Pre-Feasibility Study

Source: Pre-feasibility Study Report (2016)

The result of interview at Tete 1200 Project Office
(Date: April 21,2017 / June 20, 2017)

<u>Development Schedule (plan)</u>
- -Jun. 2016 : Pre-FS completion
- - Oct. 2017 - May 2018 : FS
- -Jan. 2019 - Sep. 2019 : EIA/FC
- -Sep. 2019 - Jun. 2025 : Construction (300MW/unit, multiple units configuration)
- -2023 – 2025 : COD (start opetation sequentially)

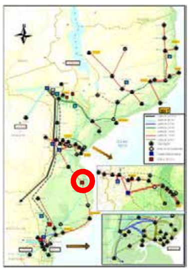
<u>Project Cost (estimation)</u>
- -Total construction cost : approx. 1,800MUSD

<u>Project Structure (plan)</u>
- -EDM, ZESCO, 3rd Party (PPP-scheme)

<u>Financing (plan)</u>
- -WB, AfDB, others

<u>Off Taker (plan)</u>
- -EDM(50%), Export(50%)

No	Descriptions
4	**Temane 400MW MGTP (Thermal)**



Plant Name	Supply Power to EDM Grid (MW)	Operation Start (COD)	Operation Type	Project Status
Temane MGTP-(PPP)	400MW	2022	Base Load	Feasibility Study

The result of interview at Temane 400MW Project Office
(Date: June 21, 2017)

Development Schedule (plan)
- -Sep. 2017 : FS completion
- -Oct. 2017 - Jun. 2018 : EIA
- -Oct. 2019 - Mar. 2022 : Construction (80~200MW/unit, multiple units configuration)
- -Oct. 2021 - Mar. 2022 : COD (start operation sequentially)

Project Cost (estimation)
- -Total construction cost : approx. 600MUSD

Project Structure (plan)
- -EDM(51%), Sasol(49%) (PPP-scheme)

Financing (plan)
- -WB, AfDB, others

Off Taker (plan)
- -EDM(50%), Export(50%)

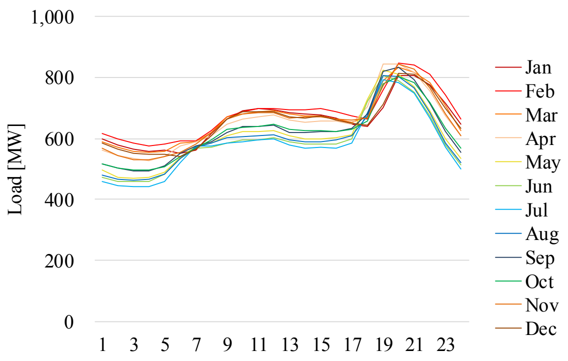
Source: JICA Study Team

Figure 5.6-2 Power generation data sheet (Development plan)

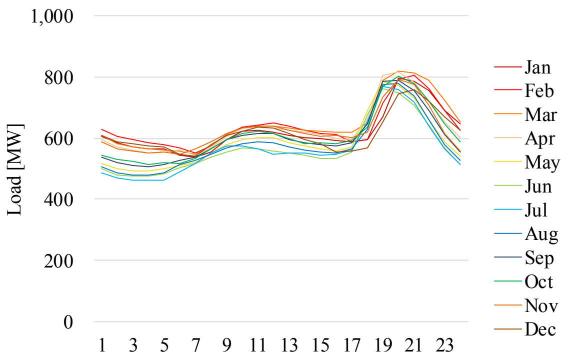
5.7 Characteristics of Load in Mozambique

For the generation development planning, it is necessary to understand characteristics of load such as dairy load curve and load duration curve in the country. These characteristics are also needed to study an introduction of solar power and wind power into the power system.

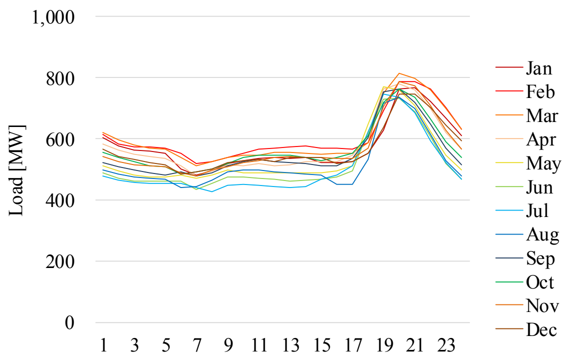
Figure 5.7-1 shows typical daily load curve in Mozambique in 2016 (weekday, Saturday and Sunday). Not only an outline of the curve but also a value of peak demand occurred in the evening for lighting are nearly the same through the year. It is cleared that dairy load in rainy season is larger than that of dry season. And it is also cleared that daytime load in weekday is the largest and that in Sunday is the smallest through the year.



(a) Weekday



(b) Saturday

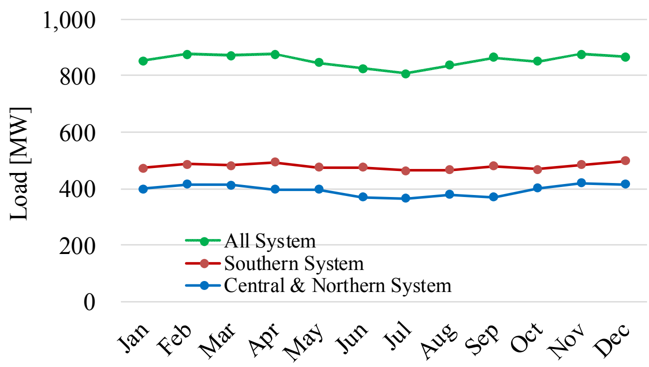


(c) Sunday

Source: JICA Study Team

Figure 5.7-1 Typical dairy load curve in 2016

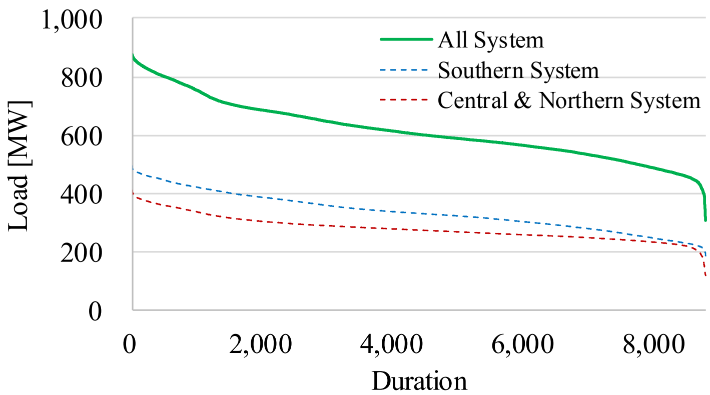
Figure 5.7-2 shows monthly peak load in 2016. About 850MW of the load is recorded through the year, however there is a tendency that the load in rainy season is higher than that in dry season.



Source: JICA Study Team

Figure 5.7-2 Monthly peak load in 2016

Figure 5.7-3 shows load duration curve (LDC) in 2016. It is cleared that at least 400MW of continuous output will be needed to supply the base demand in Mozambique.



Source: JICA Study Team

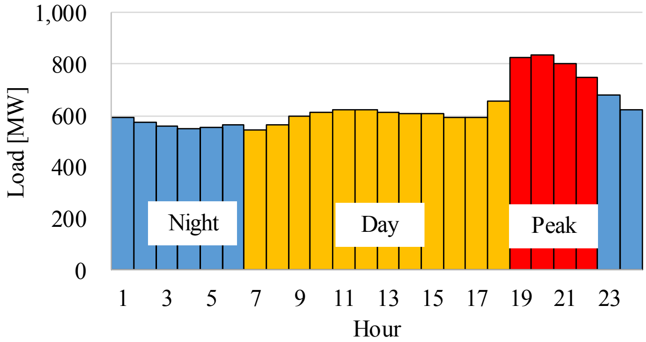
Figure 5.7-3 Load duration curve in 2016

Figure 5.7-4 shows load distribution on LDC by time zone in 2016. In the study, accurate simulation characteristics for the demand occurrence shown in the above figures was examined by using actual demand in 2016. In the examination, the demand was categorized by occurrence hour and the distribution of demand by each of the time zones shown below was checked.

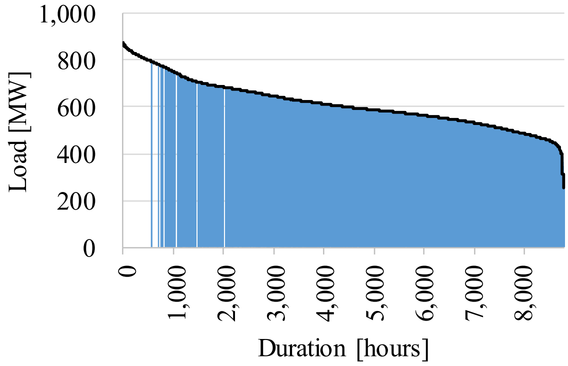
1) Midnight-time 10 pm - 6 am
2) Daytime 6 am - 6 pm
3) Peak-time 6 pm - 10 pm

The demand for each time zone is clearly distributed on the load duration curve especially in winter season. This means that the actual demand that occurred chronologically is faithfully simulated on the load duration curve.

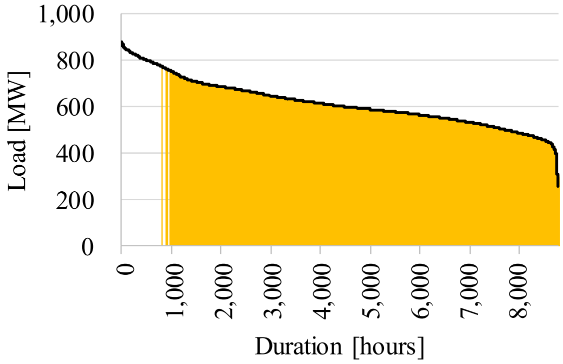
Consequently, simulation will be able to consider the actual pattern of demand occurrence with sufficient accuracy.



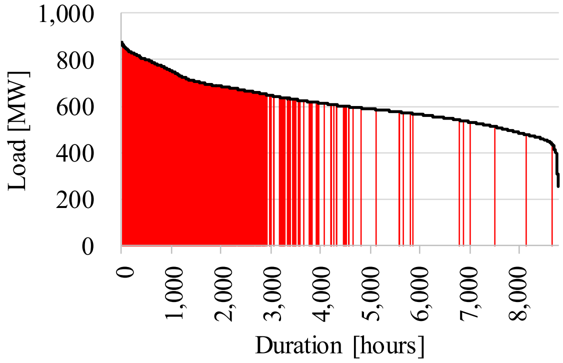
(a) Time zone model



(b) Midnight time



(c) Day time



(d) Peak time

Source: JICA Study Team

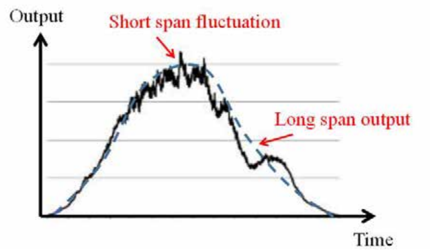
Figure 5.7-4 Load distribution on LDC by time zone in 2016

5.8 Introduction of Solar Power and Wind Power

Study for the introduction of solar power and wind power is necessary because these power sources will be introduced in the future in Mozambique. In a real situation, Mozambique has some projects to develop total 80MW of solar power and 30MW of wind power into the on-grid system. However, output of renewable energy is dependent on weather condition which changes from moment to moment, so it is difficult to forecast its output exactly and of course cannot adjust its output like a thermal power unit.

It is ideal to maintain system frequency and voltage constantly to supply electric power to customer stably. However, it entails risk to fluctuate system frequency and voltage due to an unstable output of solar power and wind power in case these units are connected with large capacity into the system, and it is needed to keep operating reserve to compensate the fluctuation of their outputs.

In this section, introduction of solar power and wind power will be studied taking into consideration long span output and short span fluctuation, and also studied calculation for necessary amount of operating reserve in the point of electrical system characteristics in Mozambique.

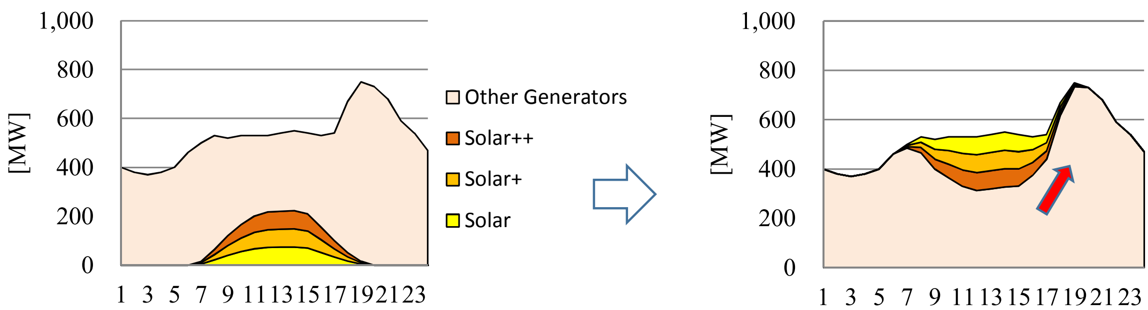


Source: JICA Study Team

Figure 5.8-1 Example of solar power output

5.8.1 Long span output of solar power and wind power

Study for the introduction of solar power and wind power in the point of long span output is necessary to make daily operation plan of other generators. In addition, solar power has a typical output curve which is related with the movement of the sun. Therefore, the larger capacity of solar power is introduced, the more significantly daily supply-demand balance operation is affected. Especially in Mozambique, the load in evening time increases by lighting against the decrease of solar power output. Therefore, too much instruction of solar power will lead the difficulty of operation by other generators and also lead uneconomical operation.

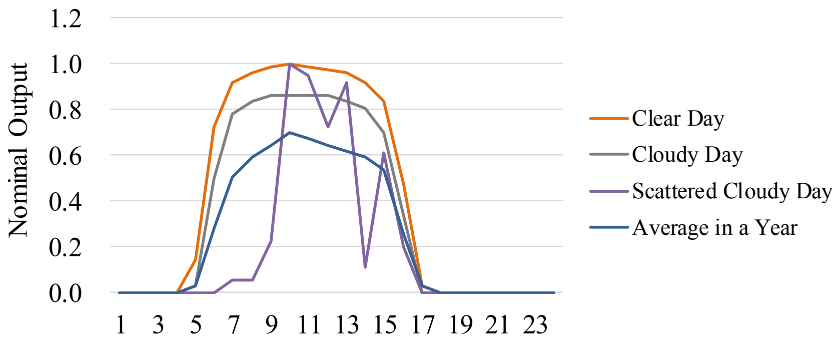


Source: JICA Study Team

Figure 5.8-2 Operation of generators with solar power output

(1) Output model of solar power

Figure 5.8-3 shows output model of solar power in Mozambique. This model is used Mocuba project data. It can be assumed that typical output curve is recorded not only clear day but also normal cloudy day. However, this figure also show that its output has possibility to change suddenly in a short time, and average of all output curve in a year corresponds to about 70% of the output curve in clear day.

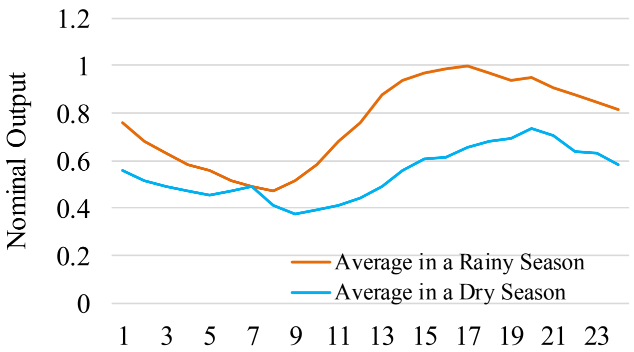


Source: JICA Study Team

Figure 5.8-3 Output model of solar power

(2) Output model of wind power

Figure 5.8-4 shows output model of wind power in Mozambique. This model is used Tofo project data. Output in rainy season is larger than that of dry season, and output in early morning is the smallest in a day in both seasons.

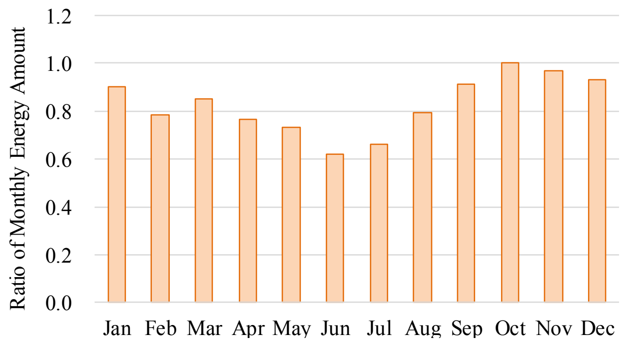


Source: JICA Study Team

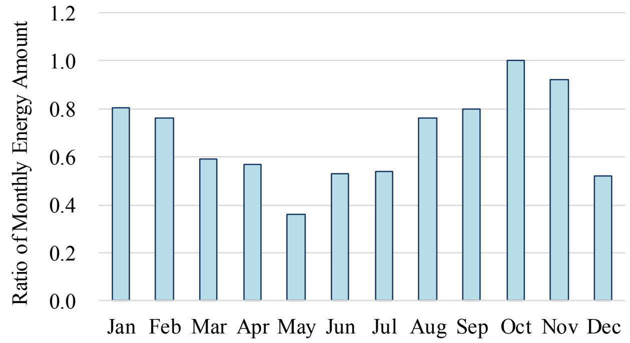
Figure 5.8-4 Output model of wind power

(3) Monthly energy amount

Figure 5.8-5 shows ratio of monthly energy amount of solar power and wind power. Energy amount in rainy season is larger than that of dry season. Especially, energy amount in October is the largest through a year.



(a) Solar power



(b) Wind power

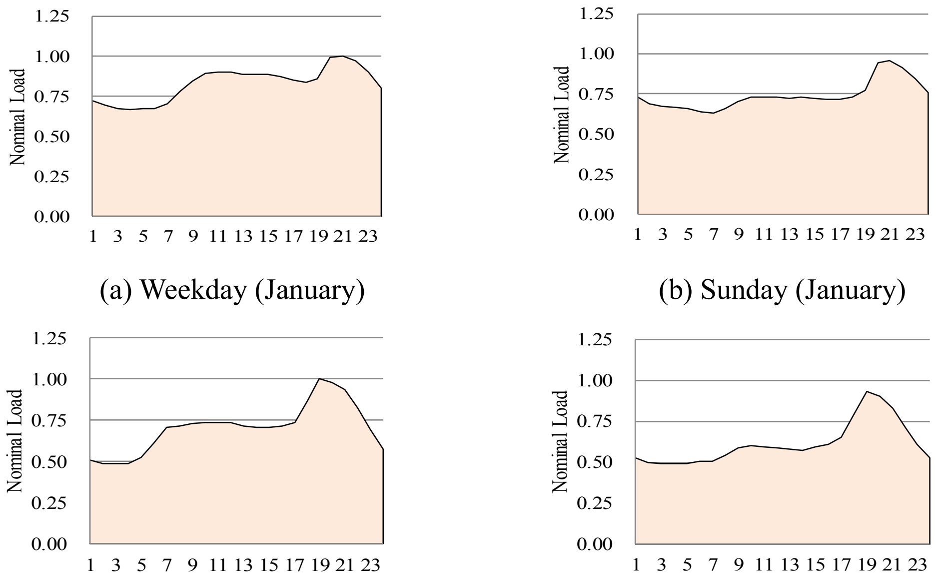
Source: JICA Study Team

Figure 5.8-5 Ratio of monthly energy amount of solar power and wind power

(4) Dairy load curve model

To evaluate an effect of solar power and wind power output, JICA Study Team made dairy load curve model using 2016 record described in section 5.4. As an example, Figure 5.8-6 shows dairy load curve model of weekday and Sunday in January as rainy season and July as dry season in southern system.

Dairy load curve in the future is assumed to have the same characteristics as that of 2016 taking into consideration present characteristics of neighboring countries as typified by South Africa.



(a) Weekday (January) (b) Sunday (January)

(c) Weekday (July) (d) Sunday (July)

Source: JICA Study Team

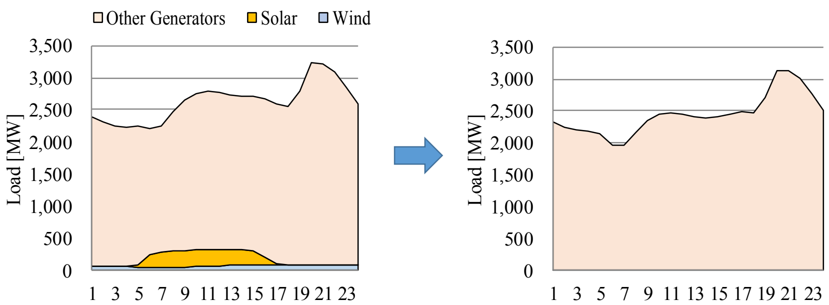
Figure 5.8-6 Dairy load curve model

(5) Evaluation of generator operation with solar power and wind power output

Using data described above, generator operation is evaluated in rainy season and dry season of following situation;

a. 2019 in Central & Northern System; Total 80MW of solar power is planned to be developed
b. 2023 in Southern System; 30MW of wind power is planned to be developed
c. 2030 and 2040 in Integrated System; large scale of solar power and wind power are assumed to be developed

In the concrete, JICA Study Team simulated daily load which is necessary to be supplied by other generators by deducting solar and wind output from dairy load curve model as Figure 5.8-7. Installed capacity of solar power and wind power until 2023 is used each project data. Installed capacity of those after 2024 is assumed to be developed 10% of peak demand and the ratio of solar power to wind power is set as 3 to 1 taking into consideration primary energy potential and investment situation of solar power.



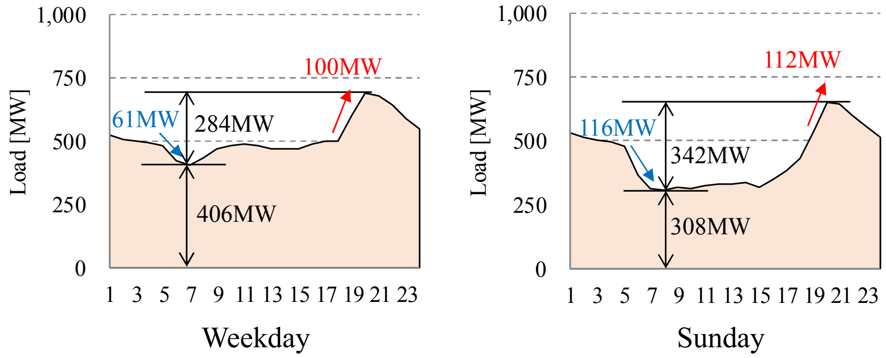
Source: JICA Study Team

Figure 5.8-7 Simulation model for the evaluation of dairy output curve

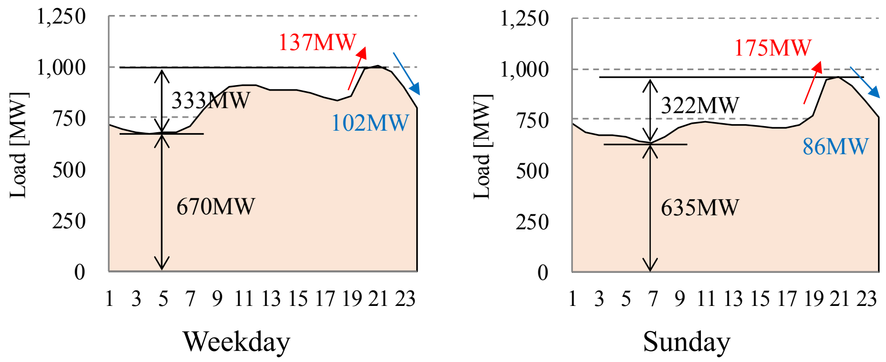
Figure 5.8-8 shows dairy load curve of weekday and Sunday on January deducted solar and wind power output in Central & Northern System in 2019 and Southern System in 2023. Red arrow in these figures shows the highest necessary amount of increase by one hour with other generator in a day and blue arrow shows the highest necessary amount of decrease. Lower number with black color is the lowest output by other generators and upper number is the difference between highest output and lowest output in a day.

From figure (a), it can be seen that solar power output will contribute the decrease of total output of other generators in daytime. However, solar power output will increase the difference between highest output and lowest output especially on Sunday.

As peak demand will occur at evening time, output of solar power will not affect the amount of short-time adjustment for lighting demand.



(a) Central & Northern System in 2019 (70MW of solar power is assumed to be developed)



(b) Southern System in 2023 (30MW of wind power is assumed to be developed)

Source: JICA Study Team

Figure 5.8-8 Simulation model for the evaluation of dairy output curve

Based on the above-mentioned characteristics, JICA study team simulated dairy load curve of weekday and Sunday on July in Central & Northern System in 2019 and Southern System in 2023, and also simulated in Integrated System in 2030 and 2040 by deducting the renewable energy output in the same way.

Table 5.8-1Table 5.8-1 shows the results of the simulation. It can be seen that the output of solar power will not affect the highest necessary amount of increase and decrease by one hour with other generators. It can be also seen that the highest output by other generators will be needed in evening time and the lowest output will be needed on early morning or midnight time in almost all cases. However, simulation resulted noontime is the lowest output by other generators on Sunday July, 2019. And it is presumed that solar power output will affect the result. This result implies that an introduction of large scale of solar power would need the large amount of margin to adjustment the difference especially in holiday.

Table 5.8-1 Characteristics of output curve by generators except the output of solar and wind power

(a) 2019, Central & Northen System

		Maximum		Minimum		Difference	Up		Down	
		Capacity (MW)	Time (hour)	Capacity (MW)	Time (hour)	(MW)	Capacity (MW)	Time (hour)	Capacity (MW)	Time (hour)
January	Weekday	689	20	406	7	284	100	18-19	-61	5-6
July		675	20	420	6	255	99	18-19	-68	22-23
January	Sunday	650	20	308	8	342	112	19-20	-116	5-6
July		649	20	284	12	366	123	18-19	-77	21-22

(b) 2023, Southern System

		Maximum		Minimum		Difference	Up		Down	
		Capacity (MW)	Time (hour)	Capacity (MW)	Time (hour)	(MW)	Capacity (MW)	Time (hour)	Capacity (MW)	Time (hour)
January	Weekday	1,004	21	670	4	333	137	19-20	-102	23-24
July		983	19	471	3	513	136	17-18	-133	22-23
January	Sunday	957	21	635	7	322	175	19-20	-86	23-24
July		914	19	476	4	438	143	17-18	-116	21-22

(c) 2030, Integrated System

		Maximum		Minimum		Difference	Up		Down	
		Capacity (MW)	Time (hour)	Capacity (MW)	Time (hour)	(MW)	Capacity (MW)	Time (hour)	Capacity (MW)	Time (hour)
January	Weekday	3,138	20	1,961	7	1,177	424	19-20	-264	23-24
July		3,081	19	1,702	4	1,379	427	18-19	-373	22-23
January	Sunday	2,984	21	1,636	7	1,348	539	19-20	-342	5-6
July		2,896	19	1,402	8	1,494	501	18-19	-359	21-22

(d) 2040, Integrated System

		Maximum		Minimum		Difference	Up		Down	
		Capacity (MW)	Time (hour)	Capacity (MW)	Time (hour)	(MW)	Capacity (MW)	Time (hour)	Capacity (MW)	Time (hour)
January	Weekday	5,500	20	3,437	7	2,063	744	19-20	-463	23-24
July		5,399	19	2,983	4	2,416	747	18-19	-654	22-23
January	Sunday	5,228	21	2,866	7	2,362	944	19-20	-600	5-6
July		5,075	19	2,458	8	2,618	878	18-19	-630	21-22

Source: JICA Study Team

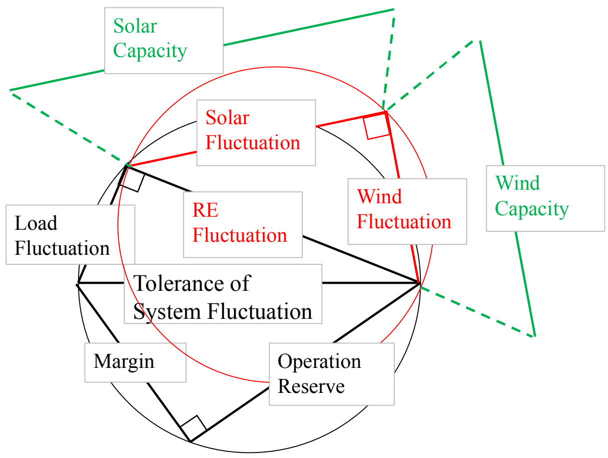
5.8.2 Short span fluctuation of solar power and wind power

Output of solar power and wind power fluctuates in short span in line with the temporary change of weather condition such as a moving of cloud and a change of wind direction. If development site of each unit is concentrated in an area, it is supposed to change its output at the same time. It means that large fluctuation of its output causes the large fluctuation of system frequency. Therefore, it is necessary to keep operating reserve to compensate the fluctuation every time.

(1) Evaluation method

Algebraic method which is shown in Figure 5.8-9 is used in this study to evaluate the characteristic of short span fluctuation of solar and wind power. This is simplified method the relationship between the system fluctuation by demand and the output of solar & wind power and the absorption of its fluctuation, and this method is generally used in Japan.

Using this method, evaluation of short span fluctuation in every 15 minutes is conducted and finally calculated amount of operating reserve to compensate the fluctuation of solar and wind power. Installed capacity of solar and wind power until 2023 is assumed to be developed existing projects such as Mocuba solar power and Tofo wind power. Installed capacity of solar and wind power after 2024 is assumed to be developed 10% of peak demand and the ratio of wind to solar is set as 1 to 3.



Source: JICA Study Team

Figure 5.8-9 Algebraic method

(2) Simulation result

Table 5.8-2 shows the simulation result. Operating reserve will be needed about 93MW in 2023 and needed 309MW in 2042. This result means that it has possibility to change 309MW of system fluctuation within 15 minutes, and also means that it will be needed to keep thermal or hydropower unit stand-by operation or install battery into the system.

Table 5.8-2 Simulation result to calculate operating reserve

	Domestic Peak Demand	Solar Capacity (cumulative)	Wind Capacity (cumulative)	Operating Reserve
	MW	MW	MW	MW
2018	1,311	40	0	57
2019	1,514	80	0	67
2020	1,638	80	0	72
2021	1,800	80	0	79
2022	1,968	80	0	86
2023	2,138	80	30	93
2024	2,314	110	30	101
2025	2,495	140	30	110
2026	2,681	170	30	120
2027	2,875	170	60	128
2028	3,076	200	60	138
2029	3,284	230	60	148
2030	3,500	260	60	159
2031	3,724	260	90	168
2032	3,955	290	90	179
2033	4,194	320	90	191
2034	4,441	350	90	203
2035	4,697	350	120	213
2036	4,962	380	120	226
2037	5,238	410	120	239
2038	5,525	440	120	252
2039	5,823	440	150	264
2040	6,133	470	150	279
2041	6,443	500	150	293
2042	6,772	530	150	309

Source: JICA Study Team

(3) Operating reserve

Installation of new generator only for compensating the fluctuation of solar and wind power will be no need. Operating reserve can be provided by hydropower with high ramp rate of its output. The reasons are shown as follows;

- In this study, solar power is assumed to be installed than wind power, therefore operating reserve will be needed mainly daytime.
- Reserve margin in daytime will be enough because peak demand in a day will occur after evening time.
- Output of solar power after evening time is almost zero.
- Mozambique has a rich potential to develop hydropower.

Total development and operation cost of battery from 2018 to 2042 is estimated 173 million USD (2017 value) in case all fluctuation in the system is compensated by battery. In this calculation, battery is chosen Lithium-ion rechargeable battery which is expected to be major battery in future to absorb short span fluctuation of solar and wind power, and estimated as present value of 700 USD/kW as assumption. However, future cost of battery system is not clear because the development of battery system is not matured. Therefore, battery cost in future is assumed to be the same as present value in this calculation.

In the generation development planning of this study, operating reserve is assumed to be provided by hydropower.

(4) Further study

In this study, fluctuation of solar and wind power is calculated using output model such as Figure 5.8-3 and Figure 5.8-4. To simulate the fluctuation more strictly, it is preferable to collect chronological record of solar radiation and wind speed at the development site. It is also needed to evaluate actual performance of solar and wind power after the development.

In this study, operating reserve was calculated under the assumption that output of all solar (or all wind) power fluctuate at the same time. Actually, chronological output of solar (wind) power will be different in each development site. Therefore, it will be needed to collect and evaluate environmental record in each site.

It is difficult to forecast the output of solar and wind power in daily power system operation. Therefore, it is possible that system operator cannot control system frequency due to suddenly and large fluctuation of solar and wind power output even if there is enough operating reserve by other generators. In that case, it is preferable to install battery which can compensate the fluctuation automatically into the power system.

5.9 Simulation for Generation Development Plan

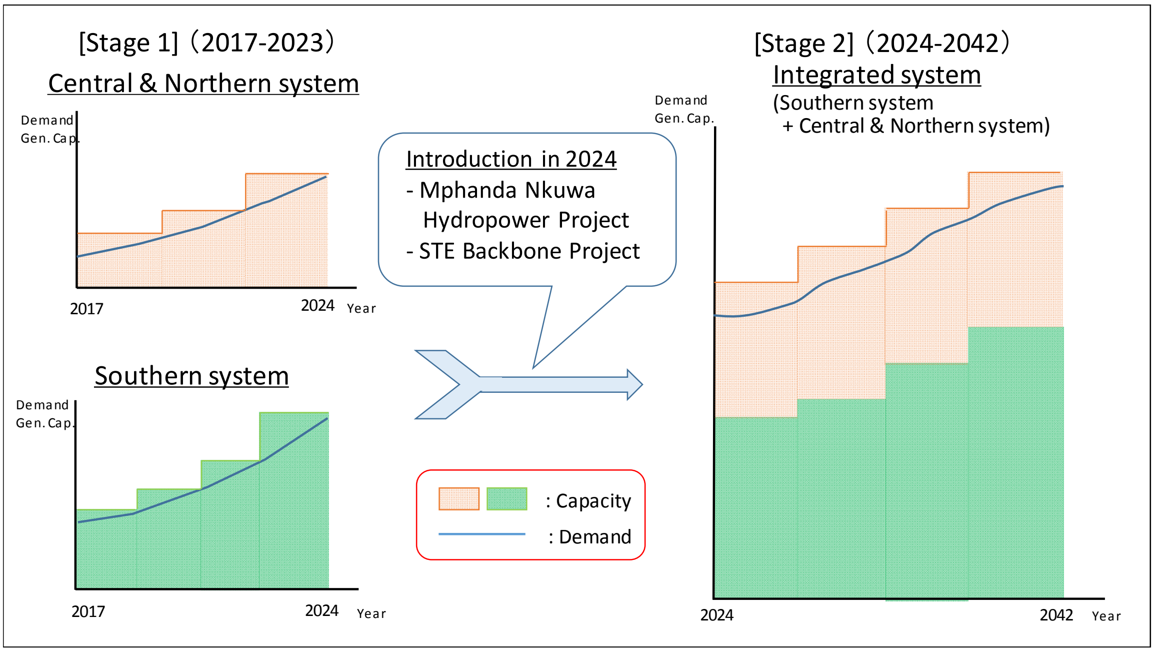
5.9.1 Development Policy

(1) Development stage

Power system in Mozambique in 2017 is divided into two systems, and generation development plan near the future should be studied in each system. However, STE Back Bone project and Mphanda Nkuwa hydropower project described in section 5.3 are planned to be operated at the same year, and after the operation of each project, divided 2 systems will be integrated.

Therefore, in this study, generation development plan will be made in 2 stages which is shown in Figure 5.9-1;

1) Two systems of Southern and Central & Northern systems
2) One integrated system



Source: JICA Study Team

Figure 5.9-1 Development stage

(2) Development scenario

Development scenario was made for mainly two concepts, one is to meet the domestic demand which is named as a "base scenario" and the other is to supply domestic and also regional countries which is named as a "export scenario". Furthermore, Mozambique has much primary energy and has a potential to supply electric power to regional countries. In the study, generation development plan was made including various generation sources, such as hydropower, thermal, solar and wind.

Preconditions for generation development plan are as follows; 1) the amount of maximum demand is set three cases, domestic oriented, export oriented with 20% and 40% of domestic peak demand. 2)the capacity of solar and wind power is set two cases, 10% and 20% of domestic peak demand respectively. Therefore, generation development scenario in the study set 6 scenarios which is shown in Table 5.9-1.

Table 5.9-1 Generation development scenario

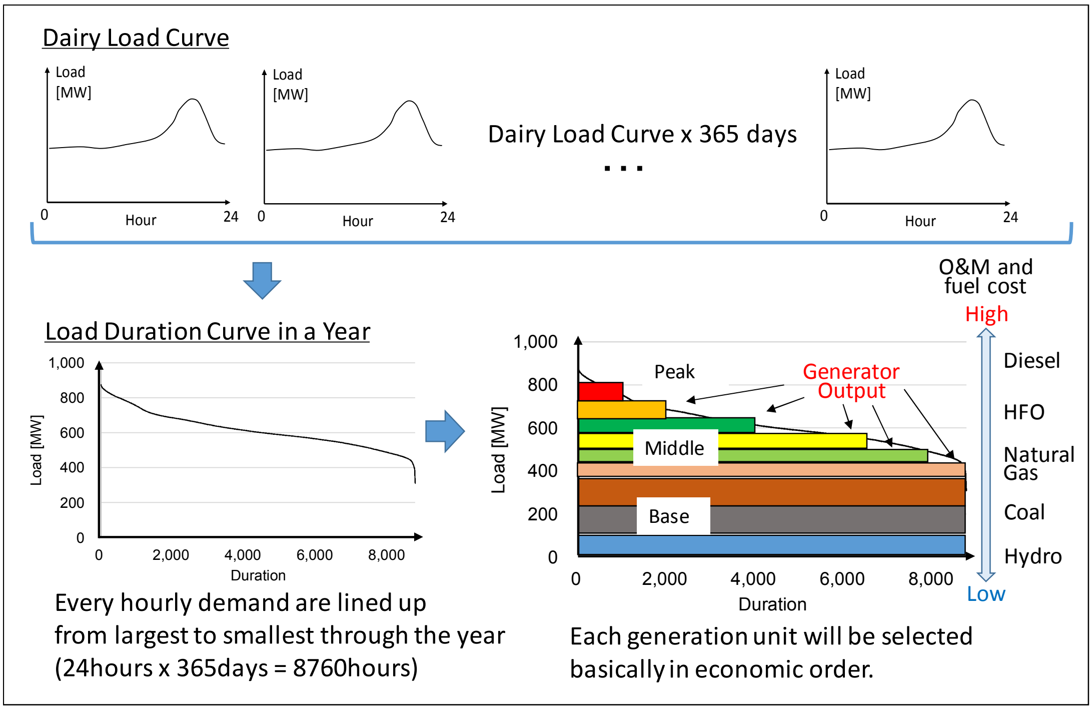
Scenario	Case	
	Domestic / Export	Solar and Wind power
Base Scenario 1-1	Domestic oriented	10% of domestic peak demand
Base Scenario 1-2		20% of domestic peal demand
Export Scenario 1-1	Export Oriented; 20% of domestic peak demand	10% of domestic peak demand
Export Scenario 1-2		20% of domestic peal demand
Export Scenario 2-1	Export Oriented; 40% of domestic peak demand	10% of domestic peak demand
Export Scenario 2-2		20% of domestic peal demand

(3) Simulation methodology

As described in section 5.1, least cost method will be used in this generation development plan.

Least cost method is to minimize total generation cost by selecting generators for the demand in the economic order. Usually, fuel cost covers main component of operation cost and hydropower unit and coal fired unit is selected as a base load. LDC is used as a total load in each year, and optimal generation development plan from 2018 to 2042 will be simulated with the method considering an introduction of each generator project and a retirement of existing generator planned by counterparts.

However, least cost method cannot simulate the output of solar power and wind power because these outputs depend on weather condition. In other words, least cost method can simulate generator whose output can be hold constant. Therefore, output of solar power and wind power should be simulated without the least cost method (The details are to be described later).



Source: JICA Study Team

Figure 5.9-2 Image of the least cost method

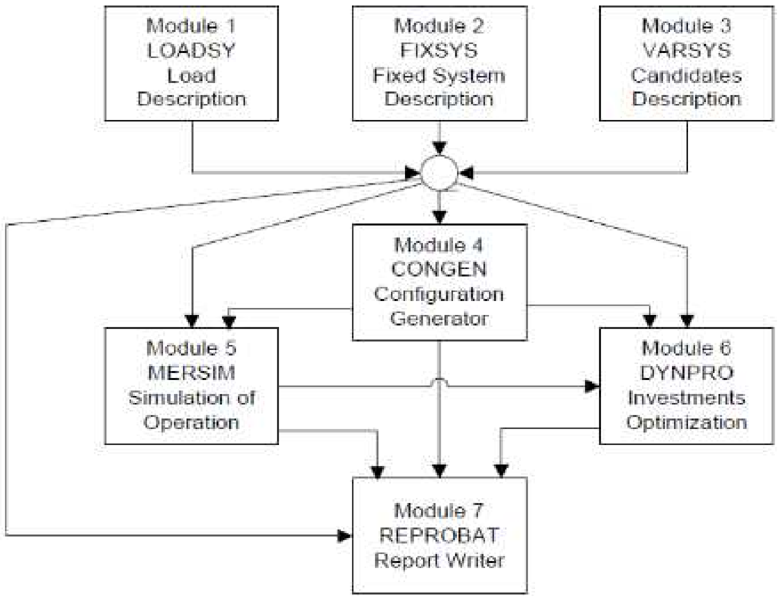
5.9.2 WASP simulation with the least cost method

To formulate optimal generation development plan with the least cost method, WASP-IV simulation tool was used in the study. In this section, the procedure of simulation using WASP-IV and the features of this kind of simulation are described.

(1) Outline

WASP-IV consists of seven (7) modules to simulate generation expansion with minimum cost through the setting period. Figure 5.9-3 shows the flowchart of WASP-IV simulation.

WASP-IV can simulate to set threshold of the amount of fuel supply and pollutant emission like CO_2 and NO_x. And more, it can simulate the characteristic of renewable unit and also easily simulate accommodation of electric power with another country by setting as thermal unit.



Source: Energy Institute "Hrvoje Požar"

Figure 5.9-3 Flowchart of WASP-IV simulation

(2) Objective function

Simulations using WASP-IV seek to minimize costs as the expense of reliability. An objective function for that purpose is configured. The costs that make up the objective function include capital costs, fuel costs and O&M costs. In addition to these, the cost corresponding to energy that is not supplied (unserved energy cost) is also taken into consideration. The write-off of capital costs is taken into account by including the salvage value according to the remaining depreciation period as part of the objective function.

$$B_j = \sum_{t=1}^{T} (I_{j,t} - S_{j,t} + F_{j,t} + L_{j,t} + M_{j,t} + O_{j,t})$$

t = time, t = 1,..., T
$I_{j,t}$ = Capital costs
$S_{j,t}$ = Salvage value
$F_{j,t}$ = Fuel costs
$L_{j,t}$ = Fuel inventory costs
$M_{j,t}$ = O&M costs
$O_{j,t}$ = Unserved energy costs

(3) Power demand

In the internal workings of WASP-IV, power demand is not a load curve arranged as a time series. Rather, it is expressed as a load duration curve. This load duration curve, together with the envisioned demand, yields the maximum annual demand. The use of this quantity expresses the load characteristic within WASP-IV. In order to simulate the detailed load characteristic, the year is divided into a maximum of 12 periods, each of which can be given a load duration curve and maximum demand.

(4) Generator operating characteristics

WASP-IV can deal with a number of different types of power plants, including hydropower, thermal power and nuclear power. The operating characteristics of thermal power plant can be modeled for each generator unit by taking into account cost characteristics such as heat rate, the heating value and the O&M costs (fixed costs and variable costs), as well as anticipated parameters such as forced outage rate, spinning reserve and the maintenance days.

Meanwhile, it is possible to model the stochastic generation characteristic of a hydropower plants by taking into account the seasonal fluctuation in water flow, the average generation capacity and the available generation energy. These data can also be configured to model the operating patterns of different types of generator, such as the run-off river type and the reservoir type.

(5) Optimization calculations

The variable costs of an existing or candidate generator unit can be calculated using the above power demand characteristic and the operating characteristic of the generator unit. By operating generator with lower-cost first, the simulation can be made to approach actual operating conditions quite closely.

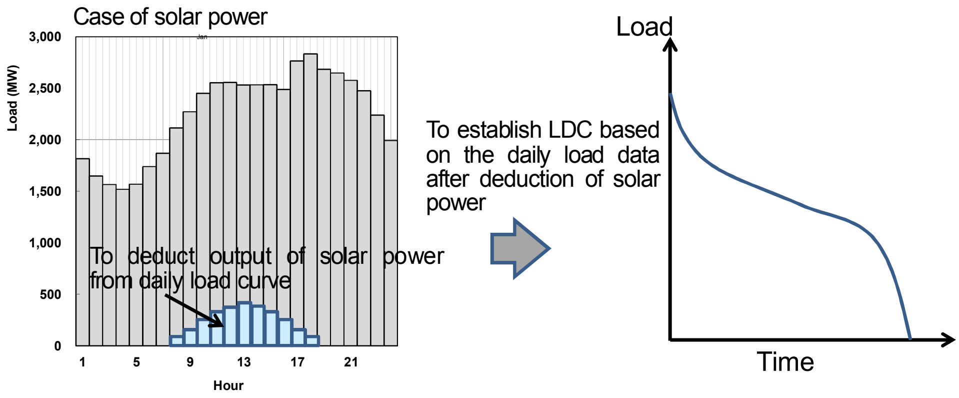
Furthermore, the capital cost of a new generator unit can be added in and the objective function described above can be minimized. This will automatically derive sequence of generation development, which shows the minimum cost during the study period.

(6) Simulation of solar power and wind power

As described above, least cost method simulates generator whose output can be kept stable. Therefore, supply amount of solar power and wind power should be deducted from LDC used in WASP simulation in advance.

In this study, dairy output of solar power and wind power are deducted from everyday dairy load curve before making LDC. Mocuba solar project data and Tofo wind project data described in section 5.5.1 are used as output curve model of each power. Future output curve models are considered installed capacity of solar power and wind power development plan.

Tariff system for solar and wind power more than 10MW class is not established in Mozambique as of November 2017. In the study, tariff of solar and wind power in the future is assumed 12 cent/kWh using that of Mocuba project.



Source: JICA Study Team

Figure 5.9-4 Image of modification of LDC

5.9.3 Specification data of power plants for WASP simulation

Table 5.9-3 and Table 5.9-4 show specification data of the existing power plants and candidate power plants in Mozambique for WASP-IV simulation, respectively. Minimum and maximum operation data shows sending-end output, and detailed specification data such as heat rate and O&M cost are used typical value widely used in this kind of simulation. Some projects in conceptual stage as of 2017 and whose operation year is assumed after 2024 are simulated typical generator model which is shown in Table 5.9-2.

Table 5.9-2 Typical generator model

Model	Capacity	Examples
CCGT	200MW	Buzi, etc. Shell is also included as 80MW model.
Coal fired	200MW	Moatize, Cuamba, etc.
Hydropower	50MW	Tsate(2025), Alto Molocue, Alto Malema, etc.
Hydropower	100MW	Lurio, Central Hidrica de Pavue, etc.

Source: JICA Study Team

Table 5.9-3 Setting data of existing power plants for WASP-IV simulation

System	Project Name	Generator Type	Number of Unit in 2017	Minimum Operation	Maximum Operation	Heat Rate at Minimum Operation	Average Incremental Heat Rate	Spinning Reserve	Forced Outage Rate	Scheduled Maintenance Days per Year	Maintenance Size	Fuel Cost in 2017	Fixed O&M cost	Variable O&M cost	Heat Value of the Fuel Used	Fuel Consumption (used in REMERSIM)
				(MW)	(MW)	(kJ/kWh)	(kJ/kWh)	(%)	(%)	(days)	(MW)	(cent / million kJ)	($/kW-month)	($/MWh)		
Southern	CTM (GT/CCGT)	OCGT/Exist	1	9	18	15,352	14,458	0	5.0	15	18	1,369	2.0	2.4	42,656 (kJ / kg)	420 (kilo-litle / GWh)
	Temane 1	Gas Engine/Exist	6	1	1	9,455	8,904	0	5.0	15	1	1,369	2.0	2.4	42,656 (kJ / kg)	259 (kilo-litle / GWh)
	Temane 2	Gas Engine/Exist	2	3	3	9,455	8,904	0	5.0	15	3	1,369	2.0	2.4	42,656 (kJ / kg)	259 (kilo-litle / GWh)
	Xai-Xai (Tavene) Back up emergency	Diesel Engine/Exist	1	3	3	9,455	8,904	0	5.0	15	3	1,369	2.0	3.0	42,656 (kJ / kg)	259 (kilo-litle / GWh)
	CTRG	Gas Engine/Exist	18	8	8	9,455	8,904	0	5.0	15	8	303	2.0	2.4	1,054 (kJ / scf)	8.71 (Mscf / GWh)
	Inhambane_Back up emergency	Diesel Engine/Exist	1	2	2	9,455	8,904	0	5.0	15	2	1,369	2.0	3.0	42,656 (kJ / kg)	259 (kilo-litle / GWh)
	Aggreko Phase 02 Ressano(Gas Engine Rental)	Gas Engine/Exist	1	27	90	9,455	8,904	5	5.0	15	90	303	2.0	2.4	1,054 (kJ / scf)	8.71 (Mscf / GWh)
	Agreeko Beluluane (Gas Engine Rental)	Gas Engine/Exist	1	12	40	9,455	8,904	5	5.0	15	40	303	2.0	2.4	1,054 (kJ / scf)	8.71 (Mscf / GWh)
	Gigawatt	Gas Engine/Exist	13	9	9	9,455	8,904	0	5.0	15	9	303	2.0	2.4	1,054 (kJ / scf)	8.71 (Mscf / GWh)
	Kuvaninga	Gas Engine/Exist	10	4	4	9,455	8,904	0	5.0	15	4	303	2.0	2.4	1,054 (kJ / scf)	8.71 (Mscf / GWh)
Central & Northern	Beira GT35	OCGT/Exist	1	12	12	15,352	14,458	0	5.0	15	12	1,369	2.0	2.4	42,656 (kJ / kg)	420 (kilo-litle / GWh)
	Nampula_Back up emergency	Diesel Engine/Exist	2	1	1	9,455	8,904	0	5.0	15	1	1,369	2.0	3.0	42,656 (kJ / kg)	259 (kilo-litle / GWh)
	Quelimane_Back up emergency	Diesel Engine/Exist	2	1	1	9,455	8,904	0	5.0	15	1	1,369	2.0	3.0	42,656 (kJ / kg)	259 (kilo-litle / GWh)
	Pemba_Back up emergency	Diesel Engine/Exist	1	1	1	9,455	8,904	0	5.0	15	1	1,369	2.0	3.0	42,656 (kJ / kg)	259 (kilo-litle / GWh)
	Lichinga _Back up emergency	Diesel Engine/Exist	1	1	1	9,455	8,904	0	5.0	15	1	1,369	2.0	3.0	42,656 (kJ / kg)	259 (kilo-litle / GWh)
	Nacala Barcassa	Diesel Engine/New	6	7	7	8,417	7,926	0	5.0	15	7	1,369	2.0	3.0	42,656 (kJ / kg)	230 (kilo-litle / GWh)
	Mavuzi 1	Hydro/Exist	2	6	6	0	0	0	5.0	30	6	0	4.0	0.0		
	Mavuzi 2	Hydro/Exist	3	15	15	0	0	0	5.0	30	15	0	4.0	0.0		
	Chicamba	Hydro/Exist	2	22	22	0	0	0	5.0	30	22	0	4.0	0.0		
	Cahora Bassa (for EDM)	Hydro/Exist	1	500	500	0	0	0	5.0	0	500	0	4.0	0.0		
	Lichinga	Hydro/Exist	1	1	1	0	0	0	5.0	30	1	0	4.0	0.0		
	Cuamba	Hydro/Exist	1	1	1	0	0	0	5.0	30	1	0	4.0	0.0		

Source: JICA Study Team

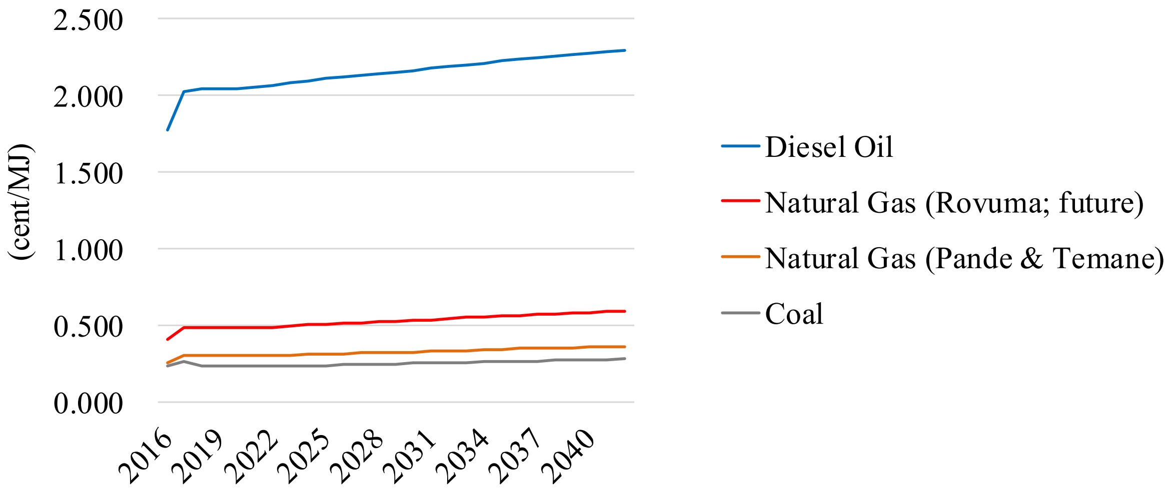
Table 5.9-4 Setting data of candidate power plants for WASP-IV simulation

Project Name	Generator Type	Installed Capacity	Minimum Operation	Maximum Operation	Heat Rate at Minimum Operation	Average Incremental Heat Rate	Spinning Reserve	Forced Outage Rate	Scheduled Maintenance Days per Year	Maintenance Size	Fuel Cost in 2017	Fixed O&M cost	Variable O&M cost	Heat Value of the Fuel Used		Fuel Consumption (used in REMERSIM)		Pure Construction Cost	Construction Year	Plant Life
		(MW)	(MW)	(MW)	(kJ/kWh)	(kJ/kWh)	(%)	(%)	(days)	(MW)	(cent / million kJ)	($/kW-month)	($/MWh)					(USD/kW)	(Year)	(Year)
CTM JICA CCGT	CCGT/New	125	29	106	7,719	7,269	5	5.0	30	106	514	2.0	2.4	1,054	(kJ / scf)	7.11	(Mscf / GWh)	1360	3	25
CTM JICA CCGT for emergency	CCGT/New		19	19	7,719	7,269	0	5.0	30	19	514	2.0	2.4	1,054	(kJ / scf)	7.11	(Mscf / GWh)	1360	3	25
Trino		100	29	97	7,719	7,269	5	5.0	30	97	303	1.8	2.4	1,054	(kJ / scf)	7.11	(Mscf / GWh)	1000	3	25
Electrotec (CCGT)	CCGT/New	40	12	39	7,719	7,269	5	5.0	30	39	303	1.8	2.4	1,054	(kJ / scf)	7.11	(Mscf / GWh)	1000	3	25
Central Termica Engco		120	35	116	7,719	7,269	5	5.0	30	116	303	1.8	2.4	1,054	(kJ / scf)	7.11	(Mscf / GWh)	1000	3	25
Temane (CCGT)	CCGT/New	100	29	97	7,719	7,269	5	5.0	30	97	253	3.1	2.4	1,054	(kJ / scf)	7.11	(Mscf / GWh)	1700	3	25
Temane (MGTP)	CCGT/New	400	116	388	9,877	9,302	5	5.0	15	388	253	2.8	2.4	1,054	(kJ / scf)	9.10	(Mscf / GWh)	1500	3	25
Moamba Major	Hydro/New	15	15	15	0	0	0	5.0	30	15	0	4.0	0.0					4000	5	40
Jindal	Coal/New	150	42	141	9,748	9,180	5	5.0	30	141	241	5.1	2.3	25,092	(kJ / kg)	377	(Ton / GWh)	2670	5	25
ENRC (Estima)	Coal/New	300	85	282	9,748	9,180	5	5.0	30	282	241	5.0	2.3	25,092	(kJ / kg)	377	(Ton / GWh)	2600	5	25
Tete Coal 1200MW	Coal/New	300	340	1,128	9,068	8,539	5	5.0	30	282	241	4.2	2.3	25,092	(kJ / kg)	351	(Ton / GWh)	2200	5	25
Central Termica da Baobab	Coal/New	200	56	188	9,748	9,180	5	5.0	30	188	241	5.0	2.3	25,092	(kJ / kg)	377	(Ton / GWh)	2600	5	25
Quelimane	Diesel Engine/New	6.0	5.8	5.8	8,417	7,926	0	5.0	15	5.8	1,369	2.2	3.0	42,656	(kJ / kg)	230	(kilo-litle / GWh)	1300	1	25
Nampula	Diesel Engine/New	6.0	5.8	5.8	8,417	7,926	0	5.0	15	5.8	1,369	2.2	3.0	42,656	(kJ / kg)	230	(kilo-litle / GWh)	1300	1	25
Lichinga	Diesel Engine/New	6.0	5.8	5.8	8,417	7,926	0	5.0	15	5.8	1,369	2.2	3.0	42,656	(kJ / kg)	230	(kilo-litle / GWh)	1300	1	25
Pemba Emegency	Diesel Engine/New	6.0	5.8	5.8	8,417	7,926	0	5.0	15	5.8	1,369	2.2	3.0	42,656	(kJ / kg)	230	(kilo-litle / GWh)	1300	1	25
Emergency Jica at Nacala S/S (GT Kerosene)	OCGT/New	40	12	39	11,225	10,571	5	5.0	15	39	1,369	2.2	2.4	42,656	(kJ / kg)	307	(kilo-litle / GWh)	1300	1	25
Jica Thermal Power at Nacala	Coal/New	200	56	188	9,068	8,539	5	5.0	30	188	301	5.0	2.3	25,092	(kJ / kg)	351	(Ton / GWh)	2600	5	25
Tsate	Hydro/New	50	15	49	0	0	0	5.0	30	49	0	5.9	0.0					4000	5	40
Mphanda Nkuwa	Hydro/New	1,500	437	1,455	0	0	0	0.0	30	364	0	2.9	0.0					1470	5	40
Cahora Bassa North	Hydro/New	1,245	362	1,208	0	0	0	0.0	30	403	0	1.4	0.0					800	2	40
Lupata	Hydro/New	650	189	631	0	0	0	0.0	30	105	0	4.6	0.0					2300	5	40
Boroma	Hydro/New	200	58	194	0	0	0	0.0	30	49	0	8.9	0.0					4500	5	40
CCGT 200MW model	CCGT/New	200	58	194	7,719	7,269	5	5.0	30	188	502	3.1	3.7	1,054	(kJ / scf)	7.11	(Mscf / GWh)	1700	3	40
Coal 200MW model	Coal/New	200	58	194	9,748	9,180	5	5.0	30	188	300	3.8	3.5	25,092	(kJ / kg)	377	(Ton / GWh)	2000	5	40
Hydro 50MW model	Hydro/New	50	15	49	0	0	0	5.0	30	49	0	6.6	0.0					3300	5	40
Hydro 100MW model	Hydro/New	100	29	97	0	0	0	5.0	30	97	0	6.6	0.0					3300	5	40

Source: JICA Study Team

5.9.4 Specification data of power plants for WASP simulation

Figure 5.9-5 shows fuel price forecast of diesel oil, natural gas and coal material from 2018 to 2042 in Mozambique. It can be seen that the price of diesel oil is the highest of all fuels. On the other hand, coal is the lowest price and lowest increase through the period.



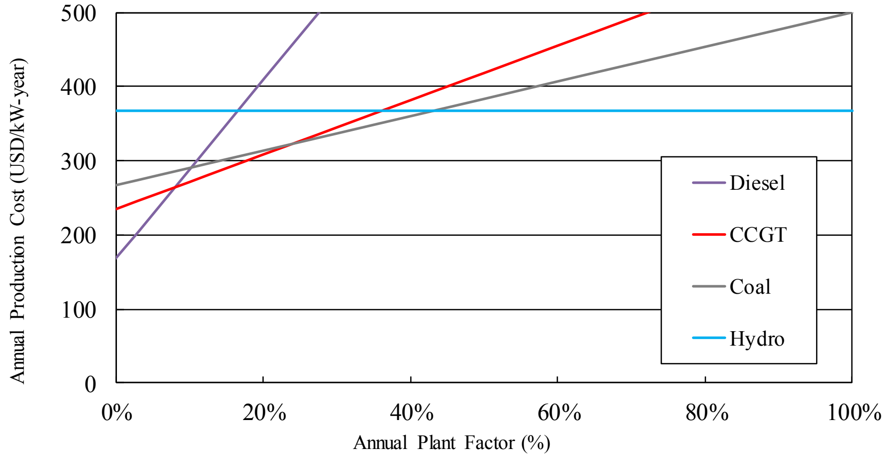
Source: JICA Study Team

Figure 5.9-5 Fuel price forecast

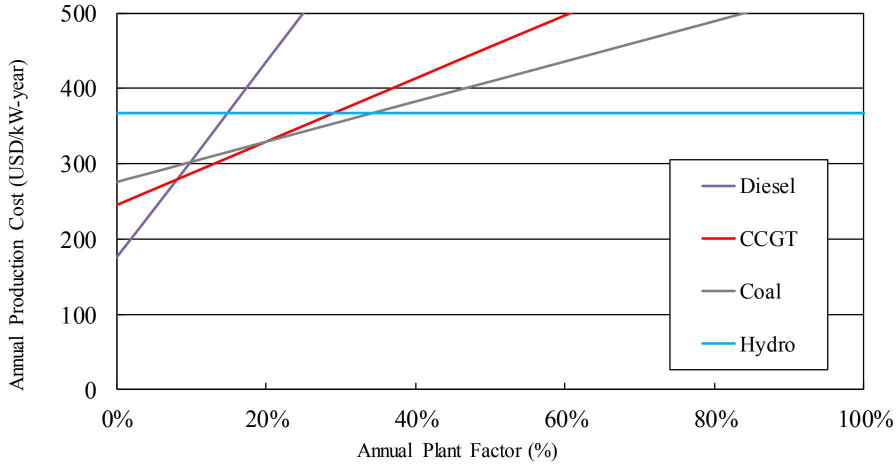
5.9.5 Analysis with screen curve

Before formulating the generation development plan using simulation tools, JICA Study Team conducted a preliminary analysis using the screening curve method. This analysis provides basic information for generation development planning such as the cost of development and operation and the roughly estimated capacity required to develop each candidate unit in the future.

Figure 5.9-6 shows the result of the screening analysis in each year 2025 and 2040 (2017 value). These fuel prices are used international market prices. From the figure, it is suggested that the operation by hydropower as a base load, coal-fired unit as middle load, CCGT or diesel as peak load will achieve the least cost operation. Fuel cost in 2040 would become higher than that in 2025, therefore the higher an annual plant factor of thermal power would lead the higher operation cost.



(a) 2025



(b) 2040

Source: JICA Study Team

Figure 5.9-6   Results of screening analysis

5.10 Simulation Result of Generation Development Plan

5.10.1 Generation Development Plan (Stage 1; Southern System)

(1) Precondition

- CTM project under construction for the operation in 2018 and Temane project planned to be operated in 2022 are assumed to be operated on schedule.
- Tofo wind power project is assumed to be operated in 2023 taking into consideration three years of feasible study and two years of financial close and construction.
- Aggreko Phase 02 Ressano project and Aggreko Beluluane project are assumed to be retired in 2017.
- Other projects are simulated with WASP for optimization of operation year considering present situation of development stage as of 2017.
- Required Additional Capacity is simulated in case supply resource is short in study period. Necessary amount of import is simulated by WASP-IV optimization.

(2) Simulation result

Table 5.10-1 shows the simulation result of generation development in stage 1 of Southern System from 2018 to 2023 by WASP-IV. As shown in the table, almost all power for additional demand will be supplied by thermal power with natural gas. And, required additional capacity is needed from 2018 to 2022, which is covered by short term procurable measures such as extra import and temporary generators.

Table 5.10-1 Simulation result of generation development (Stage 1; Southern System)

Southern System										
Year	Peak Demand [MW]	Total Installed Capacity(1) [MW]	Hydro [MW]	Diesel [MW]	Gas [MW]	Coal [MW]	Required Additional Capacity [MW]	Solar [MW]	Wind [MW]	Retire [MW]
2017	622	661			40		80			-40
2018	680	727			106		50			-90
2019	800	867					140			
2020	872	937					70			
2021	951	1,017					80			
2022	1,031	1,117			400		-300			
2023	1,115	1,233			206		-120		30	
Developed Capacity(MW)			0	0	752	0	0	0	30	-130
			652							

(1) As of end of each fiscal year

Each mumber shows assumed project and WASP proposed project

Year	Operation Start	Retire
2017	Kuvaninga (40MW)	Aggreko Beluluane (40MW)
2018	JICA CTM (106MW)	Aggreko Ressano (90MW)
2019		
2020		
2021		
2022	Temane (MGTP) (400MW)	Additional Capacity (300MW)
2023	Temane (CCGT) (100MW) CTM Phase2 (106MW) Tofo (wind) (30MW)	Additional Capacity (120MW)

Source: JICA Study Team

5.10.2 Generation Development Plan (Stage 1; Central & Northern System)

(1) Precondition

- Jindal project planned to be started of construction from 2018 is assumed to be operated in 2023 on schedule.
- Mocuba solar power project and Metoro solar power project are assumed to be operated in 2018 and 2019, respectively.
- Nacala Barcassa project is assumed to be retired in 2018.
- Other projects are simulated with WASP for optimization of operation year considering present situation of development stage as of 2017.
- Additional engine-generator is simulated in case supply resource is short in study period considering present situation of Nampula province and Cabo Delgado province. Necessary installed capacity of the generator is simulated by WASP-IV optimization.
- First unit of Tete coal fired power project is assumed to start operation in 2023.

(2) Simulation result

Table 5.10-2 shows the simulation result of generation development in stage 1 of Central & Northern System from 2018 to 2023 by WASP-IV. This result shows the possibility of energy shortage in the system from 2018 because of not only an increase of demand and the retirement of Nacala Barcassa power plant. To solve the problem, it is preferable to continue the contract of Nacala Barcassa operation or to install additional engine-generator which is able to be installed for a short period.

Table 5.10-2 Simulation result of generation development (Stage 1; Central & Northern System)

Central & Northern System										
Year	Peak Demand [MW]	Total Installed Capacity(1) [MW]	Hydro [MW]	Diesel [MW]	Gas [MW]	Coal [MW]	Required Additional Capacity [MW]	Solar [MW]	Wind [MW]	Retire [MW]
2017	498	513								
2018	725	773					260	40		-40
2019	823	913					100	40		
2020	878	963					50			
2021	981	1,073					110			
2022	1,087	1,183					110			
2023	1,194	1,313				650	-520			
Developed Capacity(MW)			0	0	0	650	110	80	0	-40
			800							

(1) As of end of each fiscal year

Each mumber shows assumed project and WASP proposed project

Year	Operation Start	Retire
2017		
2018	Mocuba (solar) (40MW)	Nacala Barcassa (40MW) for Mozambique
2019	Metoro (solar) (40MW)	
2020		
2021		
2022		
2023	Jindal (150MW) Nacala Coal (200MW) Tete Coal (1unit) (300MW)	Additional Capacity (520MW)

Source: JICA Study Team

5.10.3 Generation Development Plan (Stage 2; Integrated System, Domestic Oriented Scenario)

(1) Precondition

- Mphanda Nkuwa project is assumed to be operated from 2024. However, installed unit number from 2024 is optimized taking into consideration domestic peak demand.
- Operation year of large scale hydropower project such as Lupata and Boroma is optimized with WASP-IV as premises for the installation after 2025.
- Tsate hydropower project planning to be developed in 2025 is assumed to be operated on schedule.
- Installed capacity of solar power and wind power is assumed to be developed 10% of peak demand and the ratio of solar power to wind power is set as 3 to 1.
- CCGT unit, coal fired unit and hydropower unit are modeled as described in section 5.6.3, and operation year of these units are simulated with WASP-IV optimization.

Introduction of Cahora Bassa North hydropower project which is assumed to be operated as a peak load is set to start operation 5 years after Mphanda Nkuwa hydropower project completion.

(2) Simulation result

Table 5.10-3 and Table 5.10-4 show the simulation result of generation development in stage 2 of Integrated System on Base Scenario 1-1 and Base scenario 1-2 respectively by WASP-IV. Simulation result shows total over 6,500MW of generators is introduced. In the point of construction cost, Lupata project is installed in early period. Installed capacity of CCGT unit is the largest than other models because CCGT will be operated as middle or peak load in the point of operation cost.

Table 5.10-3 Simulation result of generation development (Stage 2; Integrated System, Base Scenario 1-1)

Each mumber shows assumed project and WASP proposed project

Integrated System													
Year	Peak Demand (Total)	Peak Demand (Domestic)	Peak Demand (Additional Export)	Total Installed Capacity(1)	Mphanda Nkuwa	Cahora Bassa North	Lupata, Boroma	Tete	Hydro	CCGT	Coal	Solar Power	Wind Power
					Hydro	Hydro	Hydro	Coal	Hydro	Gas	Coal	Solar	Wind
	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]
2024	2,314	2,314	0	3,966	1,500							30	
2025	2,495	2,495	0	4,046					50			30	
2026	2,681	2,681	0	4,076								30	
2027	2,875	2,875	0	4,186						80			30
2028	3,076	3,076	0	4,216								30	
2029	3,284	3,284	0	5,491		1,245						30	
2030	3,500	3,500	0	5,521								30	
2031	3,724	3,724	0	6,201			650						30
2032	3,955	3,955	0	6,231								30	
2033	4,194	4,194	0	6,261								30	
2034	4,441	4,441	0	6,291								30	
2035	4,697	4,697	0	6,621				300					30
2036	4,962	4,962	0	6,951				300				30	
2037	5,238	5,238	0	7,281					100	200		30	
2038	5,525	5,525	0	7,711				300	100			30	
2039	5,823	5,823	0	7,941					200				30
2040	6,133	6,133	0	8,171					200			30	
2041	6,443	6,443	0	8,601					200	200		30	
2042	6,772	6,772	0	8,931					100	200		30	
Developed Capacity [MW]					1,500	1,245	650	900	950	680	0	450	120
					6,495								

(1) As of end of each fiscal year

Source: JICA Study Team

Table 5.10-4 Simulation result of generation development (Stage 2; Integrated System, Base Scenario 1-2)

Each mumber shows assumed project and WASP proposed project

Integrated System													
Year	Peak Demand (Total)	Peak Demand (Domestic)	Peak Demand (Additional Export)	Total Installed Capacity(1)	Mphanda Nkuwa	Cahora Bassa North	Lupata, Boroma	Tete	Hydro	CCGT	Coal	Solar Power	Wind Power
					Hydro	Hydro	Hydro	Coal	Hydro	Gas	Coal	Solar	Wind
	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]
2024	2,314	2,314	0	3,996	1,500							60	
2025	2,495	2,495	0	5,556					50			60	
2026	2,681	2,681	0	5,666								60	
2027	2,875	2,875	0	5,726						80			60
2028	3,076	3,076	0	5,866								60	
2029	3,284	3,284	0	5,926		1,245						60	
2030	3,500	3,500	0	7,231								60	
2031	3,724	3,724	0	7,291									60
2032	3,955	3,955	0	7,351			650					60	
2033	4,194	4,194	0	8,061								60	
2034	4,441	4,441	0	8,121					100			60	
2035	4,697	4,697	0	8,281					100				60
2036	4,962	4,962	0	8,441				300				60	
2037	5,238	5,238	0	8,801				300	50			60	
2038	5,525	5,525	0	9,211				300	100			60	
2039	5,823	5,823	0	9,671					100				60
2040	6,133	6,133	0	9,831					100	200		60	
2041	6,443	6,443	0	10,191					300			60	
2042	6,772	6,772	0	10,551						400		60	
Developed Capacity [MW]					1,500	1,245	650	900	900	680	0	900	240
					7,015								

(1) As of end of each fiscal year

Source: JICA Study Team

5.10.4 Generation Development Plan (Stage 2; Integrated System, Export Scenario)

(1) Precondition

- Mphanda Nkuwa project is assumed to be operated in 2024. All units are installed in 2024 considering domestic peak demand and additional export.
- Capacity for export is assumed to be 20% or 40% of domestic peak demand in each year.
- Other preconditions are the same as that on Base Scenario

(2) Simulation result

From Table 5.10-5 to Table 5.10-8 show the simulation results of generation development in stage 2 of Integrated System on Export Scenario by WASP-IV. Total over 8,000MW of generators are installed into the system.

Table 5.10-5 Simulation result of generation development (Stage 2; Integrated System, Export Scenario 1-1)

Each mumber shows assumed project and WASP proposed project

Integrated System													
Year	Peak Demand (Total)	Peak Demand (Domestic)	Peak Demand (Additional Export)	Total Installed Capacity(1)	Mphanda Nkuwa	Cahora Bassa North	Lupata, Boroma	Tete	Hydro	CCGT	Coal	Solar Power	Wind Power
					Hydro	Hydro	Hydro	Coal	Hydro	Gas	Coal	Solar	Wind
	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]
2024	2,777	2,314	463	3,966	1,500							30	
2025	2,994	2,495	499	4,046					50			30	
2026	3,217	2,681	536	4,376				300				30	
2027	3,449	2,875	575	5,136			650			80			30
2028	3,691	3,076	615	5,166								30	
2029	3,941	3,284	657	6,441		1,245						30	
2030	4,201	3,500	700	6,471								30	
2031	4,469	3,724	745	6,501									30
2032	4,746	3,955	791	6,581					50			30	
2033	5,032	4,194	839	6,911					100	200		30	
2034	5,329	4,441	888	7,341				300	100			30	
2035	5,636	4,697	939	7,571					200				30
2036	5,955	4,962	992	7,901					100	200		30	
2037	6,286	5,238	1,048	8,331					200	200		30	
2038	6,629	5,525	1,105	8,761				300	100			30	
2039	6,987	5,823	1,165	9,091					100	200			30
2040	7,359	6,133	1,227	9,521						400		30	
2041	7,732	6,443	1,289	9,951						200	200	30	
2042	8,126	6,772	1,354	10,581						400	200	30	
Developed Capacity [MW]					1,500	1,245	650	900	1,000	1,880	400	450	120
					8,145								

(1) As of end of each fiscal year

Source: JICA Study Team

Table 5.10-6 Simulation result of generation development (Stage 2; Integrated System, Export Scenario1-2)

Each mumber shows assumed project and WASP proposed project

Integrated System													
Year	Peak Demand (Total)	Peak Demand (Domestic)	Peak Demand (Additional Export)	Total Installed Capacity(1)	Mphanda Nkuwa	Cahora Bassa North	Lupata, Boroma	Tete	Hydro	CCGT	Coal	Solar Power	Wind Power
					Hydro	Hydro	Hydro	Coal	Hydro	Gas	Coal	Solar	Wind
	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]
2024	2,777	2,314	463	3,996	1,500							60	
2025	2,994	2,495	499	4,106					50			60	
2026	3,217	2,681	536	4,466				300				60	
2027	3,449	2,875	575	5,256			650			80			60
2028	3,691	3,076	615	5,316								60	
2029	3,941	3,284	657	6,621		1,245						60	
2030	4,201	3,500	700	6,681								60	
2031	4,469	3,724	745	6,741									60
2032	4,746	3,955	791	6,801								60	
2033	5,032	4,194	839	7,161				300				60	
2034	5,329	4,441	888	7,621				300	100			60	
2035	5,636	4,697	939	7,881					200				60
2036	5,955	4,962	992	8,241					100	200		60	
2037	6,286	5,238	1,048	8,701					200	200		60	
2038	6,629	5,525	1,105	9,061					100	200		60	
2039	6,987	5,823	1,165	9,521					200	200			60
2040	7,359	6,133	1,227	9,981						400		60	
2041	7,732	6,443	1,289	10,441						400		60	
2042	8,126	6,772	1,354	10,951					50		400	60	
Developed Capacity [MW]					1,500	1,245	650	900	1,000	1,680	400	900	240
					8,515								

(1) As of end of each fiscal year

Source: JICA Study Team

Table 5.10-7 Simulation result of generation development (Stage 2; Integrated System, Export Scenario2-1)

Each mumber shows assumed project and WASP proposed project

Integrated System													
Year	Peak Demand (Total)	Peak Demand (Domestic)	Peak Demand (Additional Export)	Total Installed Capacity(1)	Mphanda Nkuwa	Cahora Bassa North	Lupata, Boroma	Tete	Hydro	CCGT	Coal	Solar Power	Wind Power
					Hydro	Hydro	Hydro	Coal	Hydro	Gas	Coal	Solar	Wind
	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]
2024	3,239	2,314	926	4,466	1,500			300		200		30	
2025	3,492	2,495	998	4,846				300	50			30	
2026	3,753	2,681	1,072	5,176				300				30	
2027	4,024	2,875	1,150	5,936			650			80			30
2028	4,306	3,076	1,230	5,966								30	
2029	4,598	3,284	1,314	7,241		1,245						30	
2030	4,901	3,500	1,400	7,271								30	
2031	5,214	3,724	1,490	7,401					100				30
2032	5,537	3,955	1,582	7,631					200			30	
2033	5,871	4,194	1,677	7,861					200			30	
2034	6,217	4,441	1,776	8,191					100	200		30	
2035	6,576	4,697	1,879	8,471					50	200			30
2036	6,947	4,962	1,985	9,001					100	400		30	
2037	7,333	5,238	2,095	9,431						200	200	30	
2038	7,734	5,525	2,210	9,961					100	200	200	30	
2039	8,152	5,823	2,329	10,391							400		30
2040	8,586	6,133	2,453	10,921					100	200	200	30	
2041	9,020	6,443	2,577	11,551						200	400	30	
2042	9,480	6,772	2,709	11,981							400	30	
Developed Capacity [MW]					1,500	1,245	650	900	1,000	1,880	1,800	450	120
					9,545								

(1) As of end of each fiscal year

Source: JICA Study Team

Table 5.10-8 Simulation result of generation development (Stage 2; Integrated System, Export Scenario2-2)

Each mumber shows assumed project and WASP proposed project

Integrated System													
Year	Peak Demand (Total)	Peak Demand (Domestic)	Peak Demand (Additional Export)	Total Installed Capacity(1)	Mphanda Nkuwa	Cahora Bassa North	Lupata, Boroma	Tete	Hydro	CCGT	Coal	Solar Power	Wind Power
					Hydro	Hydro	Hydro	Coal	Hydro	Gas	Coal	Solar	Wind
	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]
2024	3,239	2,314	926	4,396	1,500					400		60	
2025	3,492	2,495	998	5,006				300	50	200		60	
2026	3,753	2,681	1,072	5,066								60	
2027	4,024	2,875	1,150	5,856			650			80			60
2028	4,306	3,076	1,230	5,916								60	
2029	4,598	3,284	1,314	7,221		1,245						60	
2030	4,901	3,500	1,400	7,281								60	
2031	5,214	3,724	1,490	7,441					100				60
2032	5,537	3,955	1,582	7,701					200			60	
2033	5,871	4,194	1,677	8,161					200	200		60	
2034	6,217	4,441	1,776	8,421					200			60	
2035	6,576	4,697	1,879	8,831				300	50				60
2036	6,947	4,962	1,985	9,291						400		60	
2037	7,333	5,238	2,095	9,851				300		200		60	
2038	7,734	5,525	2,210	10,311							400	60	
2039	8,152	5,823	2,329	10,821					50	200	200		60
2040	8,586	6,133	2,453	11,381					100	200	200	60	
2041	9,020	6,443	2,577	11,891					50		400	60	
2042	9,480	6,772	2,709	12,551						200	400	60	
Developed Capacity [MW]					1,500	1,245	650	900	1,000	2,080	1,600	900	240
					10,115								

(1) As of end of each fiscal year

Source: JICA Study Team

5.10.5 Comparison of each generation development plan

(1) Developed Capacity

Table 5.10-9 shows total developed capacity in each scenario. Hydropower is mainly developed through the period in all scenarios. Installed capacity of thermal power unit with natural gas (CCGT) in export scenario is larger than that of Base Scenario. In export scenario 2-1 and 2-2 (export 40% of domestic peak demand), installed capacity of coal fired thermal is larger than in export scenario 1-1 and 1-2.

Table 5.10-9 Developed capacity (from 2018 to 2042)

		Base Scenario 1-1	Base Scenario 1-2	Export Scenario 1-1	Export Scenario 1-2	Export Scenario 2-1	Export Scenario 2-2
Condition	Domestic/ Export	Domestic		Export 20%		Export 40%	
	Solar&Wind	10%	20%	10%	20%	10%	20%
Peak Demand in 2042	Domestic	6,772 MW					
	Export	0 MW		1,354 MW		2,709 MW	
	Total	6,772 MW		8,126 MW		9,480 MW	
Development Capacity from 2018 to 2042	Hydro	4,345 MW	4,295 MW	4,395 MW	4,395 MW	4,395 MW	4,395 MW
	Gas (CCGT, Engine)	1,432 MW	1,432 MW	2,632 MW	2,432 MW	2,632 MW	2,832 MW
	Coal	1,550 MW	1,550 MW	1,950 MW	1,950 MW	3,350 MW	3,150 MW
	Solar&Wind	680 MW	1,250 MW	680 MW	1,250 MW	680 MW	1,250 MW
	Total	8.007 MW (benchmark)	8,527 MW (+520MW)	9,657MW (+1,650MW)	10,027 MW (+2,020MW)	11,057 MW (+3,050MW)	11,627 MW (+3,620MW)

Source: JICA Study Team

(2) Total installed capacity

Table 5.10-10 shows total installed capacity in 2042 with each development scenario. Total installed capacity is included existing generators and developed capacity which is shown in Table 5.10-9.

Table 5.10-10 Total installed capacity in 2042

Development Scenario	Peak Demand	Installed Capacity in 2042						
		Hydro	Diesel Engine	Natural Gas	Coal	Solar	Wind	Total
	MW	MW	MW	MW	MW	MW	MW	MW
1. Domestic, S&W10%	6,772	4,859	0	1,678	1,484	530	150	8,701
2. Export 20%, S&W10%	8,126	4,908	0	2,806	1,860	530	150	10,254
3. Export 40%, S&W10%	9,480	4,908	0	2,806	2,800	530	150	11,194
4. Domestic, S&W20%	6,772	4,811	0	1,678	1,484	980	270	9,223
5. Export 20%, S&W20%	8,126	4,908	0	2,618	1,860	980	270	10,636
6. Export 40%, S&W20%	9,480	4,908	0	2,806	2,612	980	270	11,576

Source: JICA Study Team

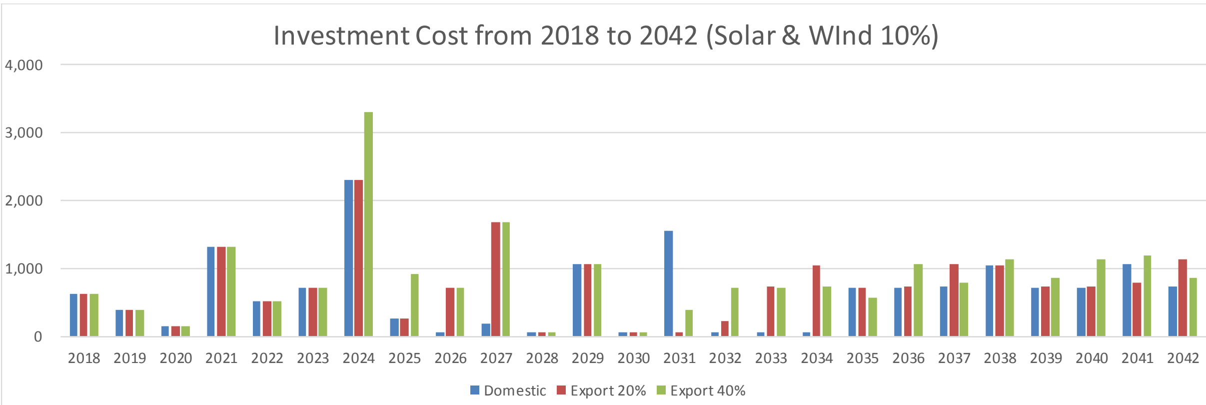
(3) Investment Cost

Table 5.10-11 shows total investment cost of each scenario from 2018 to 2042. Figure 5.10-1 and Figure 5.10-2 show annual investment cost of each scenario. Investment cost of export scenario is much higher than that of base scenario because export scenario is required much more capacity development. Also export scenario 2-1 and 2-2 are much higher than export scenario 1-1 and 1-2 because large amount of export is required. Effect of differential of solar and wind power install capacity are almost same in case of domestic oriented, export 20% and export 40% respectively.

Table 5.10-11 Total investment cost of each scenario (from 2018 to 2042, 2017 price)

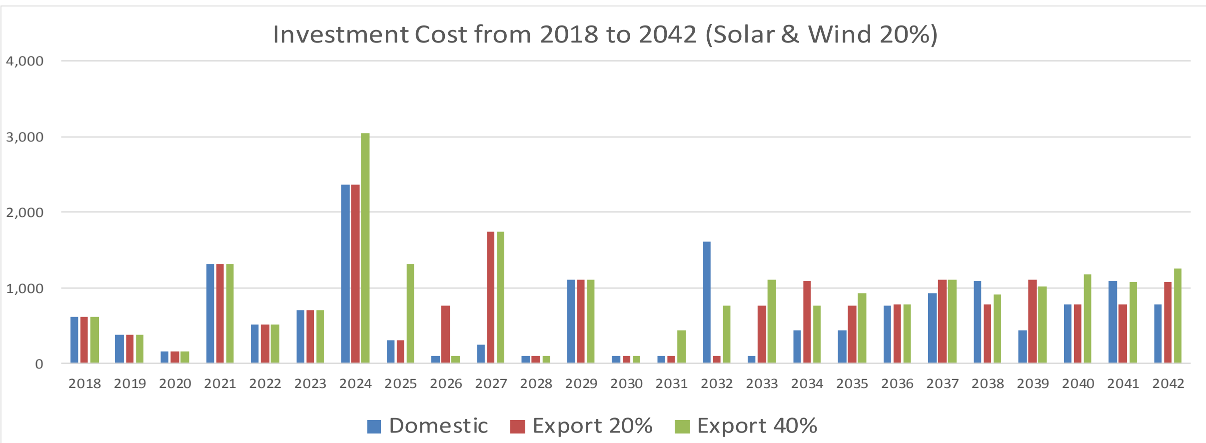
Total Investment Cost	Domestic Oriented	Export 20%	Export 40%
Solar & Wind 10%	Base Scenario 1-1 15,781 MUSD (benchmark)	Export Scenario 1-1 18,786 MUSD (+3,005 MUSD)	Export Scenario 2-1 21,586 MUSD (+5,805 MUSD)
Solar & Wind 20%	Base Scenario 1-2 16,642 MUSD (+861 MUSD)	Export Scenario 1-2 19,472 MUSD (+3,691 MUSD)	Export Scenario 2-2 22,552 MUSD (+6,771 MUSD)

Source: JICA Study Team



Source: JICA Study Team

Figure 5.10-1 Annual investment cost (Solar & Wind 10%)



Source: JICA Study Team

Figure 5.10-2 Annual investment cost (Solar & Wind 20%)

(4) Generation cost

Table 5.10-12 shows assumed generation cost by each scenario in 2042.

- Total generation cost of Export 20% scenario and Export 40% scenario is no so different.
- Total generation cost of Solar and Wind Power 20% scenario is higher than that of 10% scenario because generation cost of solar and wind power is higher than that of other generators.
- Generation cost of hydropower on Domestic Oriented scenario and Export scenario is nearly the same because development capacity of hydropower operated as base load is limited.
- On the other hand, generation cost of coal fired thermal power between Domestic Oriented and Export scenario is quite different than that of hydropower. This result implies that installed capacity and annual capacity factor of coal fired thermal power operated as middle load are different in each scenario.
- Generation cost of coal fired thermal power on Solar and Wind power 20% scenario is higher than that of 10% scenario. Generation efficiency of coal fired thermal power decreases because of the operation of solar power in daytime taking place of coal fired thermal power.

Table 5.10-12 Generation cost in 2042 (2017 price)

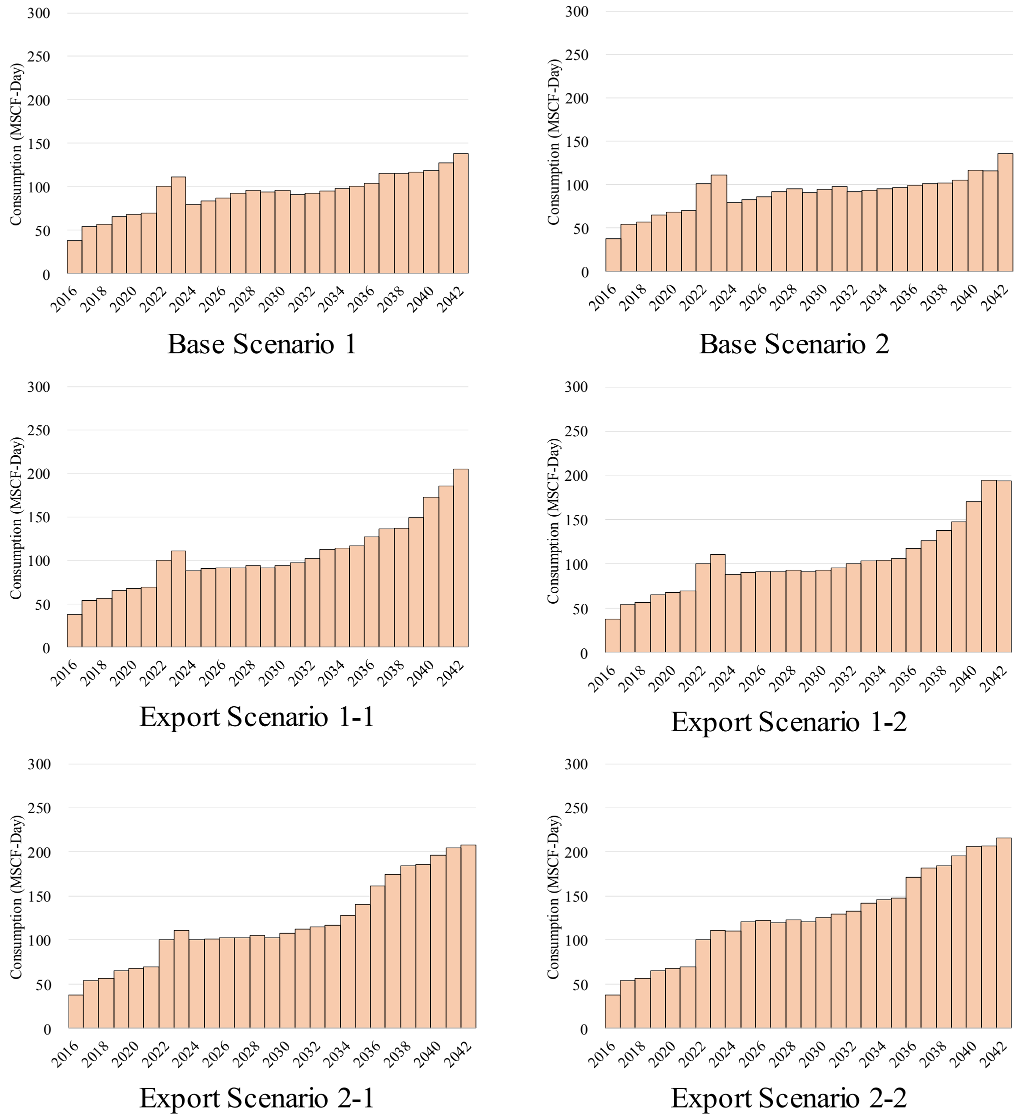
Development Scenario	Peak Demand	Unit Generation Cost in 2042							Total Investment Cost
		Hydro	Diesel Engine	Natural Gas	Coal	Solar	Wind	Total	
	MW	cent/kWh	cent/kWh	cent/kWh	cent/kWh	cent/kWh	cent/kWh	cent/kWh	MUSD
1. Domestic, S&W10%	6,772	3.2	-	10.9	11.7	12.0	12.0	5.9	15,781
2. Export 20%, S&W10%	8,126	3.1	-	8.7	8.0	12.0	12.0	5.4	18,786
3. Export 40%, S&W10%	9,480	3.1	-	8.7	6.5	12.0	12.0	5.2	21,586
4. Domestic, S&W20%	6,772	3.3	-	11.0	12.5	12.0	12.0	6.2	16,642
5. Export 20%, S&W20%	8,126	3.1	-	8.9	8.5	12.0	12.0	5.6	19,472
6. Export 40%, S&W20%	9,480	3.1	-	8.8	6.8	12.0	12.0	5.5	22,552

Note: (Total cost) = (Sum of each generation cost) / (annual energy)
Source: JICA Study Team

(5) Consumption of natural gas

Figure 5.10-3 shows consumption of natural gas (MSCF-Day) in each scenario.

- Consumption increases due to the operation of Temane project in 2022.
- Consumption decreases due to the operation of Mphanda Nkuwa hydropower project as base load from 2024.
- Consumption on Export scenarios increase from around 2035 because of the CCGT development comparing to that of Domestic Oriented scenarios.
- However, it does not increase drastically because CCGT is operated as peak load.
- Consumption on Solar and Wind power 20% scenario is not different than that of 10% scenarios so much. It is supposed that CCGT will be operated in evening time due to cessation of solar power supply.
- On the other hand, consumption on Export Scenario 2-2 become larger than that on Export Scenario 2-1. Generation efficiency of CCGT will increase taking place of coal fired thermal power because of the operation of solar power in daytime (Mechanism is reported in 5.8.1 (5))



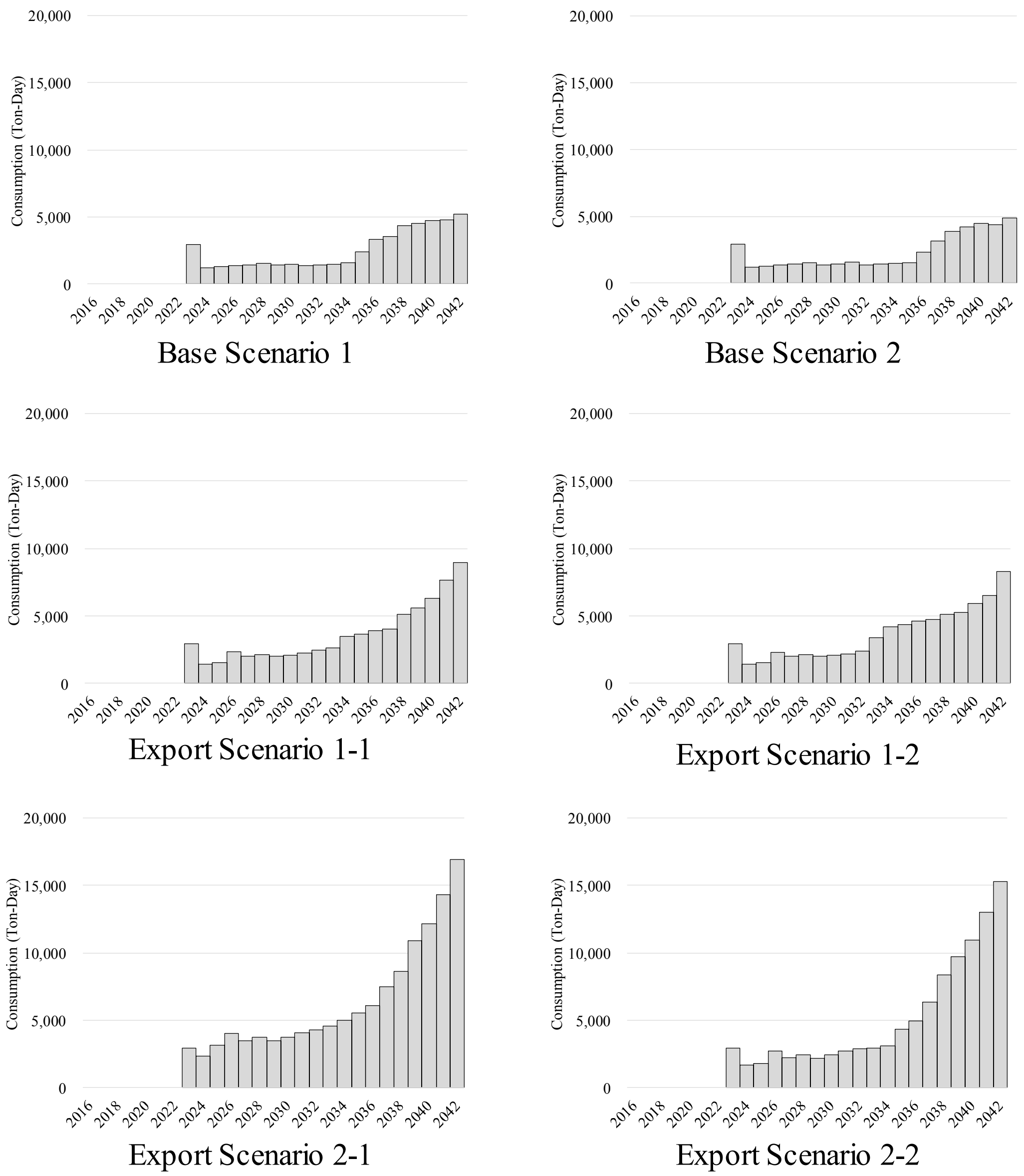
Source: JICA Study Team

Figure 5.10-3 Consumption of natural gas

(6) Consumption of coal

Figure 5.10-4 shows consumption of coal (Ton-Day) in each scenario.

- Consumption decreases by the operation of Mphanda Nkuwa hydropower project as base load from 2024.
- The more electricity is exported, the larger coal is consumed because coal fired thermal power will be operated as middle load.
- Consumption on Export Scenario 2-2 become smaller than that on Export Scenario 2-1. Generation efficiency of coal fired thermal power will decrease because of the operation of solar power in daytime.



Source: JICA Study Team

Figure 5.10-4 Consumption of coal

5.10.6 Recommended scenario

(1) Export amount

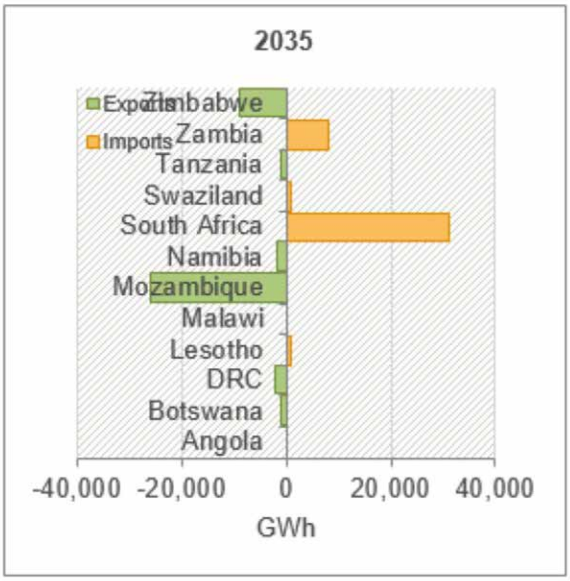
Figure 5.10-5 shows forecast for the amount of import and export in the SAPP countries in 2035. Mozambique is expected as the exporter who has huge potential of more than 25,000GWh corresponding to 2,850MW of base load. On the other hand, South Africa and Zambia are expected as importers in that year.

However, there is a possibility to change SAPP countries' generation development plan and generation cost in the future because it will be varied gratefully depending on the conditions such as economic trend and fuel price in the world. Therefore, it will be a risk for Mozambique to make generation development plan with excessive prospects for the regional countries as importers. Moreover, it is difficult to estimate the future export amount because it is also depending on the demand for an investment by off-takers.

Exportation amount is assumed to be 20% of peak demand in this MP as future development scenario in Mozambique considering following points;

- Stable supply for domestic demand as a necessary condition
- Realization of energy hub in the SAPP region
- Flexibility for the change of the condition of regional countries' development

Of course, it is possible to shift the export 40% scenario after the evaluation of future development condition in the regional countries and investment trend by off-takers.



Source: SAPP Regional Generation and Transmission Expansion Plan 2017

Figure 5.10-5 Expectation for the amount of import and export in the SAPP region in 2035

(2) Installed capacity of Solar and Wind power

Table 5.10-13 shows the characteristics for the installation of solar and wind power in Mozambique and Japan. Mozambique has rich potential for the development of solar and wind power comparing to Japan. And it is possible to install solar and wind power in several points in the whole land.

However, system capacity in Mozambique in 2017 is about 900MW and it is a risk of large fluctuation of system frequency because of just a climate condition in a short span. Although Mozambique has hydropower with high ramp-rate of its output, there is a possibility of drastic output change of solar and wind power cannot be compensated by other generators by the system operator.

There is no experiment of solar and wind power operation in Mozambique. It is necessary to consider power system stability when introducing solar and wind power into the system. Therefore, solar and wind power are assumed to be developed 10% of peak demand with less influence on the system stability to be expected in this MP.

It is necessary to measure solar radiation and wind speed in the potential area such as Mocuba solar project and Tofo wind project for a present. And it is preferable to revise the future development plan after the evaluation of operation performance after development of the projects.

Table 5.10-13 Characteristics for the installation of solar and wind power in Mozambique and Japan

	Mozambique	Japan
Annual Capacity Factor	Solar: 24.5% Wind: 30.4% (project data)	Solar: 13% Wind: 20%
Geological Distribution	Scattered (to be expected)	Scattered
Timing of each output fluctuation of solar power or wind power	Not the same time (to be expected)	Not the same time
System capacity at 2017	About 900MW	Over 100,000MW (60Hz area)
Fluctuation of system frequency by the output of solar power or wind power	Large (to be expected)	Small
Existing generator for operating reserve	Conventional Hydropower CCGT	Pumped storage hydropower Conventional Hydropower

Source: JICA Study Team

For all of these reason, recommended scenario in the study is Export Scenario 1-1, which contains amount of export is 20% of domestic peak demand and developed capacity of solar and wind power on grid is 10 % of domestic peak demand.

5.10.7 Reference scenario

For the reference, generation development plan which is recommended as export scenario 1-1 in 5.10.6 is considered in case that system integration between southern and central & northern is 5-year delayed. Table 5.10-14 shows the simulation result of generation development from 2018 to 2028 in southern system. Table 5.10-15 shows the simulation result of generation development from 2018 to 2028 in central & northern system. Table 5.10-16 shows the simulation result of generation development from 2029 to 2042 in integrated system.

Table 5.10-14 Simulation result of generation development (Southern System, from 2018 to 2028)

Southern System											
Year	Peak Demand [MW]	Total Installed Capacity [MW]	Hydro [MW]	Diesel [MW]	Gas [MW]	Coal [MW]	Required Additional Capacity [MW]	Solar [MW]	Wind [MW]	Retire [MW]
2017	622	661			40		80			-40
2018	680	717			106		40			-90
2019	800	857					140			
2020	872	927					70			
2021	951	1,177					250			
2022	1,031	1,177			400		-400			
2023	1,115	1,233			206		-180		30	
2024	1,201	1,333			100					
2025	1,289	1,463			100			30		
2026	1,379	1,563			100					
2027	1,474	1,693			100				30	
2028	1,572	1,793			100					
Developed Capacity(MW)			0	0	1,252	0	0	30	60	-130
			1,212							

Each number shows Assumed project and WASP proposed project

Year	Operation Start	Retire
2017	Kuvaninga (40MW)	Agreeko Beluluane (40MW)
2018	JICA CTM (106MW)	Aggreko Ressano (90MW)
2019		
2020		
2021		
2022	Temane (MGTP) (400MW)	
2023	Temane (CCGT) (100MW) CTM Phase2 (106MW) Tofo (wind) (30MW)	
2024		
2025		
2026		
2027		
2028		

Source: JICA Study Team

Table 5.10-15 Simulation result of generation development (Central & Northern System, from 2018 to 2028)

Central & Northern System										
Year	Peak Demand [MW]	Total Installed Capacity(1) [MW]	Hydro [MW]	Diesel [MW]	Gas [MW]	Coal [MW]	Required Additional Capacity [MW]	Solar [MW]	Wind [MW]	Retire [MW]
2017	498	513								
2018	725	773					260	40		-40
2019	823	913					100	40		
2020	878	963					50			
2021	981	1,073					110			
2022	1,087	1,183					110			
2023	1,194	1,463				650	-370			
2024	1,303	1,493						30		
2025	1,414	1,543	50							
2026	1,528	1,773				300	-100	30		
2027	1,646	1,853			80					
2028	1,768	1,883						30		
Developed Capacity(MW)			50	0	80	950	160	170	0	-40
			1,370							

(1) As of end of each fiscal year

Each mumber shows assumed project and WASP proposed project

Year	Operation Start	Retire
2017		
2018	Mocuba (solar) (40MW)	Nacala Barcassa (40MW) for Mozambique
2019	Metoro (solar) (40MW)	
2020		
2021		
2022		
2023	Jindal (150MW) Nacala Coal (200MW) Tete (1unit) (300MW)	
2024		
2025	Taste (Hydro) (50MW)	
2026	Tete (1unit) (300MW)	
2027	Shel (Gas) (80MW)	
2028		

Source: JICA Study Team

Table 5.10-16 Simulation result of generation development (Integrated System, from 2029 to 2042)

Each number shows Assumed project and WASP proposed project

Integrated System													
Year	Peak Demand (Total)	Peak Demand (Domestic)	Peak Demand (Additional Export)	Total Installed Capacity	Mphanda Nkuwa	Cahora Bassa North	Lupata, Boroma	Tete	Hydro	CCGT	Coal	Solar Power	Wind Power
					Hydro	Hydro	Hydro	Coal	Hydro	Gas	Coal	Solar	Wind
	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]
2029	3,941	3,284	657	3,506	1,500			300				30	
2030	4,201	3,500	700	5,336				300	100			30	
2031	4,469	3,724	745	5,766					100				30
2032	4,746	3,955	791	5,896			650					30	
2033	5,032	4,194	839	6,576					100			30	
2034	5,329	4,441	888	6,706		1,245						30	
2035	5,636	4,697	939	7,981					100				30
2036	5,955	4,962	992	8,111					100			30	
2037	6,286	5,238	1,048	8,241					200			30	
2038	6,629	5,525	1,105	8,471					100	200		30	
2039	6,987	5,823	1,165	8,801						400			30
2040	7,359	6,133	1,227	9,231						400		30	
2041	7,732	6,443	1,289	9,661						400		30	
2042	8,126	6,772	1,354	10,091					50		400	30	
Developed Capacity [MW]					1,500	1,245	650	600	850	1,400	400	330	90
					7,065								

Source: JICA Study Team

Table 5.10-17 shows comparison of development capacity and cost from 2018 to 2042 for recommended scenario (export scenario 1-1) and 5-year behind schedule scenario (export scenario 1-1') respectively. Development capacity and investment cost are almost same between two scenarios. As for the O&M and fuel cost, however, recommended scenario is cheaper than 5-year behind schedule scenario because huge hydropower will be commenced operation earlier. Thus, system integration among southern, central and northern area should be accomplished as soon as possible.

Table 5.10-17 Comparison of system integration year

		Recommended scenario (export scenario 1-1)	5-year behind schedule scenario (export Scenario 1-1')
Condition	Domestic/Export	Export 20%	
	System integration	2024	2029
	Solar & Wind	10%	
Peak Demand in 2042	Domestic	6,772 MW	
	Export	1,354 MW	
	Total	8,126 MW	
Development Capacity from 2018 to 2042	Hydro	4,395 MW	4,295 MW
	Gas（CCGT, Engine）	2,632 MW	2,732 MW
	Coal	1,950 MW	1,950 MW
	Solar & Wind	680 MW	680 MW
	Total	9,657MW	9,657 MW
Cost (2017 Price)	Investment Cost	18,786 MUSD	18,645 MUSD
	O&M + Fuel Cost	13,962 MUSD	15,767 MUSD
	Total	32,748 MUSD	34,412 MUSD

Chapter 6 Power System Plan and its Operations

6.1 Current condition

6.1.1 Current condition of power system and operation

(1) Outline of power system and operation

In Mozambique, two HVAC systems exist currently, one is in southern area around Maputo city that is major city and another is in north-central area which spread central to North area of Mozambique, and these are not connected yet as shown in Figure 6.1-1.

. The power system is composed of mainly 220kV and 110kV. And Maputo city area network composed loop system with each substation. Table 6.1-1 shows system jurisdiction. Characteristic of each areas are as follows. And Table 6.1-2 show specification of transmission line, transformer and reactive power compensator.

Table 6.1-1 System jurisdiction

System jurisdiction	Control center installed city	Provinces
Northern part (Divisão de Transporte Norte: DTNO)	Nampula	Cabo Delgado, Nampula, Niassa
Central-Northern part (Divisão de Transporte Centro-Norte: DTCN) [5]	Quelimane	Zambezia, Tete, Manica・part of Sofala
Central part (Divisão de Transporte Centro: DTCE)	Chimoio	Manica・Sofala・Gaza・part of Inhambane
Southern part（Divisão de Transporte Sui : DTSU）	Maputo	Gaza・part of Inhambane, Maputo（include Maputo city）

Source : JICA Study Team

(a) Southern system

The southern system covers Maputo province from Maputo

to Gaza province, Inhambane provinces. In this area, two transmission lines owned by MOTRACO (see below) with 400 kV spread to RSA and Swaziland. Additionally, transmission line with 275kV and that with 110kV also spread to Komatipoort, RSA.

(b) Central system

The central system covers Manica and Sofala provinces. Facilities of transmission belong to EDM.

(c) North-central and northern system

The north-central and northern system cover the area from Cahora Bassa at Songo (Tete Province) to Zambezia, Nampula, Niassa, and Cabo Delgado Provinces. Interconnector between Songo and Bindura,

[5] On this report, Central and Central-North systems are applied to describe the Mozambican system although these are merged by the EDM's transformation shown in Fig 6.3-10

Zimbabwe is operating 330kV HVAC[6]. And another evacuation route is from Songo to Apollo, RSA with HVDC[7].

The north-central system and the northern area system have been connected over the last decade with a 220kV HVAC transmission line between Matambo and Chibata.

Interconnection between the southern system and the central system will be achieved by STE backbone project.

(d) Interconnector

The following five routes exist as the interconnector of Mozambique.

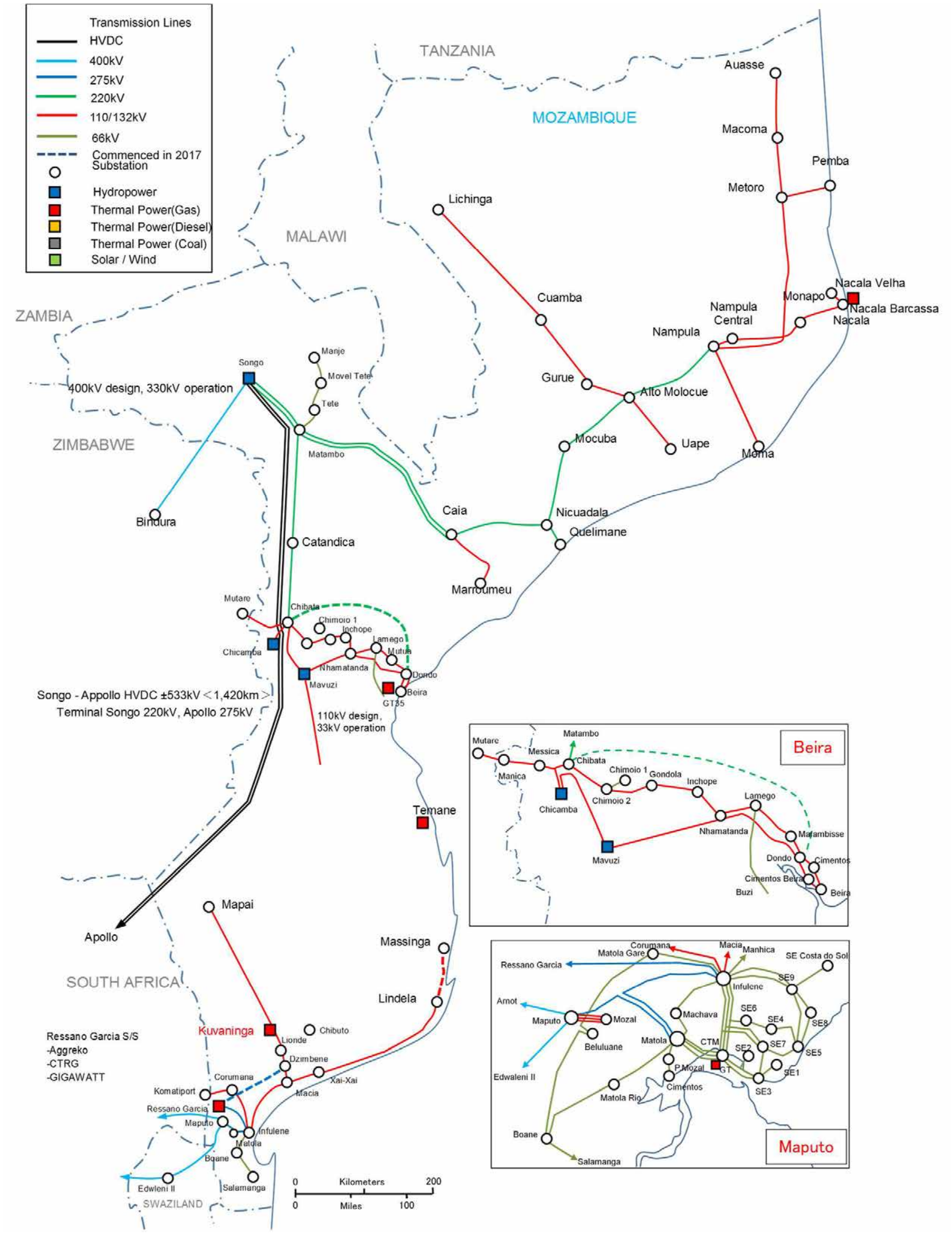
Interconnector (Mozambique)

RSA	Songo (Cahora Bassa) - Apollo DC500kV, Two lines
	Maputo – Arnot (via Swaziland), 400kV 1 line
	Maputo – Camden, 400kV 1line
Zimbabwe	Songo (Cahora Bassa) – Bindura, 330kV 1line
	Manica – Mutare,110kV 1line

Source : JICA Study Team

6 Design of this transmission line is 400kV

7 HVDC is belongs to HCB.



Source : JICA Study Team

Figure 6.1-1 Existing grid system map (2017)

Table 6.1-2 specification of power system equipment in each area

Existing transmission line

Inter connector

Voltage (kV)	from	to	area	length (km)	Conductor code name	Conductor Aluminum sectional area (mm2)	Commissioned year	Normal Rating (MVA)
535(DC)	Songo	Appollo(RSA)	Moz-RSA	898.6			1975	1,920
535(DC)	Songo	Appollo(RSA)	Moz-RSA	895.2			1975	1,920
400	Arnout	Maputo	Moz-RSA	49.9	3xTern	1206	1998	1,293
400	Edwalene	Maputo	Moz-RSA	58.1	3xTern	1206	1998	1,293
330(400)	Songo	Bidura(Zim)	Moz-Zim	125	3xBISON		1997	1,041
275	Komatipoort	Ressano Garcia	Moz-RSA	9	2xBEAR	528	1972	479

Source: EDM

Northern and Central area

Voltage (kV)	from	to	area	length (km)	Conductor code name	Conductor Aluminum sectional area (mm2)	Commissioned year	Normal Rating (MVA)
220	Songo	Matambo	Central-North	120	ZEBRA		1984	247
220	Songo	Matambo	Central-North	115	2xCONDOR	804	1984	477
220	Matambo	Chimuara	Central-North	294	2xCONDOR	804	1983	477
220	Matambo	Chimuara	Central-North	291	2xCONDOR	804	1983	477
220	Chimuara	Nicuadala	Central-North	154	2xCONDOR	804	1984	477
220	Nicuadala	Mocuba	Central-North	108	2xCONDOR	804	1984	477
220	Mocuba	Alto Molocue	Central-North	151	CONDOR	402	1986	247
220	Alto Molocue	Nampula 220	Central-North	183	CONDOR	402	1986	239
220	Nicuadala	Quelimane	Central-North	20	CONDOR	402	1986	239
220	Matambo	Catandica	Central		ZEBRA		1983	247
220	Catandica	Chibata	Central		ZEBRA		1983	247
220	Matambo	Moatize(Vale)	Central	50	2xTem	804	2015	
110	Alto Molocue	Gurue	Central-North	75.7	DOVE	282	2000	99
110	Chimuara	Marromeu	Central-North	90	LEOPARD		2008	63
110	Alto Molocue	Uape	Central-North	90	LYNX	183	2008	77
110	Gurue	Cuamba	Central-North	100	WOLF	158	2004	70
110	Cuamba	Lichinga	Central-North	235	WOLF	158	2005	70
110	Nampula 220	Nampula Central	Central-North	4	DOVE	282	1984	99
110	Nampula Central	Monapo	Central-North	131	PANTHER	212	1984	84
110	Monapo	Nacala	Central-North	64	PANTHER	212	1984	84
110	Nacala Porto	Nacala Valha(VALI	Central-North	28	DOVE	282	2015	99
110	Nacala Porto	Barcaza	Central-North	1.1	Tern	342	2016	
110	Nampula 220	Moma	Central-North	170	LYNX	183	2007	77
110	Nampula 220	Metoro	Central-North	301	LYNX	183	2005	77
110	Metoro	Pemba	Central-North	74	LYNX	183	2005	77
110	Metoro	Macomia	Central-North	132	LYNX	183	2011	77
110	Mocamia	Auasse	Central-North	87.5	LYNX	183	2012	77
110	Mavuzi	Nhamatanda	Central	80	LYNX	183	1973	77
110	Nhamatanda	Dondo	Central		LYNX	183	1973	77
110	Dondo	Cimentos Beira	Central		LYNX	183	1973	77
110	Cimentos Beira	Beira	Central		LYNX	183	1973	77
110	Mavuzi	Chicamba	Central	72	LYNX	183	1957	77
110	Chicamba	Xigodora	Central	11	LYNX	183	1957	77
110	Xigodora	E. Chicamba	Central	5	LYNX	183	1957	77
110	E. Chicamba	Machipanda	Central	50	LYNX	183	1957	77
110	Machipanda	Mutare	Central	7.5	LYNX	183	1957	77
110	Mavuzi	Beira	Central	171	WOLF	158	1955	70
110	Mavuzi	Chibabava	Central	95	DOVE	282	2015	99
110	Nhamatanda	Gondola	Central	78	DOVE	282	1987	99
110	Chibata	Xigodora	Central	12	DOVE	282	1987	99
110	Chibata	Gondola	Central	20	DOVE	282	1987	99
66	Lamego	Guaragura	Central	65	LEOPARD			38
66	Matambo	Tete	Central	20	PANTHER	212	2009	50
66	Tete	Manje	Central	109	DOVE	282	2009	60
66	Matambo	Moatize	Central	37.8	DOVE	282	2011	60
66	Matambo	Benga	Central	22.8	DOVE	282	2011	60
66	Benga	Moatize	Central	18.2	DOVE	282	2011	60

Source: EDM

Southern area

Voltage (kV)	from	to	area	length (km)	Conductor code name	Conductor Aluminum sectional area (mm2)	Commissioned year	Normal Rating (MVA)
275	SE Matola	Infulene	South	16	2xBEAR	528	2000	479
275	Ressano Garcia	Infulene	South	76	2xBEAR	528	1972	479
275	SE Maputo	Matora	South	16	2xBEAR	528	2004	479
132	Motraco	Mozal	South	10.5	3xtern	1026	1998	1,293
110	Infulene	Macia	South	125	DOVE	282	1983	99
110	Macia	Chicumbane	South	49	DOVE	282	1983	99
110	Macia	Lionde	South	53	DOVE	282	1983	99
110	Infulene	Corrumana	South	92	DOVE	282	1984	99
110	Corrumana	Komatipoort	South	40	DOVE	282	1990	99
110	Lionde	Kuvaninga	South	46	DOVE	282	2015	99
110	Kuvaninga	Mapai	South	237	DOVE	282	2015	99
110	Chicumbane	Lindela	South	233.8	AAAC150		2002	68
66	Infulene	Boane	South	42	LEOPARD		1982	120
66	Infulene	2M	South	4.5	PANTHER	212	2003	50
66	Infulene	CTM	South	7.5	PANTHER	212	2004	50
66	Infulene	CTM	South	7.5	PANTHER	212	2004	50
66	Infulene	Manhica	South	62	LEOPARD		1975	120
66	Infulene	Machava	South	7.5	LEOPARD		1991	38
66	Infulene	SE5(Compone)	South	15.1	LEOPARD		1990	38
66	Infulene	SE5(SE8)	South	16.3	BEAR	264		57
66	CTM	Matola	South	4.9	DOVE	282	1998	60
66	CTM	SE6	South	3.8	LEOPARD		1992	38
66	CTM	Matola	South	4.9	DOVE	282	1998	60
66	CTM	Matola	South	4.9	DOVE	282	1998	60
66	Matola	Machava	South	2.5	PANTHER	212	1998	50
66	Matola	Boane	South	21.9	PANTHER	212	1998	50
66	Matola	Cimentos	South	2.7	PANTHER	212	1998	50
66	SE6	SE4	South	2.4	LEOPARD		1998	120
66	SE4	SE5	South	4.8	LEOPARD		1996	120
66	CTM	SE3	South	5.4	PANTHER	212	2001	50
66	CTM	SE2/3	South	5.4	PANTHER	212	2001	50
66	Boane	Salamanga	South	76.7	PANTHER	212	2002	50
66	2M	SE7	South	7.9	PANTHER	212	2004	50
66	2M	SE7	South	7.9	PANTHER	212	2004	50
66	SE7	SE5	South	4	2xPANTHER	424	2004	88
66	SE3	SE1	South	2.1	XLPE500		2004	73
66	SE3	SE7	South	2.2	XLPE1000		2005	77
66	Infulene	SE10	South	8.3	2xDOVE	564	2015	120
66	SE9	SE11	South	8.3	2xDOVE	564	2015	120
66	Infulene	CTM	South	7.5	PARTRIDGE		1972	38

Source: EDM

Existing substation

Northern area

Substation name	Area	Province	Trans. Code	Year	Voltage [kV]	Capacity per unit [MVA]
Nampula	North	Nampula	T1		220/110/33	100/100/33
			T2		220/110/33	100/100/33
			T3		110/33	40
			T4		110/33	75
Nampula Center	North	Nampula	T1		110/33	35
			T2		110/33	40
Nampula Vale	North	Nampula			110/22	40
					110/22	40
Karpower	North	Nampula	–	–	–	–
Monapo	North	Nampula			110/33	16
Movel Monapo	North	Nampula			110/33	10
Nacala	North	Nampula			110/33	35
					110/33	35
Moma	North	Nampula			110/22	25
					110/22	25
Cuamba	North	Niassa			110/33	16
Lichinga	North	Niassa			110/33	16
					110/33	10(Mobile Tr.)
Metoro	North	Cabo Delgado			110/33	10
Pemba	North	Cabo Delgado			110/33	16
Movel Pemba	North	Cabo Delgado			110/33	10
Macomia	North	Cabo Delgado			110/33	16
Auasse	North	Cabo Delgado			110/33	16

Source: EDM

Central area

Substation name	Area	Province	Trans. Code	Year	Voltage [kV]	Capacity per unit [MVA]
Mavuzi	Central	Manica			66/110	9
Chicamba	Central	Manica	–	–	–	–
Chibata	Central	Manica			220/110/18.6	84/72/57
					220/110/18.6	84/72/57
Messica	Central	Manica			110/22/6.6	12.5/6.5/6.5
Chimoio 1	Central	Manica			66/6.6	6
					66/6.6	6
					22/6.6	4
Chimoio 2	Central	Manica			110/66	25
					110/22	20
Manica	Central	Manica			110/33	6.3
Catandica	Central	Manica			220/33/33	25/16/21
Gondola	Central	Manica			110/22	10
Mavita	Central	Manica	–	–	–	–
Marroumeu	Central	Sofala			110/33	16
Inchope	Central	Sofala			110/33	10
Nhamatanda	Central	Sofala	–	–	–	–
Dondo Cements	Central	Sofala			110/22	8
Lamego	Central	Sofala			110/66/22	25/16/9
Mafambisse	Central	Sofala			110/22	12.5
Dondo	Central	Sofala			110/22	20
Beira	Central	Sofala			110/22/6.6	30/22.5/10/5
					110/22/6.6	20/15/7
					110/22/6.6	20/15/7
Beira Cements	Central	Sofala			110/22	10
Dondo 220kV	Central	Sofala			220/110/22	100/100/0/5
					110/33/22	30/5/25
Songo	Central	Tete			220/330	570
Matambo	Central	Tete			220/66/33	45/30/10
					220/66/33	45/30/10
					220/33/66	45/15/30
Jindal	Central	Tete			220/33	20
Tete	Central	Tete			66/33	22
Manje	Central	Tete			66/33	10
Movel Tete	Central	Tete			66/33	20
Vale	Central	Tete			66/22	45
					66/22	45
Benga	Central	Tete	–	–	–	–
Chimuara(Caia)	Central	Zambezia			220/110	40
					110/33	16
Nicuadala	Central	Zambezia	–	–	–	–
Quelimane(Ceramica)	Central	Zambezia			220/33/33	50/50/20
Mocuba	Central	Zambezia			220/110/33	100/100/33
					220/110/33	100/100/33
					110/33	40
Alto Molocue	Central	Zambezia			220/110/33	100/100/33
					110/33	16
					220/7.7	35
Gurue	Central	Zambezia			110/33	16
Uape	Central	Zambezia			110/33	16

Source: EDM

Southern area

Substation name	Area	Province	Trans. Code	Year	Voltage [kV]	Capacity per unit [MVA]
SE 1	South	Maputo City	T3	2003	66/11	30
SE 2	South	Maputo City	T2	2004	66/11	30
SE 3	South	Maputo City	T1	1972	33/11	20
			T3	1999	66/11	30
			T2	2005	66/11	30
SE 4	South	Maputo City	T1	2003	66/11	30
SE 5	South	Maputo City	T1	1989	66/11	20
			T2	2000	66/11	20
SE 6	South	Maputo City	T2	2011	66/33/11	40/24/24
SE 7	South	Maputo City	T1	2003	66/11	30
SE 8	South	Maputo City	T1	2004	66/11	30
SE 9	South	Maputo City	T1	2003	66/11	30
			TR2	1999	66/30	30
SE 10	South	Maputo City	T1	2011	66/33	40
SE 11	South	Maputo City	T1	2011	66/33	40
CTM	South	Maputo City	TR2	1988	60/30	30
			TR13	1991	60/30	30
Infulene	South	Maputo City	T1	2012	275/66/11	250
			T2	1971	275/66	66
			T3	1990	275/66	120
			TR5	1983	110/66	30
			TR6	1983	110/66	30
			TR4	2005	275/110	50
Matola	South	Maputo City	T1	2003	275/66/33	160/160/112
			T2	2007	275/66/33	160/160/112
Matola Gare	South	Maputo City	TR1	2004	66/33	30
			TR2	1982	66/33	10
Matola Rio	South	Maputo City	T1	1989	66/33	30
Beluluane	South	Maputo City	T1	1998	66/11	10
Cimentos	South	Maputo City	TR1	2013	72.5/7.2	25/20
			TR2	2011	72.5/7.2	25/20
Machava	South	Maputo City	TR1	2004	66/33	30
			TR2	2004	66/33	30
Maputo	South	Maputo	TR1		400/275	400
			TR2		400/275	400
			T1		400/132	500
			T2		400/132	500
			T3		400/132	500
Mozal 132kV	South	Maputo				
Mozal 66kV	South	Maputo	TR1		66/22/11	
Xinavane	South	Maputo			110/33	16
					110/33	16
Ressano Garcia	South	Maputo	–	–	–	–
Marracuene	South	Maputo	TR1	2011	66/33	20
Manhica	South	Maputo	TR1	1985	60/30	30
Corumana	South	Maputo			110/33	3
Boane	South	Maputo	T1	1979	66/33	30
Salamanga	South	Maputo	T1	2001	66/33	10
			TR2	2001	66/33	10
Macia	South	Gaza			110/33	16
Chicumbane(Xai-Xai)	South	Gaza	TR1	2010	110/33	40
Lionde	South	Gaza			110/33	40
Dzimbene	South	Gaza		2017	275/110	250
Mapai	South	Gaza			110/33	16
Lindela	South	Inhambane	TR1	1983	110/33	16
			TR2	2001	110/33	16
Massinga	South	Inhambane				

Source: EDM

Existing reactive power compensation

Substation name	Area	Province		Voltage[kV]	Capacity[MVar]
Nampula	North	Nampula	Parallel Capacitor	110	10
			Reactor	33	20
				33	15
			STATCOM	20	±75
Nacala	North	Nampula	Parallel Capacitor	33	6.4
				33	6.4
Moma	North	Nampula	Parallel Capacitor	110	10
				22	5
Lichinga	North	Niassa	Reactor	110	5
Pemba	North	Cabo Delgado	Reactor	33	5
Macomia	North	Cabo Delgado	Reactor	110	3
Auasse	North	Cabo Delgado	Reactor	110	3
Chibata	Central	Manica	Reactor	220	15
Dondo	Central	Sofala	Capacitor Bank	22	7
Beira	Central	Sofala	Capacitor Bank	22	2*5
				6.6	2*2.5
Matambo	Central	Tete	Reactor	220	50
Chimuara(Caia)	Central	Zambezia	Reactor	220	20
			Line Reactor	220	15
Carramica	Central	Zambezia	Reactor	33	50
Mocuba	Central	Zambezia	Serise Capacitor	220	45.5
			Reactor	33	20
			SVC's Plus	11	±31.5
Alto Molocue	Central	Zambezia	Serise Capacitor	220	55.1
			Reactor	33	20
			SVC's	7.7	±35
SE 5	South	Maputo City	Parallel Capacitor	66	20.8
Infulene	Souht	Maputo City	Parallel Capacitor	275	72
Chicumbane(Xai-Xai)	South	Gaza	Parallel Capacitor	33	8
				110	10
Lionde	South	Gaza	Parallel Capacitor	33	4
Lindela	South	Inhambane	Parallel Capacitor	33	4
				110	6

Source: EDM

(2) MOTRACO

The Mozambique Transmission Company (MOTRACO) was founded in 1998 as a joint venture between the three power utilities from Mozambique, South Africa and Swaziland in particular, EDM, Eskom, and SEB[8]. The headquarters of MOTRACO is located at Maputo.

The Republic of Mozambique aiming recovery and reconstruction as the civil conflict was over in 1992 signed an Inter Governmental Memorandum of Understanding (IGMoU) with the Government of South Africa to develop hydroelectric potential and associated high voltage transmission lines in Mozambique. In the meantime, in March 1997 the Government of Mozambique signed a head of agreement with Alusaf, an aluminum smelting enterprise in South Africa for the establishment of an aluminum smelter in Mozambique. Further an electricity tariff for Mozal was agreed in the same year.

EDM however does not have sufficient transmission capacity to supply the power for Mozal and also Eskom does not have a license to sell electricity in Mozambique.

To overcome this situation Special Purpose Vehicle (SPV) was founded in March 1998 with the authorization by the Government of Mozambique.

Specifically, the Government of Mozambique, the Government of South Africa and the Government of Swaziland had concession contracts mutually for:

- ✓ Construction and ownership of transmission facilities,
- ✓ Importation of energy for direct sales to Mozal,
- ✓ Transportation of energy on behalf of EDM, Eskom and SEC, and
- ✓ Establishment of an optic fiber network on its transmission lines to ensure the reliability of power supply to Mozal.

Table 6.1-3 shows the main facilities of MOTRACO.

Table 6.1-3　Main facilities of MOTRACO

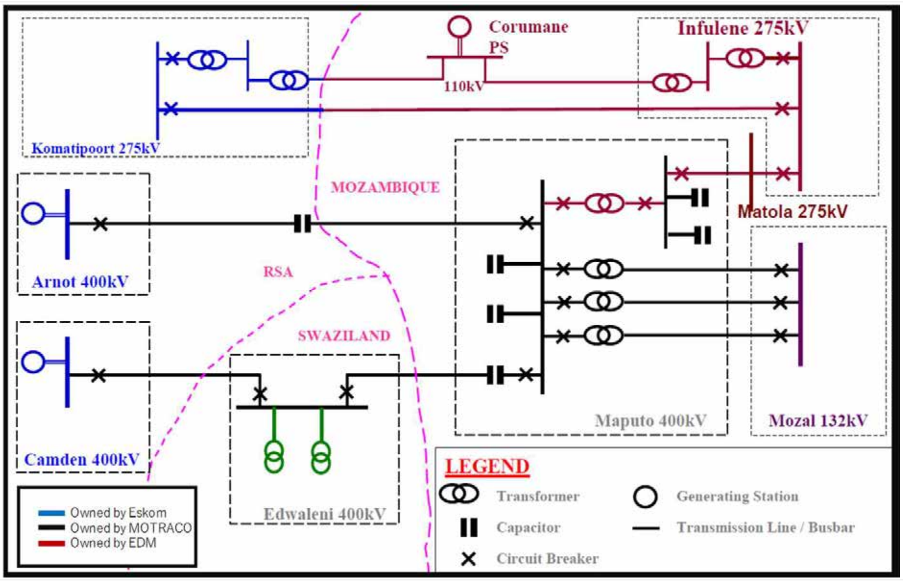
Transmission line	400kV 2 lines, at Arnot – Maputo and Camden - Maputo 132kV 3 lines, at Maputo – Mozal
Transformer	500MVA 400kV/132kV 3 transformers at Maputo
Phase modifying facilities	・400kVfixed series capacitor : 535MVar x 1, and 344MVar x 1 ・400kV shunt reactors 100MVar x 2 ・400kV shunt capacitors 150MVar x 2 ・275kV shunt capacitors 72MVar x 2
Communication facilities	24-core OPGW optic fiber cables, at Maputo – Camden

Source：MOTRACO PRESENTATION (2005), MOTRACO

For southern grid of Mozambique, linking to South African grid through the facilities of MOTRACO is meaningful for improving security and reliability of energy supply systems.

System operation of MOTRACO’s facilities is by Eskom and National Control Centre of EDM can just supervise the condition of them by the information from communication infrastructures.

[8] Swaziland Electricity Board which is former entity of Swaziland Electricity Company (SEC).



Source : MOTRACO PRESENTATION (2005), MOTRACO

Figure 6.1-2 System diagram of MOTRACO

6.2 Power system plan

6.2.1 Policy of power system planning in EDM

EDM disclosed five-year development plan, named "the EDM List of priority projects 2014 – 2018" from the existing master plan, and thereby notified its budget.

The projects on the plan is delayed and is postponed year by year. Meantime, big disturbances hit on the grid due to deterioration of existing electrical facilities and emergency issues to be fixed therefore arose to date.

In this way, EDM establishes several programs to improve the quality of the power system in terms of time factor.

(1) Urgent program

This program involves the project that should be fixe malfunction of the existing facilities. Projects listed in this category need to be implemented as soon as possible, specifically in maximum two years.

(2) Short term investment plan (STIP)

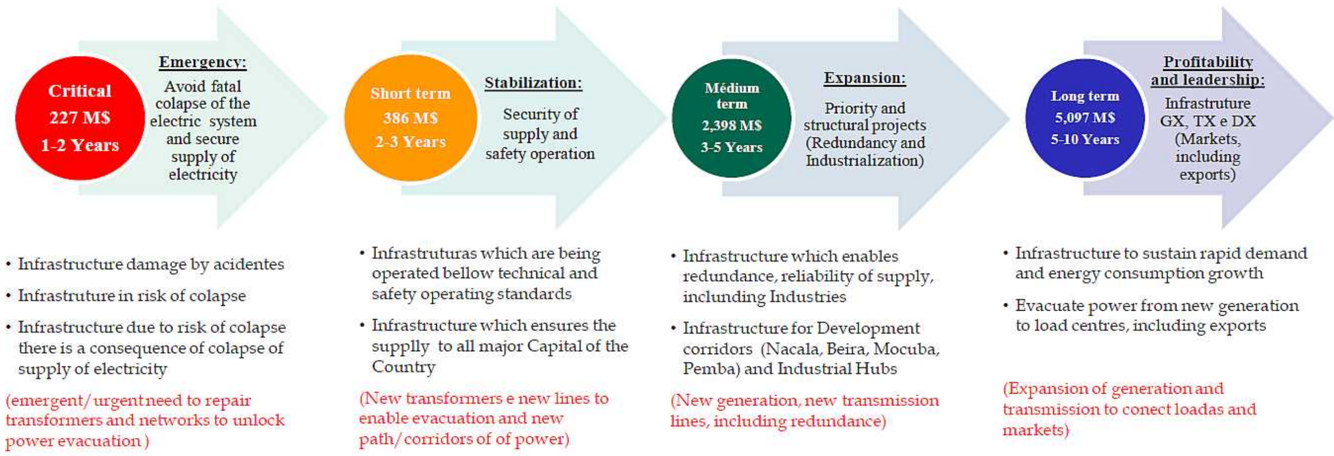
This plan involves the projects enable to meet the technical and safety aspects for the system, especially for the load centers. Projects listed in this category can renovate and upgrade the existing facilities in 2 or 3 years.

(3) Medium -term investment plan

This plan involves the projects enable to supply electric power to large consumers such as industries reliably in 3 to 5 years. Especially this plan focuses the projects in industrial area in Nacala, Beira, Mocuba and Pemba.

(4) Long-term investment plan

This plan involves the projects enable to distribute electric power from projected power plants to load centres to meet demand increase in 5 to 10 years. Also this plan involves interconnectors and transmission lines to link with them.



Source: JICA Study Team

6.2.2 Power system Plan by EDM

Table 6.2-4 - Table 6.2-12 show the construction cost of Transmission line, substation and other facility such as reactive power compensator and dispatching center plan which are divided from Urgent program, short-term investment plan, Mid-term plan and Long-term plan.

Each project cost is estimated and distributed in construction period in each project lists. Table 6.2-13 and Figure 6.2-1 show transition of yearly investment cost. These shows that the most total nominal investment cost (9,200MUSD) concentrated in 2024. This is because STE backbone project phase 2-3 are set on this period.

Project cost calculation are used unit price of representative equipment of each voltage-classes based on EDM Final Master Plan Update Report. In addition, these unit prices are considered inflation index from 2012 to 2017. This is because base unit prices are calculated in 2012. Revised unit costs are shown in Table 6.2-1-Table 6.2-3.

Table 6.2-1 Transmission lines construction costs

Specification	Unit cost*1	Inflation rate*2	Revised unit cost
400kV 4xTern	310,000 USD/km	1.095	340,000 USD/km
275kV 2xBear	180,000 USD/km	1.095	197,000 USD/km
220kV 2xCondor	187,000 USD/km	1.095	205,000 USD/km
110kV 1xDove	112,000 USD/km	1.095	123,000 USD/km
66kV 2xDove	122,000 USD/km	1.095	134,000 USD/km
66kV 1xDove	101,000 USD/km	1.095	111,000 USD/km
DC500kV 4xLapwing	312,000 USD/km	1.095	342,000 USD/km

*1 Final Master Plan update Report

*2 IMF data (2012-2017)

Source: JICA Study Team, based on the information from EDM

Table 6.2-2 Substations construction costs

Specification	Unit cost*1,3	Inflation rate*2	Revised unit cost
400/220kV Double Busbar substation 250MVA transformer x2	35.73 MUSD	1.095	39.135 MUSD
275/110kV Double Busbar substation 150MVA transformer x2	28.13 MUSD	1.095	30.811 MUSD
220/110kV Double Busbar substation 150MVA transformer x2	20.36 MUSD	1.095	22.3 MUSD
110/66kV Double Busbar substation 125MVA transformer x2	14.31 MUSD	1.095	15.674 MUSD
66/33kV Single Busbar substation 30MVA transformer x2	7.46 MUSD	1.095	8.171 MUSD
Converter station of a 2,650MW HVDC bipolar transmission line	546 MUSD	1.095	597.87 MUSD

*1 Final Master Plan update Report

*2 IMF data (2012-2017)

*3 Including Base cost, Transformer cost, Line bay cost, Transformer bay cost

Source: JICA Study Team, based on the information from EDM

Table 6.2-3 Additional transformer construction per unit costs

Specification	Unit cost*1,3	Inflation rate*2	Revised unit cost
400/220kV 250MVA transformer	15.6 MUSD	1.095	17.087 MUSD
275/110kV 150MVA transformer	12.56 MUSD	1.095	13.757 MUSD
220/110kV 150MVA transformer	8.94 MUSD	1.095	9.792 MUSD
110/66kV 125MVA transformer	6.41 MUSD	1.095	7.021 MUSD
66/33kV 40MVA transformer	3.41 MUSD	1.095	3.735 MUSD

*1 Final Master Plan update Report

*2 IMF data (2012-2017)

*3 Including Transformer cost, Transformer bay cost

Source: JICA Study Team, based on the information from EDM

Each project list are as follows.

Urgent program

For securing of supply reliability in Maputo city, there are reinforcement plan such as additional transformer, rebuilding transmission line in Maputo city system by World Bank financing.

Table 6.2-4 Transmission development plan (Urgent program) (As of December 2017)

Voltage (kV)	from	to	length (km)	Construction start year	Commissioned year	Funding	Remarks	investment classification	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	[kUSD] total
66	New Marracuene	SE 11	14	2017	2019	World Bank		Emergency	518	518	518														1,554
66	New Marracuene	Old Marracuene	3	2017	2019	World Bank		Emergency	111	111	111														333
66	SE 10	SE 11	11	2017	2019	World Bank		Emergency	407	407	407														1,221
66	SE 11	SE 5	9	2017	2019	World Bank		Emergency	333	333	333														999
66	Infulene	SE 6(DL2)	5.8	2017	2019	World Bank		Emergency	215	215	215														644
66	Infulene	CTM	7.5	2017	2019	World Bank		Emergency	278	278	278														833
66	SE 1	SE 7	3	2017	2019	World Bank		Emergency	111	111	111														333
66	SE 1	SE 5	6	2017	2019	World Bank		Emergency	222	222	222														666
									2,194	2,194	2,194	0	0	0	0	0	0	0	0	0	0	0	0	0	6,582

Source: JICA Study Team, based on the information from EDM

Table 6.2-5 Substation development plan (Urgent program) (As of December 2017)

Substation	Voltage	Construction start year	Commissioned year	Funding	Remarks	investment classification	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	total
Lichinga	66/33	2017	2019	World Bank	Installation of aditional transformer	Emergency	1245	1245	1245														3,735
SE 1	66/33	2017	2019	World Bank	Installation of aditional transformer	Emergency	1245	1245	1245														3,735
SE 2	66/33	2017	2019	World Bank	Installation of aditional transformer	Emergency	1245	1245	1245														3,735
SE 4	66/33	2017	2019	World Bank	Installation of aditional transformer	Emergency	1245	1245	1245														3,735
SE 5	66/33	2017	2019	World Bank	Installation of aditional transformer	Emergency	1245	1245	1245														3,735
SE 7	66/33	2017	2019	World Bank	Installation of aditional transformer	Emergency	1245	1245	1245														3,735
SE 8	66/33	2017	2019	World Bank	Installation of aditional transformer	Emergency	1245	1245	1245														3,735
New Marracuene	275/66	2017	2019	World Bank	New substation	Emergency	10270	10270	10270														30,811
Quelimane(Ceramica)		2017	2018	World Bank	Replacement of obsolete panels in all substations of the LCN including assembly of one MiniSCADA at Quelimane	Emergency	13500	13500															27,000
Pemba(STATCOM)	15MVAr	2017	2019	World Bank		Emergency	3000	3000	3000														9,000
Nacala(Shunt Capacitor)	15MVAr	2017	2019	World Bank		Emergency	3000	3000	3000														9,000
							38485	38485	24985	0	0	0	0	0	0	0	0	0	0	0	0	0	101,956

Source: JICA Study Team, based on the information from EDM

Short-term investment plan

For securing substation reliability, transformer addition for substation in around Maputo city, Central and North area of Mozambique by AfDB and European framework (Danida, kfw, EIB) financing.

Table 6.2-6 Substation development plan (Short-term investment plan) (As of December 2017)

Substation	Voltage	Construction start year	Commissioned year	Funding	Remarks	investment classification	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	total [kUSD]
Matola Gare	66/33	2016	2017	Norway, kfw, EIB	Installation of new transformer	Short-term	1867.5																1,868
SE9(Laulane)	66/33	2016	2017	Norway, kfw, EIB	Installation of transformer	Short-term	1867.5																1,868
New Canangola, Tete	66/33	2016	2017	Norway, kfw, EIB	Construction of new substation	Short-term	4085.5																4,086
Infulene		2018	2019	Norway, kfw, EIB	Replacement of all 66kV obsolete equipment to renew protection equipment	Short-term		6350	6350														12,700
CTM		2017	2018	Norway, kfw, EIB	Replacement of all 66kV obsolete equipment to renew protection equipment	Short-term	6450	6450															12,900
																							0
							14270.5	12800	6350	0	0	0	0	0	0	0	0	0	0	0	0	0	33,421

Source: JICA Study Team, based on the information from EDM

Medium-term investment plan

Development of 275kV network in Maputo city, system reinforcement in Central and Northern area in Mozambique and construction of new dispatching center are planned as shown in Table 6.2-7 and Table 6.2-8. Donors will be Shinohydro, Mochi, Eurico Ferreira and World Bank etc..

Table 6.2-7 Transmission development plan (Mid-term investment plan) (As of December 2017)

[kUSD]

Voltage (kV)	from	to	area	Construction start year	Commissioned year	Funding	Remarks	investment classification	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	total
110	Nampula	Angoche	Central-North	2022	2025	Sinohydoro ou CCC		Mid-term						5,535	5,535	5,535	5,535								22,140
275	Maputo	Salamanga	South	2017	2019	Sinohydoro ou CCC		Mid-term	9,850	9,850															19,700
275	Ressano Garcia	Beluluane	South	2016	2018	Mochi	Construction of 90km of 275kV Line between Ressano Garcia and Beluluane and interconnection with the existing 275 & 66kV Network	Mid-term	5,910	5,910															11,820
275	Maputo	(New)Marracuene	South	2016	2019	Eurico Ferreira	Construction of 50km of 275kV Line between SE Maputo and Marracuene and interconnection with STE, and Southern Region Network	Mid-term	2,463	2,463	2,463														7,388
275	Infulene	(New) Marracuene(-SE7-Baixa)	South	2016	2019	World Bank	Construction of 81km of 275 & 66kV line between SE Infulene-Marracuene-SE7 and new SE in the Maxaquene (Baixa)	Mid-term	1,231	1,231	1,231														3,694
66	(New) Marracuene	SE7-Baixa	South	2016	2019	World Bank	Construction of 81km of 275 & 66kV line between SE Infulene-Marracuene-SE7 and new SE in the Maxaquene (Baixa)	Mid-term	1,554	1,554	1,554														4,662
220	Dondo	Manga	Central	2020	2022	Fedha Advisory	Construction of 20km of 220km line between Dondo and Manga and 8km of 110kV line between Manga and Airport. Construction of Substation and airport	Mid-term				6,082	6,082	6,082											18,245
110	Manga	Airport	Central	2020	2022	Fedha Advisory		Mid-term				328	328	328											984
110	Lamego	Buzi	Central	2016	2019	Pinggao	Increased capacity of the 110kV Lines of the Center region including the reconstruction of the Lamego - Buzi Line for 110kV	Mid-term	2,306	2,306	2,306														6,919
400	Namialo	Metoro	Central-North	2020	2025		Tanzania interconnector	Mid-term				12,240	12,240	12,240	12,240	12,240	12,240								73,440
220	Namialo	Metoro	Central-North	2022	2025		Construction of 216 km of 220 kV Line between Namialo and Metoro and interconnection with the existing 110 kV Network	Mid-term						11,070	11,070	11,070	11,070								44,280
400	Palma	Metoro	Central-North	2025	2030		Construction of a Line of 220 (400) kV Metoro – Palma and interconnection with SE Auasse	Mid-term									11,900	11,900	11,900	11,900	11,900	11,900			71,400
110	Metro	2nd Pemba	North	2020	2025		Construction of 100km of 110kV Line and 110 / 33kV Substation in Pemba for second power to the City.	Mid-term				2,050	2,050	2,050	2,050	2,050	2,050								12,300
									23,314	23,314	7,554	6,410	6,410	11,945	5,535	5,535	5,535	0	0	0	0	0	0	0	95,551

Source: JICA Study Team, based on the information from EDM

Table 6.2-8 Substation development plan (Mid-term investment plan) (As of December 2017)

Substation	Voltage	Construction start year	Commissioned year	Funding	Remarks	investment classification	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	total [kUSD]
Nampula 220	220/110	2016	2018	AfDB	installation of additional transformer	Mid-term	3264.0	3264.0															6,528
Boane	66/33	2016	2018	AfDB	Installation of additional transformer	Mid-term	1245.0	1245.0															2,490
Lionde		2016	2018	AfDB	Installation of additional transformer	Mid-term	2340.3	2340.3															4,681
Macia		2016	2018	AfDB	Installation of additional transformer	Mid-term	2340.3	2340.3															4,681
Chicumbane(Xai-Xai)		2016	2018	AfDB	Installation of additional transformer	Mid-term	2340.3	2340.3															4,681
Munhava(Beira area)	110/22/6.6	2016	2018	AfDB	Acquisition of new transformer Urgent Rehabilitation project	Mid-term	5224.7	5224.7															10,449
Chimoio 2	110/22	2016	2018	AfDB	Acquisition of new trasnformer and interconnection with Chimoio1 Urgent Rehabilitation project	Mid-term	5224.7	5224.7															10,449
Mafambisse		2016	2018	AfDB	Installation of additional transformer	Mid-term	2340.3	2340.3															4,681
Gondola		2016	2018	AfDB	Installation of additional transformer	Mid-term	2340.3	2340.3															4,681
Inchope		2016	2018	AfDB	Installation of additional transformer	Mid-term	2340.3	2340.3															4,681
Catandica		2016	2018	AfDB	Installation of additional transformer	Mid-term	2340.3	2340.3															4,681
	110/22	2016	2018	AfDB	Acquisition of mobile substation for the national electrical network of 110 / 22kV, 10MVA and 66 / 33kV, 16MVA and 110 / 33kV, 16MVA. Urgent Rehabilitation project	Mid-term	1755.7	1755.7															3,511
New mobile transformer	66/33	2016	2018	AfDB	Acquisition of mobile substation for the national electrical network of 110 / 22kV, 10MVA and 66 / 33kV, 16MVA and 110 / 33kV, 16MVA. Urgent Rehabilitation project	Mid-term	1755.7	1755.7															3,511
	110/33	2016	2018	AfDB	Acquisition of mobile substation for the national electrical network of 110 / 22kV, 10MVA and 66 / 33kV, 16MVA and 110 / 33kV, 16MVA. Urgent Rehabilitation project	Mid-term	1755.7	1755.7															3,511
New Salamanga	275/66/33	2017	2019	Sinohydro ou CCC	New substation 275/66/33kV	Mid-term	10,270	27,591	10,270														48,132
Angoche	110/33	2022	2025	Sinohydro ou CCC	110kV Nampula-Angoche Mid-term project	Mid-term						5224.7	5,225	5,225									
new substation in aterro de Maxaquene(Baixa)	66/33	2016	2019	World Bank		Mid-term	2,043	2,043	2,043														6,128
Beluluane	275/66/33	2016	2018	Mochi	Construction of 90km of 275kV Line between Ressano Garcia and Beluluane and interconnection with the existing 275 & 66kV Network	Mid-term	10,270	10,270															20,541
Manga	220/110/33	2020	2022	Fedha Advisory	Construction of 20km of 220kV line between Dondo and Manga and 8km of 110kV line between Manga and Airport. Construction of Substations in Manga and airport	Mid-term				10270.33	10270.33	10270.33											30,811
Manga Airport	110/33	2020	2022	Fedha Advisory	Construction of 20km of 220kV line between Dondo and Manga and 8km of 110kV line between Manga and Airport. Construction of Substations in Manga and airport	Mid-term				5224.667	5224.667	5224.667											15,674
Buzi	110/66/33	2016	2019	Pinggao	Increased capacity of the 110kV Lines of the Center region including the reconstruction of the Lamego - Buzi Line for 110kV	Mid-term	3,919	3,919	3,919														11,756
2nd Pemba	110/33	2020	2025		Construction of 100km of 110kV Line and 110 / 33kV Substation in Pemba for second power to the City.	Mid-term				2,612	2,612	2,612	2,612	2,612	2,612								15,674
Metoro	400/220	2025	2030		Construction of a Line of 220 (400) kV Metoro - Palma and interconnection with SE Auasse	Mid-term									6,523	6,523	6522.5	6522.5	6522.5	6,523			39,135
Namialo	220/110	2016	2019		Construction of 216 km of 220 kV Line between Namialo and Metoro and interconnection with the existing 110 kV Network	Mid-term	5,575	5,575	5,575														16,725
Metoro	220/110	2016	2019		Construction of 216 km of 220 kV Line between Namialo and Metoro and interconnection with the existing 110 kV Network	Mid-term	5,575	5,575	5,575														16,725
Mafambisse, Manica	110/66	2017	2019	Alstom, GE	Rehabilitation of LCN Substations including Mafambisse and Manica	Mid-term	50,000	50,000	50,000														150,000
Munhava/Dondo(STATCOM)		2016	2017	Fedha Advisory		Mid-term	19,000																19,000
Maputo and/or Quelimane(Dispach Center)		2017	2020	MOCHI	Construction of National dispatch center	Mid-term	19,000	19,000	19,000	19000													76,000
							125,652	123,973	96,382	37,107	18,107	23,332	7,837	7,837	9,135	6,523	6,523	6,523	6,523	6,523	0	0	466,300

Source: JICA Study Team, based on the information from EDM

Long-term investment plan

There are STE project, MoZiSa project, Zambia interconnector, Malawi interconnector, etc. in this plan.

Table 6.2-9 Transmission development plan (Long-term investment plan) (As of December 2017)

[kUSD]

Voltage (kV)	from	to	area	Construction start year	Commissioned year	Funding	Remarks	investment classification	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	total
400	Vilanculos	Chibuto	South	2018	2021		STE Phase 1-1 HVAC	Long-term		28,858	28,858	28,858	28,858												115,430
400	Chibuto	Marracuene	South	2018	2021		STE Phase 1-1 HVAC	Long-term		15,241	15,241	15,241	15,241												60,962
400	Marracuene	Maputo	South	2018	2021		STE Phase 1-1 HVAC	Long-term		3,706	3,706	3,706	3,706												14,824
400	Songo	Cataxa	Central	2019	2024		STE Phase 1 HVAC	Long-term			3,043	3,043	3,043	3,043	3,043	3,043									18,258
400	Cataxa	Matambo	Central	2019	2024		STE Phase 1 HVAC	Long-term			3,632	3,632	3,632	3,632	3,632	3,632									21,794
400	Matambo	Lupata	Central	2019	2024		STE Phase 1 HVAC	Long-term			4,556	4,556	4,556	4,556	4,556	4,556									27,336
400	Lupata	Inchope	Central	2019	2024		STE Phase 1 HVAC	Long-term			17,204	17,204	17,204	17,204	17,204	17,204									103,224
400	Inchope	Vilanculos	Central	2019	2024		STE Phase 2 HVAC	Long-term			19,958	19,958	19,958	19,958	19,958	19,958									119,748
DC500	Cataxa	Maputo		2019	2024		STE Phase 1&2 HVDC	Long-term			72,732	72,732	72,732	72,732	72,732	72,732									436,392
DC500	Cataxa	Maputo		2019	2024		STE Phase 1&2 HVDC	Long-term			72,732	72,732	72,732	72,732	72,732	72,732									436,392
400	Matambo	Phomebeya(Mal) via Moatize	Central	2018	2021		Malawi interconnector	Long-term		18,530	18,530	18,530	18,530												74,120
400	Matambo	Chipata West(Zam)	Central	2019	2021		Zambia interconnector	Long-term			41,707	41,707	41,707												125,120
400	Ncondezi	Chipata West(Zam)	Central	2019	2024		2nd Zambia interconnector	Long-term			20,967	20,967	20,967	20,967	20,967	20,967									125,800
400	Metoro	Mtwara(Tan)	Central-North	2020	2025		Tanzania interconnector	Long-term				27,427	27,427	27,427	27,427	27,427	27,427								164,560
400	Cataxa	Inchope	Central	2020	2025		MoZiSa Project	Long-term				20,400	20,400	20,400	20,400	20,400	20,400								122,400
400	Inchope	Orange Grove(Zim)	Central	2020	2025		MoZiSa Project	Long-term				10,483	10,483	10,483	10,483	10,483	10,483								62,900
400	Inhaminga	Chimuara	Central	2025	2030		Construction of 400kV Chimuara Line – Inhaminga-Inchope, 400 / 220kV Substation in Inhaminga and interconnection Inhaminga – Dondo at 220kV	Long-term									7,083	7,083	7,083	7,083	7,083	7,083			42,500
400	Inhaminga	Inchope	Central	2025	2030		Construction of 400kV Chimuara Line – Inhaminga-Inchope, 400 / 220kV Substation in Inhaminga and interconnection Inhaminga – Dondo at 220kV	Long-term									7,933	7,933	7,933	7,933	7,933	7,933			47,600
400	Inhaminga	Macossa	Central	2025	2030		Construction of 400kV Chimuara Line – Inhaminga-Inchope, 400 / 220kV Substation in Inhaminga and interconnection Inhaminga – Dondo at 220kV	Long-term									5,667	5,667	5,667	5,667	5,667	5,667			34,000
220	Inhaminga	Dondo	Central	2025	2030		Construction of 400kV Chimuara Line – Inhaminga-Inchope, 400 / 220kV Substation in Inhaminga and interconnection Inhaminga – Dondo at 220kV	Long-term									4,442	4,442	4,442	4,442	4,442	4,442			26,650
220	Metoro	Montepuez	Central-North	2019	2024		Construction of a 220kV Metoro – Montepuez Line, Montepuez Substation and 110kV Line Montepuez – Marrupa	Long-term			3,929	3,929	3,929	3,929	3,929	3,929									23,575
110	Marrupa	Montepuez	Central-North	2019	2024		Construction of a 220kV Metoro – Montepuez Line, Montepuez Substation and 110kV Line Montepuez – Marrupa	Long-term			1,989	1,989	1,989	1,989	1,989	1,989									11,931
220	Palma	Auasse	Central-North	2025	2030		Construction of a Line of 220 (400) kV Metoro – Palma and interconnection with SE Auasse	Long-term									2,563	2,563	2,563	2,563	2,563	2,563			15,375
220	Nicoadala	Quelimane(Ceramica)	Central	2020	2025		Conversion of PS Nicoadala into SE Nicoadala and construction of second line Nicoadala-Ceramica at 220kV	Long-term				683	683	683	683	683	683								4,100
110	Mocuba	Pebane(Magiga/Caravela)	Central	2020	2025		Construction of a 110kV Line, 140km, between Mocuba and Magiga / Caravela, in Pebane and its 110 / 33kV Substation	Long-term				2,870	2,870	2,870	2,870	2,870	2,870								17,220
110	Mocuba	Milange	Central	2020	2025		Construction of 120km of 110kV Line between Mocuba and Milange and its Substation in Milange	Long-term				2,460	2,460	2,460	2,460	2,460	2,460								14,760
66	Moatize	Mussacama	Central	2022	2023		Construction of 80km of Moatize – Mussacama 66kV Line and its Substation in Mussacama	Long-term						4,440	4,440										8,880
66	Mussacama	Ulongue	Central	2022	2023		Construction of 80km of 66kV Mussacama – Ulongue Line and its Substation in Ulongue	Long-term						4,440	4,440										8,880
66	Matambo	Guro	Central	2018	2022		Construction of a 66kV Line, 90km between SE Matambo and Guro and its Substation in Guro	Long-term		1,998	1,998	1,998	1,998	1,998											9,990
275	Dzimbene	Chongoene	South	2018	2021		Construction of 80km of 275kV line between new SE Macia and Chongoene, 275 / 110kV substation in Chongoene and	Long-term		3,940	3,940	3,940	3,940												15,760
110	Infulene	Moamba	South	2017	2019		Construction of the SE 110 / 33kV in Moamba and interconnection with the existing network	Long-term	2,050	2,050	2,050														6,150
66	Beluluane	Tchumene	South	2017	2019			Long-term	111	111	111														333
									2,161	74,433	336,881	399,044	399,044	295,943	293,945	285,065	92,011	27,688	27,688	27,688	27,688	27,688	0	0	2,316,964

Source: JICA Study Team, based on the information from EDM

Table 6.2-10 Substation development plan (Long-term investment plan) (As of December 2017)

Substation	Voltage	Construction start year	Commissioned year	Funding	Remarks	investment classification	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	total [kUSD]
Vilanculos	400/110	2018	2021		STE Phase 1-1 HVAC	Long-term		9,784	9,784	9,784	9,784												39,135
Chibuto	400/110	2018	2021		STE Phase 1-1 HVAC	Long-term		9,784	9,784	9,784	9,784												39,135
(New)Marracuene	400/110	2018	2021		STE Phase 1-1 HVAC	Long-term		9,784	9,784	9,784	9,784												39,135
Maputo	400/110	2018	2021		STE Phase 1-1 HVAC	Long-term		9,784	9,784	9,784	9,784												39,135
Songo	400/	2019	2024		STE Phase 1 HVAC	Long-term			6,523	6,523	6,523	6,523	6,523	6,523									39,135
Cataxa	400/	2019	2024		STE Phase 1 HVAC MoZiSa project	Long-term			6,523	6,523	6,523	6,523	6,523	6,523									39,135
Matambo	400/	2018	2021		STE Phase 1 HVAC Malawi interconnector Zambia interconnector	Long-term		9,784	9,784	9,784	9,784												39,135
Lupata	400/	2019	2024		STE Phase 1 HVAC	Long-term			6,523	6,523	6,523	6,523	6,523	6,523									39,135
Macossa	400/	2019	2024		STE Phase 1 HVAC	Long-term			6,523	6,523	6,523	6,523	6,523	6,523									39,135
Metoro	400/220	2020	2025		Tanzania interconnector	Long-term				6,523	6,523	6,523	6,523	6,523	6,523								39,135
Cataxa	/DC500	2019	2024		STE Pahse 1&2 HVDC	Long-term			99,645	99,645	99,645	99,645	99,645	99,645									597,870
Maputo	DC500/	2019	2024		STE Pahse 1&2 HVDC	Long-term			99,645	99,645	99,645	99,645	99,645	99,645									597,870
Inchope	400/110	2019	2024		STE Pahse 1 HVAC MoZiSa project	Long-term			6,523	6,523	6,523	6,523	6,523	6,523									39,135
Inhaminga	400/220	2024	2030		400kV Inghaminga-Chimuara	Long-term								5,591	5,591	5,591	5590.714	5590.714	5590.714	5,591			39,135
Montepuez	220/110/33	2019	2024		Construction of a 220kV Metoro - Montepuez Line, Montepuez Substation and 110kV Line Montepuez - Marrupa	Long-term			3,717	3,717	3,717	3,717	3,717	3,717									22,300
Palma	220/110	2025	2030		Construction of a Line of 220 (400) kV Metoro - Palma and interconnection with SE Auasse	Long-term									3,717	3,717	3716.667	3716.667	3716.667	3,717			22,300
Palma	400/220	2025	2030		Construction of a Line of 220 (400) kV Metoro - Palma and interconnection with SE Auasse	Long-term									6,523	6,523	6522.5	6522.5	6522.5	6,523			39,135
Auasse	220/110	2025	2030		Construction of a Line of 220 (400) kV Metoro - Palma and interconnection with SE Auasse	Long-term									3,717	3,717	3716.667	3716.667	3716.667	3,717			22,300
Pebane(Magiga/Caravela)	110/33	2020	2025		Construction of a 110kV Line, 140km, between Mocuba and Magiga / Caravela, in Pebane and its 110 / 33kV Substation	Long-term				2,612	2,612	2,612	2,612	2,612	2,612								15,674
Milange	110/33	2020	2025		Construction of 120km of 110kV Line between Mocuba and Milange and its Substation in Milange	Long-term				2,612	2,612	2,612	2,612	2,612	2,612								15,674
Moatize(Vale)	400/66/33	2018	2022		Construction of a Substation in Moatize from SE Vale	Long-term		7,827	7,827	7,827	7,827	7,827											39,135
Mussacama	66/33	2022	2023		Construction of 80km of Moatize - Mussacama 66kV Line and its Substation in Mussacama	Long-term						4,086	4,086										8,171
Ulongue	66/33	2022	2023		Construction of 80km of 66kV Mussacama - Ulongue Line and its Substation in Ulongue	Long-term						4,086	4,086										8,171
Guro	66/33	2018	2022		Construction of a 66kV Line, 90km between SE Matambo and Guro and its Substation in Guro	Long-term		1,634	1,634	1,634	1,634	1,634											8,171
Chongoene	275/110	2018	2021		Construction of 80km of 275kV line between new SE Macia and Chongoene, 275 / 110kV substation in Chongoene and interconnection with existing 110 & 33kV network	Long-term		7,703	7,703	7,703	7,703												30,811
Moamba	110/33	2017	2019		Construction of the SE 110 / 33kV in Moamba and interconnection with the existing network	Long-term	5,225	5,225	5,225														15,674
Tchumene	66/33	2016	2019		Construction of Beluluane Line - Tchumene and respective SE in Tchumene	Long-term	2,043	2,043	2,043														6,128
																							0
							7,267	73,350	308,969	313,449	313,449	264,999	255,537	252,957	31,294	19,547	19,547	19,547	19,547	19,547	0	0	1,919,004

Source: JICA Study Team, based on the information from EDM

Other investment plan

Network reinforcement project and Caia (Chimuara)-Nacala project etc. are listed.

Table 6.2-11 Transmission development plan (Other investment plan) (As of December 2017)

Voltage (kV)	from	to	length (km)	Construction start year	Commissioned year	Funding	Remarks	investment classification	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	[kUSD] total
275	Ressano Garcia	Dzimbene	142	2015	2017				9,325																9,325
220	Chibata	Dondo	170	2015	2017				11,617																11,617
110	Lindela	Massinga	110	2015	2017				4,510																4,510
110	Cuamba	Marrupa	110	2017	2019				4,510	4,510	4,510														13,530
275	Maputo	Beluluane	2	2018	2020					131	131	131													394
110	Massinga	Vilanculos	159.4	2018	2020					6,535	6,535	6,535													19,606
400	Chimuara	Namialo	780	2017	2022	IsDB, (AfDB,JICA)	Caia-Nacala		44,200	44,200	44,200	44,200	44,200	44,200											265,200
220	Namialo	Nampula	90	2017	2022	IsDB, (AfDB,JICA)	Caia-Nacala		3,075	3,075	3,075	3,075	3,075	3,075											18,450
220	Namialo	Nacala	100	2017	2022	IsDB, (AfDB,JICA)	Caia-Nacala		3,417	3,417	3,417	3,417	3,417	3,417											20,500
110	Chibabava	Vilanculos	240	2020	2022							9,840	9,840	9,840											29,520
275	New Marracuene	SE 11	14	2017	2019				919	919	919														2,758
66	Facim	SE 1	3	2017	2019				111	111	111														333
66	Infulene	CTM(DL3)	7.5	2017	2019		Rebuildng		278	278	278														833
66	Infulene	CTM(DL4)	7.5	2017	2019		Rebuildng		278	278	278														833
66	Infulene	Machava(DL6)	7.5	2017	2019		Rebuildng		278	278	278														833
66	CTM	SE 2(DL19)	5.4	2017	2019		Rebuildng		200	200	200														599
66	CTM	SE 3(DL18)	5.4	2017	2019		Rebuildng		200	200	200														599
									82,915	64,131	64,131	67,198	60,532	60,532	0	0	0	0	0	0	0	0	0	0	399,439

Source: JICA Study Team, based on the information from EDM

Table 6.2-12 Substation development plan (Other investment plan) (As of December 2017)

Substation	Voltage	Construction start year	Commissioned year	Funding	Remarks	investment classification	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	total [kUSD]
Dzimbene	275/110	2017	2017		275kV Ressano Garcia-Dzimbebe		30,811																30,811
Dondo	220/110	2017	2017		220kV Chibata-Dondo		22,300																22,300
Massinga	110/	2017	2017		110kV Lindela-Massinga		15,674																15,674
Marrupa	110/	2017	2019		110kV Cuamba-Marrupa		5,225	5,225	5,225														15,674
Vilanculos	110/	2018	2020		110kV Massinga-Vilanculos			5,225	5,225	5,225													15,674
Chimuara(Caia)	400/	2018	2022	IsDB, (AfDB,JICA)	400kV Caia-Nacala			7,827	7,827	7,827	7,827	7,827											39,135
Namialo	400/	2018	2022	IsDB, (AfDB,JICA)	400kV Caia-Nacala			7,827	7,827	7,827	7,827	7,827											39,135
Nacala valha	220/	2018	2022	IsDB, (AfDB,JICA)	400kV Caia-Nacala			4,460	4,460	4,460	4,460	4,460											22,300
Chibabava	110/	2018	2022		110kV Chibabava-Vilanculos			3,135	3,135	3,135	3,135	3,135											15,674
Facim	66/11	2017	2019		new substation		2,724	2,724	2,724														8,171
Lindela(STATCOM)		2017	2019				4,015	4,015	4,015														12,045
Infulene	275/66	2018	2020	JICA	Tr replace			4,586	4,586	4,586													13,757
																							0
							80,748	45,022	45,022	33,059	23,249	23,249	0	0	0	0	0	0	0	0	0	0	250,350

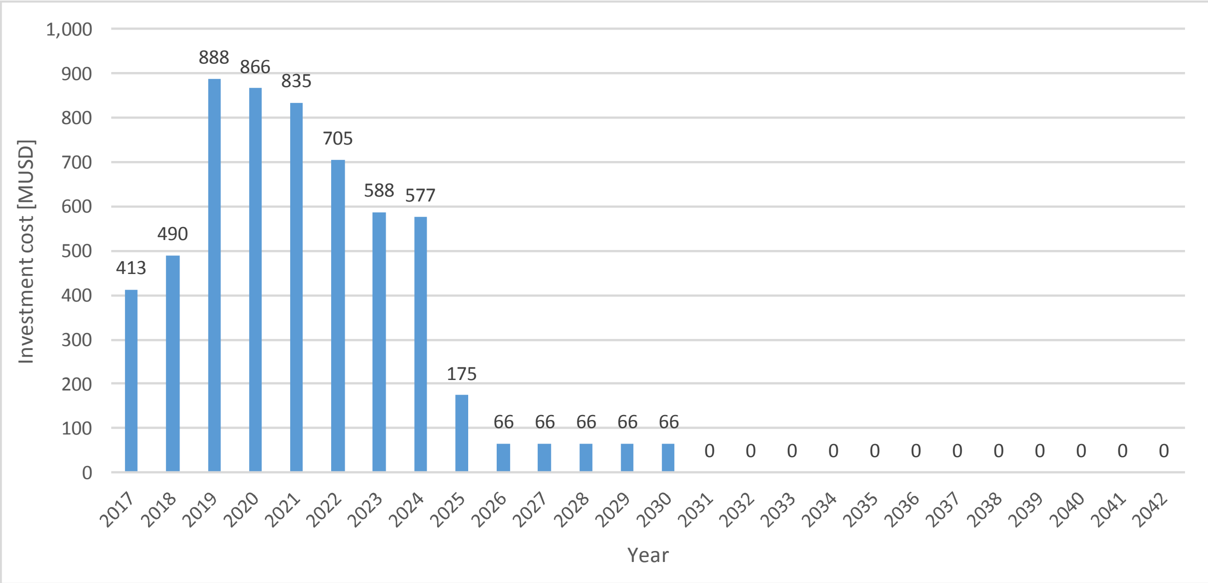
Source: JICA Study Team, based on the information from EDM

Table 6.2-13 Transmission line and substation investment cost (As of December 2017)

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	total
T/L	110	164	411	487	480	394	325	316	135	40	40	40	40	40	0	0	0	0	0	0	0	0	0	0	0	0	3,019
S/S	303	326	477	379	355	312	263	261	40	26	26	26	26	26	0	0	0	0	0	0	0	0	0	0	0	0	2,846
Total cost	413	490	888	866	835	705	588	577	175	66	66	66	66	66	0	0	0	0	0	0	0	0	0	0	0	0	5,867

*T/L: transmission line project, S/S: substation project, other: reactive power facilities plan and new dispatching center

Source: JICA Study Team, based on the information from EDM



Source: JICA Study Team, based on the information from EDM

Figure 6.2-1 Transmission investment cost by yearly EDM (As of December 2017)

6.2.3 Interconnector project

Numerous interconnector projects arise in Mozambique and these project teams are founded in EDM. Table 6.2-14 introduces each project team.

Table 6.2-14 Interconnector project

Project name
STE Backbone project
MoZiSa project
Mozambique – Zambia interconnector
Mozambique – Tanzania interconnector
Mozambique – Malawi interconnector

Below shows the progress of each interconnector project with the interviews from the directors.

(1) STE Backbone project

In 2000s, the plan stressing the interconnection between the Southern region, Maputo area where the load center is located and the Central region, Tete Province where had large potential of hydropower and thermal stations arose[9].

In 2009, the Mozambique's generation master plan disclosed different options for power generation in the country in parallel with the power transmission lines connecting the Central and Southern regions of the country. And at result, the original form of Mozambique regional transmission backbone project named Sociedade Nacional de Transporte de Energia (STE) was launched in 2011.

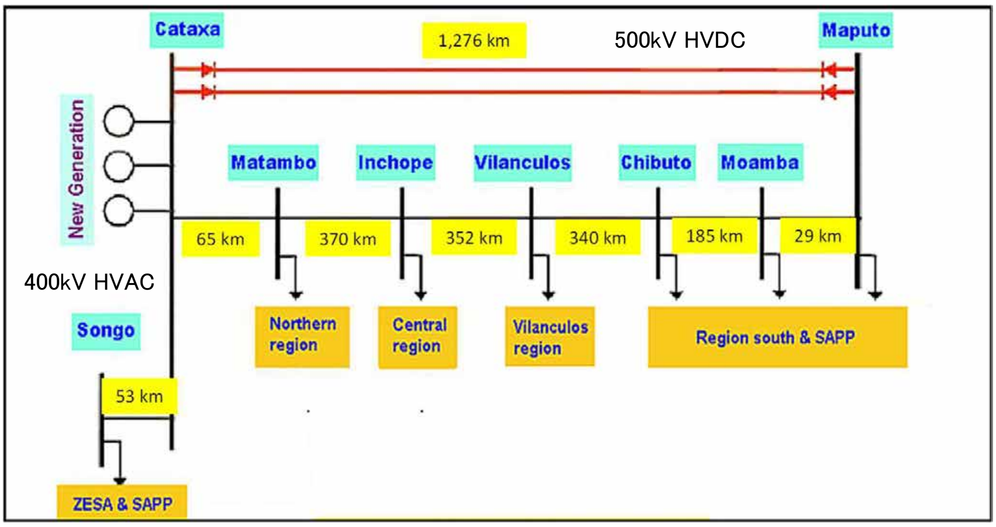
The current strategy of the STE backbone project is to wheel power from Central area where most of the generation takes place to the load center in the Southern area, while also providing access to the central region of the country. Further it will allow the power trade with other members of SADC through the Southern African Power Pool (SAPP).

Original specification of the transmission lines were two lines of 800kV High Voltage Direct Current (HVDC) plus one line of 400kV High Voltage Alternate Current (HVAC).

Currently the specification is a bit changed to utilize 500kV HVDC from original one [10].

[9] The regional transmission plan was called CESUL (Centro-Sul) and now it's called STE Backbone.

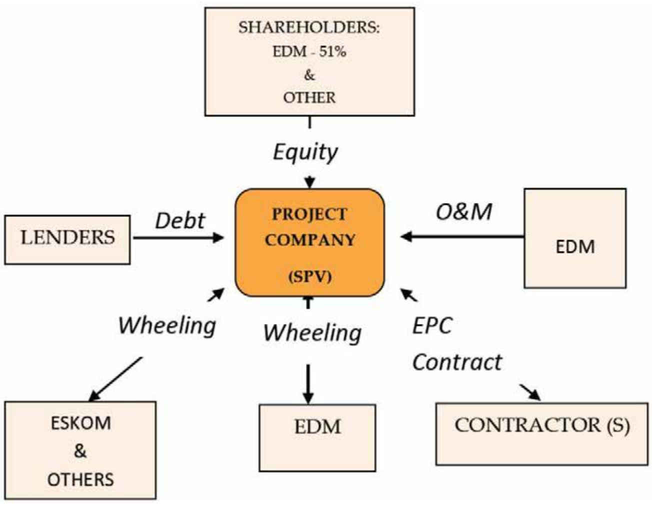
[10] A 400kV HVAC transmission line had been changed to 500kV design in the past, but now applies 400kV design with 400kV operation.



Source: JICA Study Team based on information by EDM

Figure 6.2-2 STE backbone project

SPV driving this project was founded in 2012 (see Figure 6.2-3). Financing was by China State Grid Corporation, Chinese state owned company (46% of all fund), EDM (20%), Eskom (20%) and consortium of Portuguese company such as REN (14%). The government of Mozambique participated this project through EDM.



Source: Mozambique transmission backbone project brief – SADC (2013)

Figure 6.2-3 Figure Project scheme of STE backbone project

SPV was planning to have the Joint Development Agreement (JDA) with shareholders to agree project scheme, budget plan, procurement procedures etc. The agreement however has not been signed.

The power from Tete area is planned to distribute to EDM and Eskom, while 20% is for EDM and the rest was for Eskom. Further power purchase agreement will be negotiated with off-takers, such as EDM, Eskom etc. and power producers, such as HCB, etc..

Mphanda Nkuwa hydropower generation project however sticks due to the unexpected difficulty of its developer. SPVs of Mphanda Nkuwa hydropower generation project and this project therefore can be liquidated by the government of Mozambique and the government takes the lead to promote this project, together with EDM and HCB[11].

Starting from 2017, the project moves forward. Conventional plan composed two phases, while phase-1 is a 400kV HVAC transmission line from Songo to Maputo and a 500kV HVDC transmission line from Cataxa to Maputo (the 1st line) and phase-2 is an another 500kV HVDC transmission line (the 2nd line).

Revised plan has three phases, while phase-1-1 is a 400kV HVAC transmission line from Vilanculos to Maputo to meet introduction of thermal power generation in Temane, phase-1-2 is the rest of former HVAC section, and phase-1 is 500kV HVDC 2 circuits transmission lines and phase-2 is the reinforcement of converter station for HVDC. The current progress of each phase is shown in Table 6.2-15.

Table 6.2-15 Current status of STE backbone project

Phase-1	EIA: FS and EIA completed in 2012 are being updated except for the route in vicinity of Maputo due to route rearrangement. FS and EIA for the rearranged route, from Vilanculos to Marraquene, should be newly studied. EIA will be finished in end of January 2018, and Resettlement Action Plan (RAP) will be done in 2018. Total cost of EIA is 0.55MUSD. Construction: The construction will be started in 2019 and its completion will be in 2022. Construction cost is estimated 600MUSD with 4xTern conductor (950MW).
Phase-1-2 (HVAC), Phase-1&2 (HVDC)	EIA: Route rearrangement in Tete Province needs to study newly due to reconsideration of gird access to Lupata hydropower and coal-fired thermal power plants. FS and EIA for these routes are now studying and schedule of them are same as that of phase-1. Construction: Funding is not yet determined. Neither does the specification, such as transmission capacity. Construction of 400kV HVAC and that of 500kV HVDC should be synchronized due to system reliability even though it is needed to supply power to load center in Central region such as Beira with HVAC as soon as possible. Total construction cost for 400kV HVAC including phase-1 component and a 500kV HVDC transmission line will be estimate 1.1～1.3BUSD.

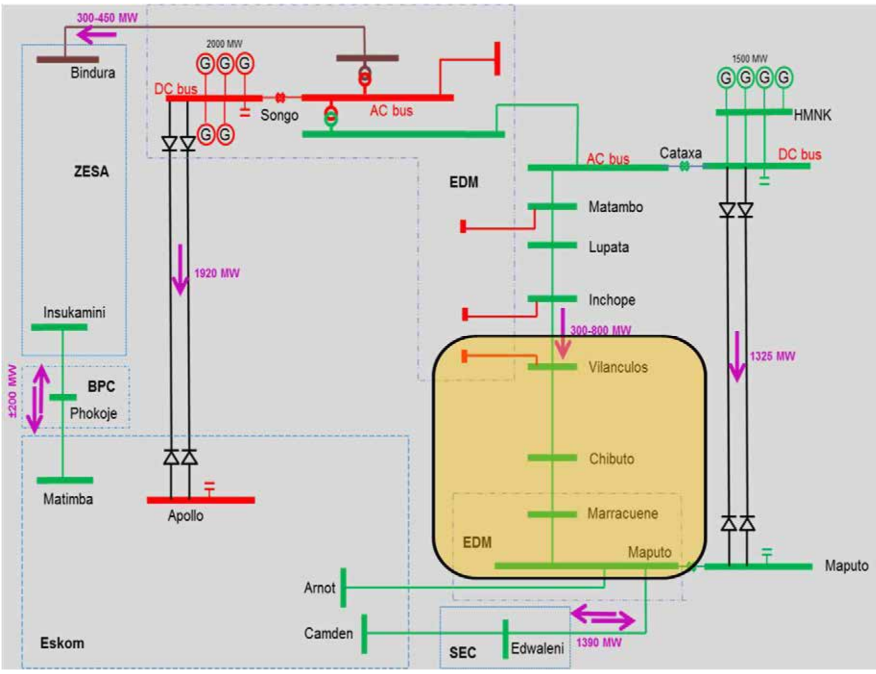
Source : JICA Study team based on EDM's interview

[11] The transfer to the government has not been completed as of April 2017.

(2) Temane transmission project

In February 2017, the Temane transmission project[12], a component of the STE backbone project as the phase-1 was disclosed in accordance with the launch of gas-fired generation implementation[13] in Temane, Central region in Mozambique.

This transmission project is the portion of STE backbone project and positioned a proceeding lot prior to the launch of entire project. The progress of Mphanda Nkuwa hydropower generation project and STE backbone project, which are steered by the Government of Mozambique are mandated by EDM and HCB. That is the reason why HCB has healthy financial structure to promote their investments. Its transmission route is from MGtP generator to Maputo, specifically 400kV double circuits will be from MGtP to Vilanculos substation with two bundled Tern conductors, and 400kV single circuit will be from Vilanculos substation to Maputo substation via Chibulo and Matalane substations with four bundled Tern conductors. The project cost will be estimated 500 – 600 MUSD. 2021 is the target of the commissioning year of this project.



Source: Temane Transmission Project – Development Update and Status (Feb.2017)

Figure 6.2-4 Temane transmission project

12 It is called TTP, Temane Transmission Project.

13 It is called MGtP, Mozamique Gas to Power.

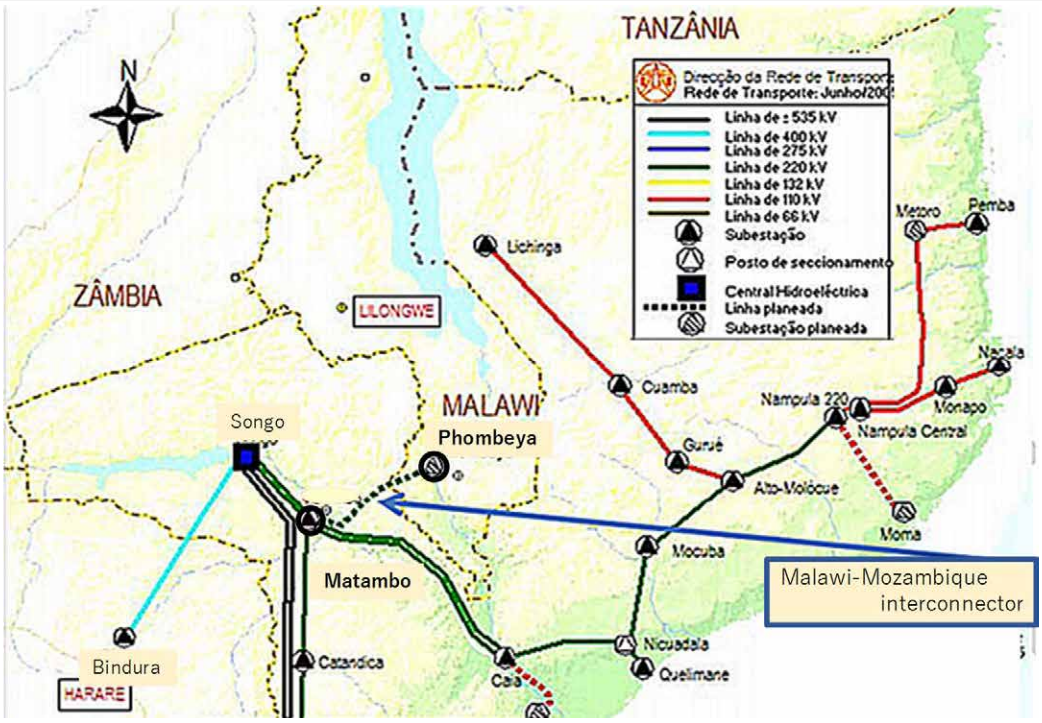
(3) Mozambique - Malawi Project

In 1990s, the Government of Malawi aimed the construction of interconnector as one of the strategic development plan to uplift electricity access and improve electric power quality in Republic of Malawi, which had no interconnectors to trade power[14].

FS conducted in 1996 proposed a 220kV transmission line from Blantyre to Matambo, Central region in Mozambique. Recently terminal has been changed to Phombeya due to reconsideration of system configuration. Further, voltage class for the interconnector has been changed to 400kV due to the regional trunk transmission line's upgrading.

The project had been accelerated when the Government of Mozambique and the Government of Malawi had signed IGMoU regarding this interconnector project.

Originally this project composes two phases, while one is from Matambo to Phombeya, Malawi and the other is from Phombeya to Nacala. EDM and Electricity Supply Corporation of Malawi Limited (ESCOM), power utility in Malawi will construct their own facilities in their own area to hold it as their assets. In this condition, former route from Matambo to Phombeya is just on progress.

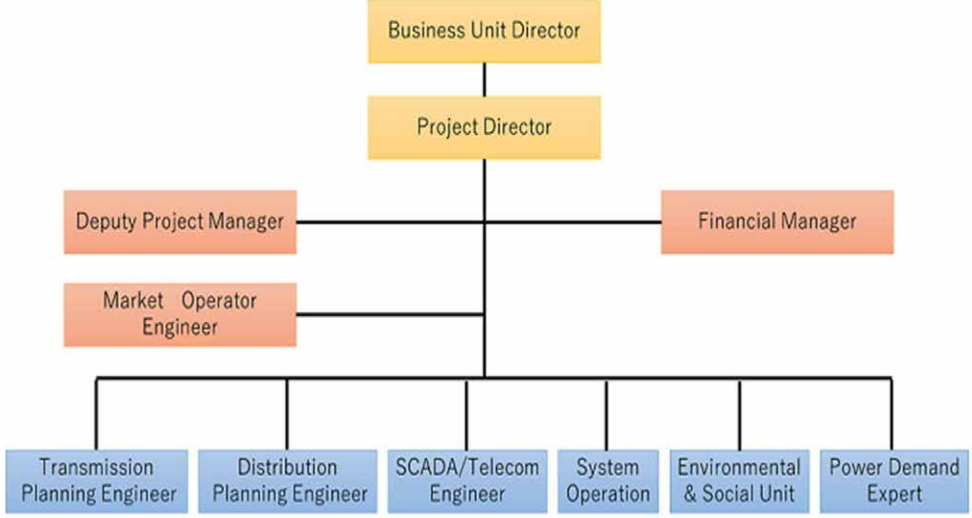


Source: Mozambique - Malawi Interconnector Project Brief (2013), SADC

Figure 6.2-5 Malawi – Mozambique interconnector project

[14] Especially drought situation hit in 1914 to 1935 along the Shire River basin influenced this solution to keep the supply capacity in the evidence of SADC.

Currently the project team in EDM is driving the project. (See Figure 6.2-6)



Source: EDM

Figure 6.2-6 Malawi – Mozambique interconnector project team formation

Under the management of the project team FS for the route from Matambo to Phombeya was implemented and completed on 15th December 2017. And EIA will succeed in December 2017. Budget for FS was funded by Norwegian Trust Fund which is being administered by the World Bank. Construction will be started in February 2019 and its completion is targeted in 2021.

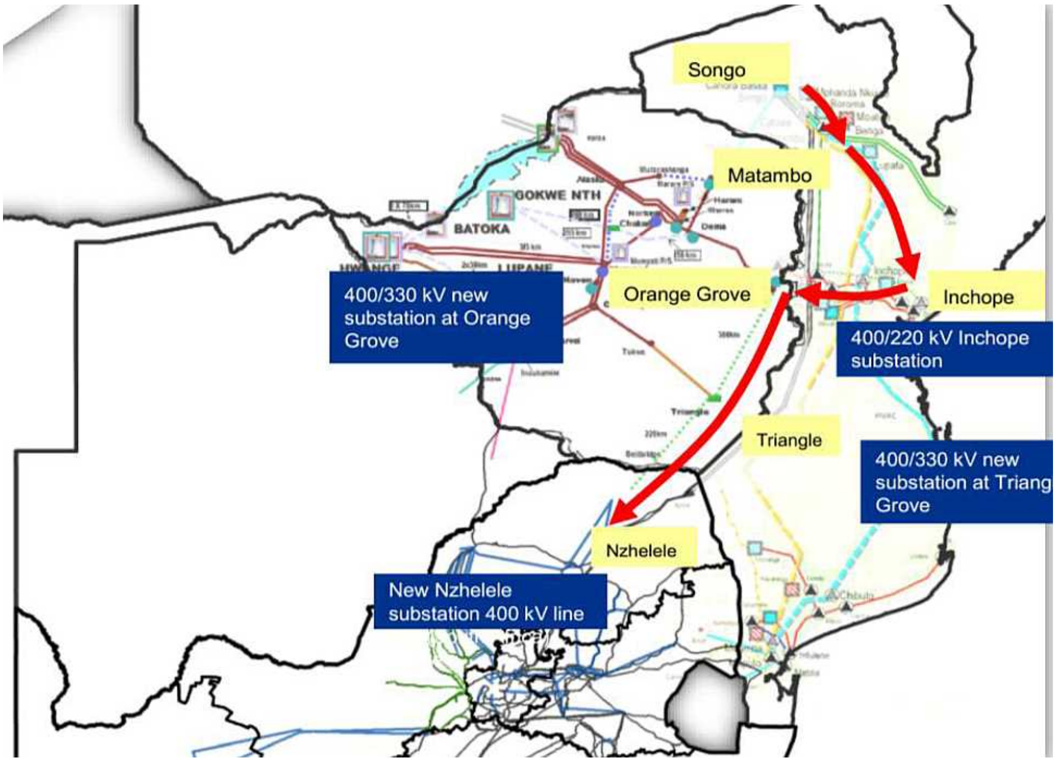
Transmission line applies 400kV and its capacity is 1,200MW, Preliminary engineering design is ongoing together with preparation of draft tender documents. EDM and ESCOM have already agreed to follow the double circuit design but with only one circuit being implemented initially while the second circuit will be implemented in 2025 and the potential financiers have already agreed with the selected design option by EDM and ESCOM.

Negotiations between EDM and ESCOM on the bilateral commercial and technical agreements begun in June 2017. Signing of these agreement in December 2017.

(4) Mozambique – Zimbabwe – South Africa interconnector project (MoZiSa project)

The Zambezi River, where has much hydropower potential, lies between Zambia and Zimbabwe as an international river and flows into the Indian Sea through Tete Province. Development of large-scale hydropower generations on the Zambezi River Basin is one of the most important issue for not only the Republic of Mozambique but SAPP.

Further, Tete Province has abundant coal resources. To energize the power trade from this area to not only nationwide but whole SAPP, two SAPP priority projects entitled the 2nd Mozambique - Zimbabwe Interconnector and the 2nd Zimbabwe - South Africa Interconnector were renovated to the project, Mozambique-Zimbabwe-South Africa interconnector project (MoZiSa project), with brand-new concept.



Source: JICA Study Team

Figure 6.2-7　MoZiSa project

A point to be emphasized of this project is that this project has an integrated shape of two existing interconnector projects adding Mozambican national grid's development by feeding power to northern region of Mozambique from central region of Mozambique where rich in coal and water resource improving power supply quality.

As of November 2015, a technical input report was submitted to the countries concerned and was reviewed.

Further this project will be separated into two phases, namely Mozambique – Zimbabwe and Zimbabwe – South Africa.

Regional transmission development plan from Songo to Inchope in central region of Mozambique is held on the same route with MoZiSa and STE backbone projects despite both project teams are not studying this issue jointly. To design the system well and operate smoothly, it is important to share the information with both project team, it is expected that designing of this development should be done with the aspect of system operation.

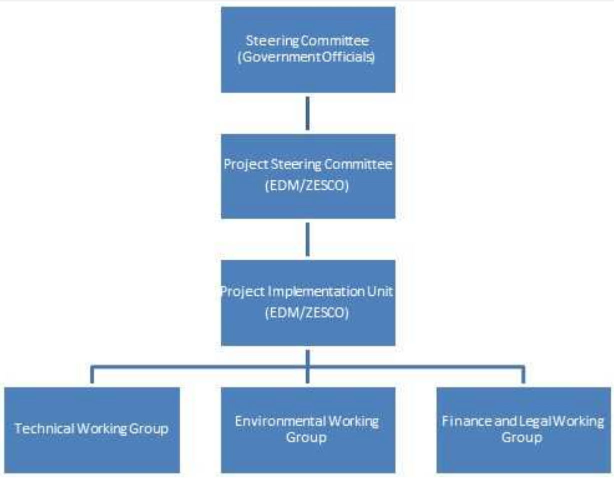
(5) Zambia-Mozambique Project

Source: Proposed Mozambique-Zambia HVAC Interconnector Project Concept Paper (Draft) - EDM (2016)

Figure 6.2-8 Zambia – Mozambique interconnector project

In March 2016, the Government of Mozambique and the Government of Zambia signed IGMoU to study the feasibility of this interconnector with implementation of 1,200MW coal-fired power plant with Advanced Ultra Super Critical (A-USC) technology.

As of December 2016, project teams are founded in EDM and in ZESCO, as shown in Figure 6.2-9.



Source: Zambia-Mozambique Interconnector project office, EDM

Figure 6.2-9 Project team framework of Zambia – Mozambique project

Table 6.2-16 Project implementation and project steering units of Zambia – Mozambique interconnector

Project Implementation Unit (utility level, as per IUMoU)	
The ZESCO members of the PIU are:	
Name	**Designation**
Kennedy Mwanza	Project Manager Transmission Development North (Team Leader for Transmission Line)
Mundia Simainga	Senior Manager Consultancy Services (Team Leader for Generation)
Chitembo Simwanza	Senior Manager Business Development
Saidi Chimya	Senior Manager Treasury
Brian C. Kambole	Senior Manager Procurement
McRobby Chiwale	Senior Manager Legal Services
Brenda L. Musonda Chizinga	Manager Environmental Analysis Unit
The EDM members of the PIU are:	
Name	**Designation**
Jonas Chitsumba	Project Director
Esmeralda Calima	Deputy Planning Director
Fernando Balane	Financier Business Development Unity
António Munguambe	Market Operator Engineer
Joaquim Ten Jua	Generation Engineer
Aderito Barros	Transmission Engineer

Project Steering Committee (utility level, as per IUMoU)	
ZESCO members of the PSC (utility level)	
Victor M. Mundende	Managing Director
Webster Musonda	Director Transmission
Fidelis Mubiana	Director Generation
Rodgers Chisambi	Director Finance
Mbile Vukovic	Director Legal
EDM members of the PSC (utility level)	
Carlos Yum	Board Member for Operations
Aly Sicola	Board Member for Planning and Projects
Noel Ngovene	Board Member for Finance
João Paulo	Legal Assistant for Board Members

Source: Zambia-Mozambique Interconnector project office, EDM

3.5MUSD is funded by NEPAD Infrastructure Project Preparation Facility (NEPAD IPPF) for the FS, and FS will be done by both power utilities concerned under SAPP Coordination Centre's management.

The strategies of this interconnector are not only power evacuation from 1,200MW-class coal-fired power plant to Zambian grid but power supply to national grid as well as SAPP northern area and even EAPP market. Sources for power interchange are therefore hydropower generations and coal-fired power plants in Tete Province. Meanwhile, coal-fired generation developments are still stagnated by the environmental issues and discrepancy of WB's policy.

Project teams have discussed since July 2016. The meetings are involved the experts from SAPP Project Advisory Unit (SAPP PAU) to assist the progress of this project.

According to the project director, the transmission line will be owned by EDM and ZESCO respectively in accordance with their equities without establishment of SPV. The construction will be started in 2019 and completed in 2022 in preferable condition. In case of delay of funding, the construction will be started in 2021 and completed in 2024. And double circuits will be introduced.

The specification of conductor is not yet determined. Originally Mozambican grid applies 4 bundled Tern (capacity is 1,100MW) as the 400kV transmission line.

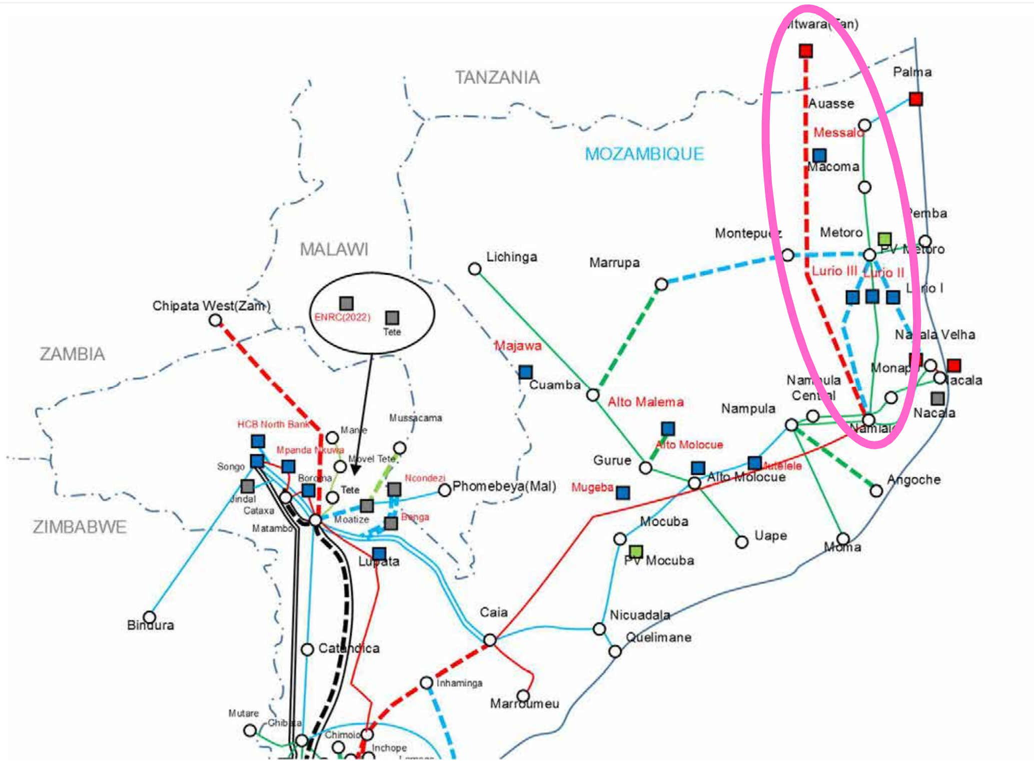
Table 6.2-17 Zambia-Mozambique Interconnector project roadmap

	MOZAMBIQUE - ZAMBIA POWER INTERCONNECTOR: IMPLEMENTATION ROADMAP		
	Name of Activity		
1	Signing of IGMoU		Complete
2	Signing of IUMoU		Complete
3	Project Kick-Off Meeting		Complete
4	Institutional Arrangements: Appointment of Project members (SC, PMU)		Complete
5	Preparation of the Project Concept Paper [1 month]		Complete
6	Preparation of ToRs for Transaction Advisor [1 month]		Complete
8	Mobilising Finances for Preparatory Activties [6 months]		Complete
9	Procurement of (Legal, finance, Technical, ESIA) [6 months]		Started
10	TA Activities		Started
11	Feasibility Study by Consultant; → Bankable Report, Design and Tender Documents [24 months]		
	Phase 1		
	Concept Study Report	Month 3	
	Scoping Study Draft Report.	Month 5	
	Scoping Study Final Report.	Month 6	
	Part-2 TOR, including approach, schedule and costing.	Month 6	
	Phase 2		
	Revised Pre-feasibility Report	Month 8	
	Draft Feasibility Report	Month 18	
	Final Draft Feasibility Report	Month 20	
	Final Feasibility Report	Month 21	
	Phase 3		
	EPC Tender Document	Month 25	
	EPC Contractor Letter of Appointment	Month 31	
	Financial Close Report	Month 31	
12	ESIA by Consultant; → EIS and RAP	24 months	
	Environmental & Social Review		
	ESIA Report		
	RAP Report		
13	Commercial and Legal Closure	12 months	
	Detailed Market Analysis		
	Business Case		
	Preferred Commercial Structure		
	Legal & Regulatory Assessment		
	Development of Business Structure		
	Develop Legal Framework		
	Funding agreements		
	Commercial closure		
14	Financial Feasibility Report & PIM	24 Months	
15	Commercial closure	24 Months	
17	Financial Close	24 Months	
18	Financial Mobilisation	24 months	
19	Procurement of Project Supervision Consultant	6 months	
20	Construction of Interconnector (36 months)	36 months	

Source: Zambia-Mozambique Interconnector project team, EDM

(6) Mozambique - Tanzania interconnector project

In March 2016, EDM and TANESCO, Tanzanian power utility signed Inter Utility Memorandum of Understanding (IUMoU) to conduct a feasibility study for development of interconnector to energize gas-fired generation enhancement in Rovuma area, border between Tanzania and Mozambique. With this interconnector, EDM will be keen to feed power generated at northern area to Eastern Africa Power Pool (EAPP) through TANESCO grid. And Tanesco is keen to send power generated at Mtwara area to Mozambican grid as one of the supply options.



Source: JICA Study Team

Figure 6.2-10 Tanzania – Mozambique interconnector project

In October 2016, EDM and TANESCO established the project teams in each utility. This project is, however still in conceptual stage and is being prepared to sign the IGMoU to way forward in earnest.

The budget for EIA study, which is the component of feasibility study, is estimated around 3 MUSD. This amount would be requested to some trust fund of SAPP. Currently the main theme of this project is balancing demand in northern area with the output from gas-fired power plant (300MW) in Mtwara, Tanzania in preparation for the delay of commissioning of the regional grid integration including STE project. Further, this interconnector will be utilized to evacuate the bulk power generated in Mozambique to Tanzania and EAPP to be the powerful exporter by the strategies of system planning division, EDM.

Planned route will be from Namialo to Mtwara via Metoro with 400kV transmission line. And currently any other apparent specifications are not determined. Target of the commissioning is set in 2021.

6.2.4 Issues for system planning

EDM applies the N-1 criterion as the standard for system planning and operations, however current configuration of the system cannot satisfy this criterion due to complicated constraints, such as a shortage of budget, rapid growth of the demand etc. 66kV system in Maputo is designed to be able to switch the load from current system to neighboring system without its blackout[15] to minimize the SAIDI. 110kV system in southern part of Mozambique linking to Lindela and Manhiça applies single radial configuration, however this system cannot meet N-1 criterion thereby.

System planning for hereafter should be complied with N-1 criterion strictly as the standards and should be establish the efficient work styles, such as the classification of substation configuration in accordance with the categorized load centers, to mobilize all over the planning sections

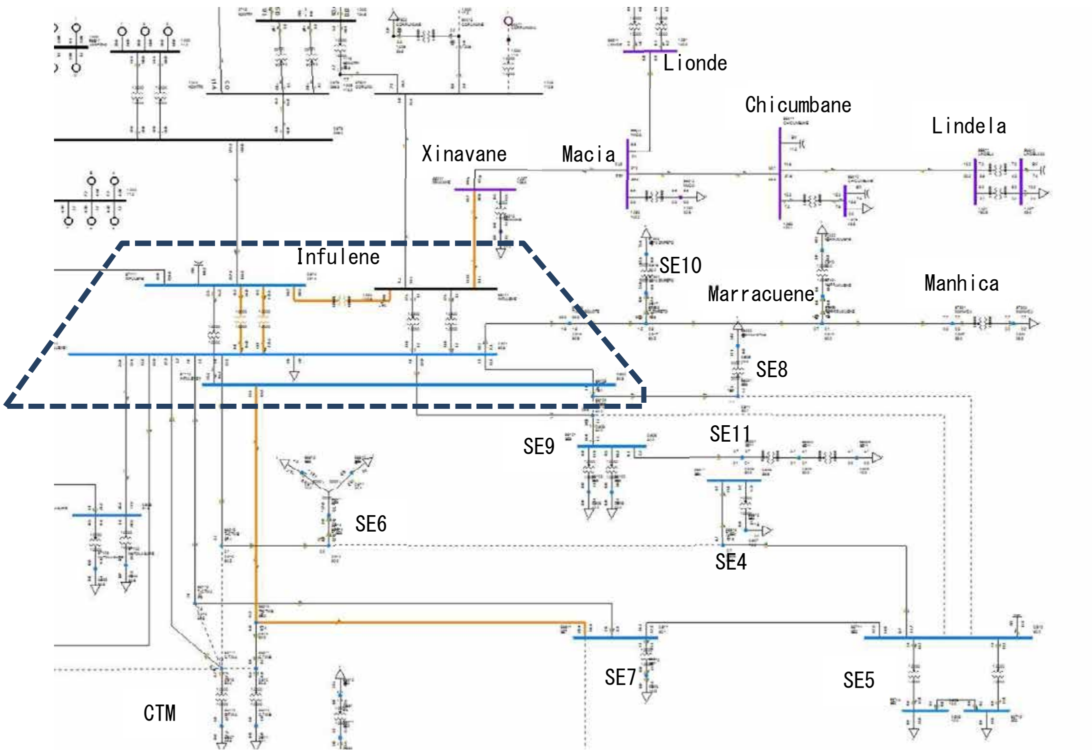


Figure 6.2-11 Network in Maputo city

6.2.5 Power system planning

(1) Condition of power system planning

Condition of power system analysis using PSS/E are as follows.

Analysis year	2022, 2027, 2032, 2042
Demand condition	Peak demand, Off peak demand
Analysis items	Power flow with N-1 check and short circuit analyses

✓ Consideration of N-1 criterion

15 It is named loop switching.

In order to ensure the soundness of the power system, overload of the equipment considering a single fault of the transmission line or the transformer is confirmed. Since the N-1 criterion is not satisfied in the current system, a power system that satisfies the N-1 criterion is planned by the analysis in 2022.

✓ Condition of each substation demand forecast

As substations demand forecast, heavy loading and light loading are considered. Demand for the substation at light loading was set at 45% of heavy loading. This value was set to the ratio of the minimum demand 424 MW (7 AM, 10th July's data) to the maximum demand 876 MW (8 PM, 29th February's data), using the generation output data for each hour for each month of 2016.

✓ Short circuit analysis

The fault current at three-phase of substation of over 66kV was confirmed. And it was confirmed that the fault current was under 31.5kA in the 66kV system, under 40kA in the 110kV system, under 50kA in the 220 or 275 kV system, under 63 kA in the 400kV system.

✓ System voltage criteria

The allowable voltage of the system is as follows.

Condition	Allowable voltage range
Normal system state	95%～105%
Contingency state	90%～110%

✓ Power interchange of international interconnector

As for the power interchange amount of the international interconnector after 2024, the value in the electricity export scenario 1-1 (20% of domestic demand exported) which is the recommended development scenario of the power development plan is used. The power interchange balance of each international interconnector are as follows. The 60% of power interchange will be exported to South Africa with large system capacity, and the rest will be exported to Zimbabwe (MoZiSa and Zimbabwe interconnector), Zambia, Malawi and Tanzania.

Table 6.2-18 Power interchange of international interconnector

	2022	2027	2032	2042
South Africa Maputo-Arnot (Existing) Maputo-Carmden (Existing)	950MW※1 (import)	345-950※1 =605MW (import)	475-950※1 =475MW (import)	812-950※1 =138MW (import)
Zimbabwe MoZiSa (scheduled to commence operation in 2025)	0MW	58MW	79MW	108MW
Zimbabwe Songo-Bindura（Existing）	0MW	58MW	79MW	108MW
Zambia Zambia interconnector (scheduled to commence operation in 2021)	0MW	58MW	79MW	108MW
Malawi Malawi interconnector (scheduled to commence operation in 2021)	0MW	58MW	79MW	108MW
Tanzania Tanzania interconnector (scheduled to commence operation in 2026)	0MW	58MW	0MW	135MW
Total	0-950※1 =950MW (import)	575-950※1 =375MW (import)	791-950※1 =159MW (import)	1,354-950※1 =404MW

※1：The value of power interchange for South Africa is deducted the import amount of 950MWfor Mozal

Source: JICA Study Team

(2) Transmission line and substation specification and cost

Specification and cost of transmission line and substation for power system planning were selected from standardly used in EDM based on the Final Master Plan update Report. Also, the construction period was set as 4 years, and the investment cost was distributed. The value used for the investment cost calculation is the cost as of 2017 taking into consideration the rise in the price of the US dollar. Since the unit cost of the Final Master plan was calculated in 2012. Table 6.2-19 - Table 6.2-21 show the unit cost of each facilities

Table 6.2-19 Unit cost of transmission lines

Specification	Base unit cost*1	Inflation rate*2	Correction unit cost
400kV 4xTern	310,000 USD/km	1.095	340,000 USD/km
275kV 2xBear	180,000 USD/km	1.095	197,000 USD/km
220kV 2xCondor	187,000 USD/km	1.095	205,000 USD/km
110kV 1xDove	112,000 USD/km	1.095	123,000 USD/km
66kV 1xDove	101,000 USD/km	1.095	111,000 USD/km
66kV 2x Dove	122,000 USD/km	1.095	134,000 USD/km
DC500kV 4xLapwing	312,000 USD/km	1.095	342,000 USD/km

*1 Final Master Plan update Report

*2 IMF data (2012-2017)

Source : JICA study team

Table 6.2-20 substation unit cost

Specification	Base unit cost*1	Inflation rate*2	Correction unit cost
400/220kV Double Busbar substation 250MVA transformer x2	35.73 MUSD	1.095	39.135 MUSD
400/33kV Double Busbar substation 40MVA transformer x2	24.93 MUSD	1.095	27.306 MUSD
275/110kV Double Busbar substation 250MVA transformer x2	28.13 MUSD	1.095	30.811 MUSD
275/33kV Double Busbar substation 40MVA transformer x2	19.05 MUSD	1.095	20.865 MUSD
220/110kV Double Busbar substation 100MVA transformer x2	20.36 MUSD	1.095	22.3 MUSD
220/33kV Double Busbar substation 40MVA transformer x2	15.84 MUSD	1.095	17.35 MUSD
110/66kV Double Busbar substation 125MVA transformer x2	14.31 MUSD	1.095	15.674 MUSD
100/33kV Double Busbar substation 40MVA transformer x2	10.61 MUSD	1.095	11.621 MUSD
66/33kV Single Busbar substation 40MVA transformer x2	7.46 MUSD	1.095	8.171 MUSD
Converter station of a 2,650MW HVDC bipolar transmission line	546 MUSD	1.095	597.87 MUSD

*1 Final Master Plan update Report

*2 IMF data (2012-2017)

*3 Base cost, Transformer cost, Line bay cost, Transformer bay cost

Source: JICA study team

Table 6.2-21 Transformer additional unit cost

Specification	Base unit cost*1	Inflation rate*2	Correction unit cost
400/220kV 250MVA transformer	15.6 MUSD	1.095	17.087 MUSD
400/33kV 40MVA transformer	10.96 MUSD	1.095	12.004 MUSD
275/110kV 250MVA transformer	12.56 MUSD	1.095	13.757 MUSD
275/33kV 40MVA transformer	8.42 MUSD	1.095	9.222 MUSD
220/110kV 100MVA transformer	8.94 MUSD	1.095	9.792 MUSD
220/33kV 40MVA transformer	7.08 MUSD	1.095	7.755 MUSD
110/66kV 125MVA transformer	6.41 MUSD	1.095	7.021 MUSD
110/33kV 40MVA transformer	4.75 MUSD	1.095	5.203 MUSD
66/33kV 40MVA transformer	3.41 MUSD	1.095	3.735 MUSD

*1 Final Master Plan update Report

*2 IMF data (2012-2017)

*3 Base cost (extension), Transformer cost(additional), Line bay cost(additional), Transformer bay cost

Source: JICA study team

(3) substation demand forecast

Table 6.2-22 – Table 6.2-23 show substation demand forecast. The maximum demand of each substation in 2017 ware provided by EDM. Demand for substation in each year was calculated based on the demand growth rate of each province calculated by the demand forecasting JST team and corrected to match with the demand of whole Mozambique. The new substation was planned to satisfy the N-1 criteria in 2022 with the composition of 40MVA as a standard. And also, the lifetime of the transformer is assumed to be 30 Years, and plan to replace the transformer that has passed 30 years.

Table 6.2-22 North-Central area substation demand forecast

[illegible]

Source: JICA Study Team

Table 6.2-23 South area substation demand forecast

bus number	bus name	Tr.(MVA)/installed year								Province	2017			2018			2019			2020			2021			2022			2023			2024			2025			2026			2027			2028			2029			2030			2031			2032			2033			2034			2035			2036			2037			2038			2039			2040			2041			2042		
		Tr.1		Tr.2		Tr.3		Tr.4			Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA	Pload	Qload	MVA
97712	Boane 33	30	1979	40	2018	40	2022			Maputo	15.4	8.5	17.6	21.8	12.0	24.9	29.0	16.0	33.2	30.9	17.1	35.3	34.1	18.8	38.9	18.6	10.3	21.3	20.2	11.2	23.1	21.9	12.1	25.0	23.6	13.0	27.0	25.3	14.0	28.9	27.0	14.9	30.9	28.8	15.9	32.9	30.5	16.9	34.9	32.3	17.8	36.9	34.4	19.0	39.2	24.2	13.3	27.6	25.5	14.1	29.1	26.8	14.8	30.6	28.2	15.6	32.2	29.6	16.3	33.8	31.1	17.1	35.5	32.6	18.0	37.2	34.1	18.8	38.9	26.8	14.8	30.6	28.0	15.5	32.0	29.3	16.2	33.5
	2nd Boane 33	40	2022	40	2022					Maputo																18.6	10.3	21.3	20.2	11.2	23.1	21.9	12.1	25.0	23.6	13.0	27.0	25.3	14.0	28.9	27.0	14.9	30.9	28.8	15.9	32.9	30.5	16.9	34.9	32.3	17.8	36.9	34.4	19.0	39.2	24.2	13.3	27.6	25.5	14.1	29.1	26.8	14.8	30.6	28.2	15.6	32.2	29.6	16.3	33.8	31.1	17.1	35.5	32.6	18.0	37.2	34.1	18.8	38.9	26.8	14.8	30.6	28.0	15.5	32.0	29.3	16.2	33.5
	3rd Boane 33	40	2031	40	2031					Maputo																																														24.2	13.3	27.6	25.5	14.1	29.1	26.8	14.8	30.6	28.2	15.6	32.2	29.6	16.3	33.8	31.1	17.1	35.5	32.6	18.0	37.2	34.1	18.8	38.9	26.8	14.8	30.6	28.0	15.5	32.0	29.3	16.2	33.5
	4th Boane 33	40	2040	40	2040					Maputo																																																																									26.8	14.8	30.6	28.0	15.5	32.0	29.3	16.2	33.5
97522	Manhica 33	30	1985	40	2022	40	2022			Maputo	7.7	2.8	8.2	10.9	4.0	11.6	14.5	5.3	15.5	15.5	5.6	16.5	17.0	6.2	18.1	18.6	6.8	19.8	20.2	7.4	21.5	21.9	8.0	23.3	23.6	8.6	25.2	25.3	9.2	26.9	27.0	9.8	28.8	28.8	10.5	30.6	30.5	11.1	32.5	32.3	11.8	34.4	34.4	12.5	36.6	36.3	13.2	38.6	19.1	6.9	20.3	20.1	7.3	21.4	21.1	7.7	22.5	22.2	8.1	23.6	23.3	8.5	24.8	24.4	8.9	26.0	25.6	9.3	27.2	26.8	9.7	28.5	28.0	10.2	29.8	29.3	10.7	31.2
	2nd Manhica 33	40	2033	40	2033					Maputo																																																	19.1	6.9	20.3	20.1	7.3	21.4	21.1	7.7	22.5	22.2	8.1	23.6	23.3	8.5	24.8	24.4	8.9	26.0	25.6	9.3	27.2	26.8	9.7	28.5	28.0	10.2	29.8	29.3	10.7	31.2
97512	Machanva 33	30	2004	30	2004	40	2022	40	2022	Maputo	41.3	10.8	42.7	58.4	15.3	60.4	77.9	20.4	80.5	82.9	21.7	85.7	91.4	23.9	94.4	33.3	8.7	34.4	36.2	9.5	37.4	29.3	7.7	30.3	31.7	8.3	32.8	33.9	8.9	35.1	36.2	9.5	37.5	38.6	10.1	39.9	32.8	8.6	33.9	34.7	9.1	35.9	36.9	9.6	38.1	32.4	8.5	33.5	34.2	8.9	35.3	36.0	9.4	37.2	37.8	9.9	39.1	34.0	8.9	35.2	35.7	9.3	36.9	37.4	9.8	38.7	34.3	9.0	35.4	35.9	9.4	37.1	37.6	9.8	38.9	35.0	9.1	36.1
	2nd Machanva 33	40	2022	40	2022					Maputo																33.3	8.7	34.4	36.2	9.5	37.4	29.3	7.7	30.3	31.7	8.3	32.8	33.9	8.9	35.1	36.2	9.5	37.5	38.6	10.1	39.9	32.8	8.6	33.9	34.7	9.1	35.9	36.9	9.6	38.1	32.4	8.5	33.5	34.2	8.9	35.3	36.0	9.4	37.2	37.8	9.9	39.1	34.0	8.9	35.2	35.7	9.3	36.9	37.4	9.8	38.7	34.3	9.0	35.4	35.9	9.4	37.1	37.6	9.8	38.9	35.0	9.1	36.1
	3rd Machanva 33	40	2022	40	2022					Maputo																33.3	8.7	34.4	36.2	9.5	37.4	29.3	7.7	30.3	31.7	8.3	32.8	33.9	8.9	35.1	36.2	9.5	37.5	38.6	10.1	39.9	32.8	8.6	33.9	34.7	9.1	35.9	36.9	9.6	38.1	32.4	8.5	33.5	34.2	8.9	35.3	36.0	9.4	37.2	37.8	9.9	39.1	34.0	8.9	35.2	35.7	9.3	36.9	37.4	9.8	38.7	34.3	9.0	35.4	35.9	9.4	37.1	37.6	9.8	38.9	35.0	9.1	36.1
	4th Machanva 33	40	2024	40	2024					Maputo																						29.3	7.7	30.3	31.7	8.3	32.8	33.9	8.9	35.1	36.2	9.5	37.5	38.6	10.1	39.9	32.8	8.6	33.9	34.7	9.1	35.9	36.9	9.6	38.1	32.4	8.5	33.5	34.2	8.9	35.3	36.0	9.4	37.2	37.8	9.9	39.1	34.0	8.9	35.2	35.7	9.3	36.9	37.4	9.8	38.7	34.3	9.0	35.4	35.9	9.4	37.1	37.6	9.8	38.9	35.0	9.1	36.1
	5th Machanva 33	40	2029	40	2029					Maputo																																						32.8	8.6	33.9	34.7	9.1	35.9	36.9	9.6	38.1	32.4	8.5	33.5	34.2	8.9	35.3	36.0	9.4	37.2	37.8	9.9	39.1	34.0	8.9	35.2	35.7	9.3	36.9	37.4	9.8	38.7	34.3	9.0	35.4	35.9	9.4	37.1	37.6	9.8	38.9	35.0	9.1	36.1
	6th Machanva 33	40	2032	40	2032					Maputo																																															32.4	8.5	33.5	34.2	8.9	35.3	36.0	9.4	37.2	37.8	9.9	39.1	34.0	8.9	35.2	35.7	9.3	36.9	37.4	9.8	38.7	34.3	9.0	35.4	35.9	9.4	37.1	37.6	9.8	38.9	35.0	9.1	36.1
	7th Machanva 33	40	2036	40	2036					Maputo																																																												34.0	8.9	35.2	35.7	9.3	36.9	37.4	9.8	38.7	34.3	9.0	35.4	35.9	9.4	37.1	37.6	9.8	38.9	35.0	9.1	36.1
	8th Machanva 33	40	2039	40	2039					Maputo																																																																				34.3	9.0	35.4	35.9	9.4	37.1	37.6	9.8	38.9	35.0	9.1	36.1
	9th Machanva 33	40	2042	40	2042					Maputo																																																																											35.0	9.1	36.1
97812	Salamanga 33	10	2001	10	2001	40	2022	40	2022	Maputo	11.1	3.7	11.7	15.7	5.2	16.6	10.5	3.5	11.0	11.1	3.7	11.7	12.3	4.1	12.9	13.4	4.5	14.2	14.6	4.9	15.4	15.8	5.3	16.6	17.0	5.7	18.0	18.2	6.1	19.2	19.5	6.5	20.5	20.7	6.9	21.9	22.0	7.3	23.2	23.3	7.8	24.6	24.8	8.3	26.1	26.1	8.7	27.5	27.5	9.2	29.0	29.0	9.7	30.6	30.5	10.2	32.1	32.0	10.7	33.7	33.6	11.2	35.4	35.2	11.7	37.1	36.9	12.3	38.9	25.7	8.6	27.1	27.0	9.0	28.4	28.2	9.4	29.7
	2nd Salamanga	40	2019	40	2019					Maputo							10.5	3.5	11.0	11.1	3.7	11.7	12.3	4.1	12.9	13.4	4.5	14.2	14.6	4.9	15.4	15.8	5.3	16.6	17.0	5.7	18.0	18.2	6.1	19.2	19.5	6.5	20.5	20.7	6.9	21.9	22.0	7.3	23.2	23.3	7.8	24.6	24.8	8.3	26.1	26.1	8.7	27.5	27.5	9.2	29.0	29.0	9.7	30.6	30.5	10.2	32.1	32.0	10.7	33.7	33.6	11.2	35.4	35.2	11.7	37.1	36.9	12.3	38.9	25.7	8.6	27.1	27.0	9.0	28.4	28.2	9.4	29.7
	3rd Salamanga 33	40	2040	40	2040					Maputo																																																																						25.7	8.6	27.1	27.0	9.0	28.4	28.2	9.4	29.7
97612	Matola Rio	40	1989	40	2022	40	2022			Maputo	21	4	21.4	29.7	5.7	30.2	19.8	3.8	20.2	21.1	4.0	21.5	23.2	4.4	23.6	25.4	4.8	25.9	27.6	5.3	28.1	29.8	5.7	30.4	32.2	6.1	32.8	34.5	6.6	35.1	36.9	7.0	37.5	39.2	7.5	39.9	20.8	4.0	21.2	22.0	4.2	22.4	23.4	4.5	23.8	24.7	4.7	25.2	26.1	5.0	26.5	27.4	5.2	27.9	28.8	5.5	29.3	30.3	5.8	30.8	31.8	6.0	32.3	33.3	6.3	33.9	34.9	6.6	35.5	36.5	7.0	37.2	38.2	7.3	38.9	26.7	5.1	27.1
	2nd Matola Rio	40	2029	40	2029					Maputo																																						20.8	4.0	21.2	22.0	4.2	22.4	23.4	4.5	23.8	24.7	4.7	25.2	26.1	5.0	26.5	27.4	5.2	27.9	28.8	5.5	29.3	30.3	5.8	30.8	31.8	6.0	32.3	33.3	6.3	33.9	34.9	6.6	35.5	36.5	7.0	37.2	38.2	7.3	38.9	26.7	5.1	27.1
	3rd Matola Rio	40	2042	40	2042					Maputo																																																																													26.7	5.1	27.1
97422	Marracuene 33	30	2011	40	2022					Maputo	10.8	4.1	11.6	15.3	5.8	16.3	10.2	3.9	10.9	10.8	4.1	11.6	11.9	4.5	12.8	13.1	5.0	14.0	14.2	5.4	15.2	15.3	5.8	16.4	16.6	6.3	17.7	17.8	6.7	19.0	19.0	7.2	20.3	20.2	7.7	21.6	21.4	8.1	22.9	22.7	8.6	24.3	24.1	9.1	25.8	25.4	9.7	27.2	26.8	10.2	28.7	28.2	10.7	30.2	29.7	11.3	31.7	31.1	11.8	33.3	32.7	12.4	34.9	34.2	13.0	36.6	35.9	13.6	38.4	25.0	9.5	26.8	26.2	10.0	28.1	27.4	10.4	29.3
97425	New Marracuene	40	2019	40	2019					Maputo							10.2	3.9	10.9	10.8	4.1	11.6	11.9	4.5	12.8	13.1	5.0	14.0	14.2	5.4	15.2	15.3	5.8	16.4	16.6	6.3	17.7	17.8	6.7	19.0	19.0	7.2	20.3	20.2	7.7	21.6	21.4	8.1	22.9	22.7	8.6	24.3	24.1	9.1	25.8	25.4	9.7	27.2	26.8	10.2	28.7	28.2	10.7	30.2	29.7	11.3	31.7	31.1	11.8	33.3	32.7	12.4	34.9	34.2	13.0	36.6	35.9	13.6	38.4	25.0	9.5	26.8	26.2	10.0	28.1	27.4	10.4	29.3
	2nd NewMarracuene	40	2040	40	2040					Maputo																																																																					25.0	9.5	26.8	26.2	10.0	28.1	27.4	10.4	29.3
97622	Coruma 33	3	1989	40	2022	40	2022			Maputo	2	0.8	2.2	2.8	1.1	3.0	3.8	1.5	4.1	4.0	1.6	4.3	4.4	1.8	4.8	4.8	1.9	5.2	5.3	2.1	5.7	5.7	2.3	6.1	6.1	2.5	6.6	6.6	2.6	7.1	7.0	2.8	7.6	7.5	3.0	8.0	7.9	3.2	8.5	8.4	3.4	9.0	8.9	3.6	9.6	9.4	3.8	10.1	9.9	4.0	10.7	10.4	4.2	11.3	11.0	4.4	11.8	11.5	4.6	12.4	12.1	4.8	13.0	12.7	5.1	13.7	13.3	5.3	14.3	13.9	5.6	15.0	14.6	5.8	15.7	15.2	6.1	16.4
97624	Moamba	40	2019	40	2019					Maputo							19.1	5.8	19.9	20.3	6.2	21.2	22.3	6.9	23.4	24.4	7.5	25.6	26.5	8.1	27.8	28.7	8.8	30.0	31.0	9.5	32.4	33.2	10.2	34.7	35.4	10.9	37.1	37.7	11.6	39.5	20.0	6.1	20.9	21.2	6.5	22.2	22.5	6.9	23.6	23.8	7.3	24.9	25.1	7.7	26.2	26.4	8.1	27.6	27.7	8.5	29.0	29.1	8.9	30.5	30.6	9.4	32.0	32.0	9.8	33.5	33.5	10.3	35.1	35.1	10.8	36.7	36.8	11.3	38.5	25.7	7.9	26.8
	2nd Moamba	40	2029	40	2029					Maputo																																						20.0	6.1	20.9	21.2	6.5	22.2	22.5	6.9	23.6	23.8	7.3	24.9	25.1	7.7	26.2	26.4	8.1	27.6	27.7	8.5	29.0	29.1	8.9	30.5	30.6	9.4	32.0	32.0	9.8	33.5	33.5	10.3	35.1	35.1	10.8	36.7	36.8	11.3	38.5	25.7	7.9	26.8
	3rd Moamba	40	2042	40	2042					Maputo																																																																													25.7	7.9	26.8
97916	Tchumene	40	2019	40	2019					Maputo							19.8	3.8	20.2	21.1	4.0	21.5	23.2	4.4	23.6	25.4	4.8	25.9	27.6	5.3	28.1	29.8	5.7	30.4	32.2	6.1	32.8	34.5	6.6	35.1	36.9	7.0	37.5	39.2	7.5	39.9	20.8	4.0	21.2	22.0	4.2	22.4	23.4	4.5	23.8	24.7	4.7	25.2	26.1	5.0	26.5	27.4	5.2	27.9	28.8	5.5	29.3	30.3	5.8	30.8	31.8	6.0	32.3	33.3	6.3	33.9	34.9	6.6	35.5	36.5	7.0	37.2	38.2	7.3	38.9	26.7	5.1	27.1
	2nd Tchumene	40	2029	40	2029					Maputo																																						20.8	4.0	21.2	22.0	4.2	22.4	23.4	4.5	23.8	24.7	4.7	25.2	26.1	5.0	26.5	27.4	5.2	27.9	28.8	5.5	29.3	30.3	5.8	30.8	31.8	6.0	32.3	33.3	6.3	33.9	34.9	6.6	35.5	36.5	7.0	37.2	38.2	7.3	38.9	26.7	5.1	27.1
	3rd Tchumene	40	2042	40	2042					Maputo																																																																												26.7	5.1	27.1
	growth rate									Maputo City					0.0664			0.0734			0.1105			0.0787			0.0760			0.0736			0.0714			0.0695			0.0679			0.0664			0.0651			0.0639			0.0629			0.0620			0.0612			0.0606			0.0600			0.0595			0.0591			0.0588			0.0585			0.0582			0.0580			0.0565			0.0570	
98112	CTM A 33	30	1991	40	2022	40	2022			Maputo City	27.2	4.2	27.5	36.7	5.7	37.1	39.8	6.1	40.3	44.5	6.9	45.0	48.2	7.4	48.8	26.1	4.0	26.4	28.1	4.3	28.4	30.2	4.7	30.6	32.6	5.0	32.9	34.9	5.4	35.3	37.3	5.8	37.7	26.5	4.1	26.8	28.3	4.4	28.6	30.1	4.6	30.4	32.2	5.0	32.6	34.2	5.3	34.6	36.3	5.6	36.7	38.5	5.9	38.9	30.6	4.7	31.0	32.4	5.0	32.8	34.3	5.3	34.7	36.3	5.6	36.8	38.4	5.9	38.9	32.5	5.0	32.9	34.3	5.3	34.7	36.2	5.6	36.6
	2nd CTM A 33	40	2022	40	2022					Maputo City																26.1	4.0	26.4	28.1	4.3	28.4	30.2	4.7	30.6	32.6	5.0	32.9	34.9	5.4	35.3	37.3	5.8	37.7	26.5	4.1	26.8	28.3	4.4	28.6	30.1	4.6	30.4	32.2	5.0	32.6	34.2	5.3	34.6	36.3	5.6	36.7	38.5	5.9	38.9	30.6	4.7	31.0	32.4	5.0	32.8	34.3	5.3	34.7	36.3	5.6	36.8	38.4	5.9	38.9	32.5	5.0	32.9	34.3	5.3	34.7	36.2	5.6	36.6
	3rd CTM A 33	40	2028	40	2028					Maputo City																																		26.5	4.1	26.8	28.3	4.4	28.6	30.1	4.6	30.4	32.2	5.0	32.6	34.2	5.3	34.6	36.3	5.6	36.7	38.5	5.9	38.9	30.6	4.7	31.0	32.4	5.0	32.8	34.3	5.3	34.7	36.3	5.6	36.8	38.4	5.9	38.9	32.5	5.0	32.9	34.3	5.3	34.7	36.2	5.6	36.6
	4th CTM A 33	40	2035	40	2035					Maputo City																																																									30.6	4.7	31.0	32.4	5.0	32.8	34.3	5.3	34.7	36.3	5.6	36.8	38.4	5.9	38.9	32.5	5.0	32.9	34.3	5.3	34.7	36.2	5.6	36.6
	5th CTM A 33	40	2040	40	2040					Maputo City																																																																							32.5	5.0	32.9	34.3	5.3	34.7	36.2	5.6	36.6
98212	CTM B 33	30	1988	40	2022	40	2022			Maputo City	6	1.9	6.3	8.1	2.6	8.5	8.8	2.8	9.2	9.8	3.1	10.3	10.6	3.4	11.2	11.5	3.6	12.1	12.4	3.9	13.0	13.3	4.2	14.0	14.4	4.5	15.1	15.4	4.9	16.1	16.4	5.2	17.2	17.5	5.6	18.4	18.7	5.9	19.6	19.9	6.3	20.9	21.3	6.7	22.3	22.6	7.2	23.7	24.0	7.6	25.2	25.5	8.1	26.7	27.0	8.5	28.3	28.6	9.1	30.0	30.3	9.6	31.8	32.1	10.1	33.6	33.9	10.7	35.6	35.9	11.4	37.6	37.8	12.0	39.7	20.0	6.3	20.9
	2nd CTM B 33	40	2042	40	2042					Maputo City																																																																													20.0	6.3	20.9
98312	SE 1 11	30	2003	40	2019	40	2030			Maputo City	16.4	8.2	18.3	22.1	11.1	24.7	12.0	6.0	13.4	13.4	6.7	15.0	14.5	7.3	16.3	15.7	7.9	17.6	16.9	8.5	18.9	18.2	9.1	20.4	19.6	9.8	22.0	21.0	10.5	23.5	22.5	11.2	25.1	24.0	12.0	26.8	25.6	12.8	28.6	27.2	13.6	30.4	29.1	14.5	32.5	30.9	15.5	34.6	32.8	16.4	36.7	34.8	17.4	38.9	18.4	9.2	20.6	19.5	9.8	21.9	20.7	10.3	23.1	21.9	11.0	24.5	23.2	11.6	25.9	24.5	12.3	27.4	25.8	12.9	28.9	27.3	13.6	30.5
	2nd SE 1 11	40	2035	40	2035					Maputo City																																																									18.4	9.2	20.6	19.5	9.8	21.9	20.7	10.3	23.1	21.9	11.0	24.5	23.2	11.6	25.9	24.5	12.3	27.4	25.8	12.9	28.9	27.3	13.6	30.5
98412	SE 2 11	30	2004	40	2019	40	2023			Maputo City	13.5	6	14.8	18.2	8.1	19.9	19.7	8.8	21.6	22.1	9.8	24.2	23.9	10.6	26.2	25.9	11.5	28.3	27.9	12.4	30.5	30.0	13.3	32.8	32.3	14.4	35.4	34.6	15.4	37.9	18.5	8.2	20.2	19.7	8.8	21.6	21.0	9.3	23.0	22.4	10.0	24.5	23.9	10.6	26.2	25.5	11.3	27.9	27.0	12.0	29.6	28.7	12.7	31.4	30.4	13.5	33.2	32.2	14.3	35.2	34.1	15.1	37.3	36.1	16.0	39.5	25.4	11.3	27.8	26.9	12.0	29.4	28.4	12.6	31.0	29.9	13.3	32.8
	2nd SE 2 11	40	2027	40	2027					Maputo City																																18.5	8.2	20.2	19.7	8.8	21.6	21.0	9.3	23.0	22.4	10.0	24.5	23.9	10.6	26.2	25.5	11.3	27.9	27.0	12.0	29.6	28.7	12.7	31.4	30.4	13.5	33.2	32.2	14.3	35.2	34.1	15.1	37.3	36.1	16.0	39.5	25.4	11.3	27.8	26.9	12.0	29.4	28.4	12.6	31.0	29.9	13.3	32.8
	3rd SE 2 11	40	2039	40	2039					Maputo City																																																																					25.4	11.3	27.8	26.9	12.0	29.4	28.4	12.6	31.0	29.9	13.3	32.8
98512	SE 3 11	30	1999	30	2005	40	2022	40	2022	Maputo City	25.3	13.3	28.6	34.1	17.9	38.5	37.0	19.5	41.8	41.4	21.7	46.7	44.9	23.6	50.7	24.3	12.7	27.4	26.1	13.7	29.5	28.1	14.8	31.7	30.3	15.9	34.2	32.4	17.0	36.6	34.6	18.2	39.1	24.7	13.0	27.9	26.3	13.8	29.7	28.0	14.7	31.6	29.9	15.7	33.8	31.8	16.7	35.9	33.8	17.7	38.1	26.9	14.1	30.3	28.5	15.0	32.2	30.1	15.8	34.1	31.9	16.8	36.1	33.8	17.8	38.2	28.6	15.0	32.3	30.2	15.9	34.2	31.9	16.8	36.0	33.7	17.7	38.0
	2nd SE 3 11	40	2022	40	2022					Maputo City																24.3	12.7	27.4	26.1	13.7	29.5	28.1	14.8	31.7	30.3	15.9	34.2	32.4	17.0	36.6	34.6	18.2	39.1	24.7	13.0	27.9	26.3	13.8	29.7	28.0	14.7	31.6	29.9	15.7	33.8	31.8	16.7	35.9	33.8	17.7	38.1	26.9	14.1	30.3	28.5	15.0	32.2	30.1	15.8	34.1	31.9	16.8	36.1	33.8	17.8	38.2	28.6	15.0	32.3	30.2	15.9	34.2	31.9	16.8	36.0	33.7	17.7	38.0
	3rd SE 3 11	40	2028	40	2028					Maputo City																																		24.7	13.0	27.9	26.3	13.8	29.7	28.0	14.7	31.6	29.9	15.7	33.8	31.8	16.7	35.9	33.8	17.7	38.1	26.9	14.1	30.3	28.5	15.0	32.2	30.1	15.8	34.1	31.9	16.8	36.1	33.8	17.8	38.2	28.6	15.0	32.3	30.2	15.9	34.2	31.9	16.8	36.0	33.7	17.7	38.0
	4ht SE 3 11	40	2028	40	2028					Maputo City																																																		26.9	14.1	30.3	28.5	15.0	32.2	30.1	15.8	34.1	31.9	16.8	36.1	33.8	17.8	38.2	28.6	15.0	32.3	30.2	15.9	34.2	31.9	16.8	36.0	33.7	17.7	38.0
	5ht SE 3 11	40	2028	40	2028					Maputo City																																																																		28.6	15.0	32.3	30.2	15.9	34.2	31.9	16.8	36.0	33.7	17.7	38.0
98513	SE 3 11↑									Maputo City	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98612	SE 4 11	30	2003	40	2019	40	2026			Maputo City	11.6	4	12.3	15.6	5.4	16.5	17.0	5.9	17.9	19.0	6.5	20.1	20.6	7.1	21.8	22.2	7.7	23.5	24.0	8.3	25.4	25.8	8.9	27.3	27.8	9.6	29.4	29.7	10.3	31.4	31.8	11.0	33.6	33.9	11.7	35.9	36.1	12.5	38.2	19.2	6.6	20.4	20.6	7.1	21.8	21.9	7.5	23.1	23.2	8.0	24.6	24.6	8.5	26.0	26.1	9.0	27.6	27.6	9.5	29.2	29.3	10.1	31.0	31.0	10.7	32.8	32.8	11.3	34.7	34.7	12.0	36.7	36.6	12.6	38.7	25.7	8.9	27.2
	2nd SE 4 11	40	2030	40	2030					Maputo City																																									19.2	6.6	20.4	20.6	7.1	21.8	21.9	7.5	23.1	23.2	8.0	24.6	24.6	8.5	26.0	26.1	9.0	27.6	27.6	9.5	29.2	29.3	10.1	31.0	31.0	10.7	32.8	32.8	11.3	34.7	34.7	12.0	36.7	36.6	12.6	38.7	25.7	8.9	27.2
	3rd SE 4 11	40	2042	40	2042					Maputo City																																																																													25.7	8.9	27.2
98712	SE 5 11	20	1989	20	2000	40	2019	40	2019	Maputo City	25.6	10.8	27.8	34.5	14.6	37.5	37.4	15.8	40.6	41.9	17.7	45.4	45.4	19.2	49.3	24.5	10.4	26.6	26.4	11.2	28.7	28.4	12.0	30.9	30.6	12.9	33.3	32.8	13.8	35.6	35.1	14.8	38.1	24.9	10.5	27.1	26.6	11.2	28.9	28.3	11.9	30.7	30.3	12.8	32.9	32.2	13.6	34.9	34.2	14.4	37.1	36.2	15.3	39.3	28.8	12.1	31.3	30.5	12.9	33.1	32.3	13.6	35.1	34.2	14.4	37.1	36.2	15.3	39.3	30.6	12.9	33.2	32.3	13.6	35.0	34.1	14.4	37.0

Source: JICA Study Team

(4) Generation plan

Table 6.2-24 shows the introduction year, capacity, location and fuel type. Generation plan was set based on the Export Scenario 1 (20% of domestic demand exported) and taking into account the generation potential of Mozambique.

Table 6.2-24 Generation plan

Name	Substation	Province	District	Type	Start	Retire	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Temane (Engine)		Inhambane		Diesel																												
CTRG (Capacity; 175MW, EDM/Sasol)	Ressano Garcia	Maputo		Gas	Existing	-	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Gigawatt	Ressano Garcia	Maputo		Gas	Existing	-	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
Kuvaninga	Kuvaninga	Gaza		Gas	Existing	-	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Aggreko Beluluane	Beluluane	Maputo		Gas	Existing	2017																										
Aggreko Ressano	Ressano Garcia	Maputo		Gas	Existing	2018	90																									
JICA CTM	CTM	Maputo City	Maputo City	Gas	2018	-		106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106
Temane (CCGT)	Vilanculos	Inhambane	Vilanculos	Gas	2023	-							100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Temane (MGTP)	Vilanculos	Inhambane	Vilanculos	Gas	2022	-						400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
JICA CTM Phase2	CTM	Maputo City	Maputo City	Gas	2023	-							106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106
Additional Capacity (South2018)-1	Maputo	Maputo		Diesel	2018	2024		50	50	50	50	50	50																			
Additional Capacity (South2019)-2	Maputo	Maputo		Diesel	2019	2024			140	140	140	140	140																			
Additional Capacity (South2020)-3	Maputo	Maputo		Diesel	2020	2024				70	70	70	70																			
Additional Capacity (South2021)-4	Maputo	Maputo		Diesel	2021	2024					250	250	250																			
BeiraGT35	Beira	Sofala		Diesel	Existing	2024	12	12	12	12	12	12	12																			
Mavuzi	Mavuzi	Manica		Hydro	Existing	-	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57
Chicamba	Chicamba	Manica		Hydro	Existing	-	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
Cahora Bassa for EDM (Capacity; 2075MW)	Songo	Tete		Hydro	Existing	-	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Nacala Barcassa for EDM (Capacity; 102MW)	Nacala	Nampula	Nacala	HFO	Existing	2018	40																									
Jindal	Jindal	Tete	Chirodzi	Coal	2023	-							150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Nacala Coal	Nacala Velha	Nampula	Nacala	Coal	2023	-							200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Additional Capacity (Central & North2018)-1	Nacala Velha	Nampula		Diesel	2018	2024		260	260	260	260	260	260																			
Additional Capacity (Central & North2019)-2	Nacala Velha	Nampula		Diesel	2019	2024			100	100	100	100	100																			
Additional Capacity (Central & North2020)-3	Nacala Velha	Nampula		Diesel	2020	2024				50	50	50	50																			
Additional Capacity (Central & North2022)-4	Nacala Velha	Nampula		Diesel	2021	2024						60	60																			
Tete Coal-1	Matambo	Tete		Coal	2023	-							300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Tete Coal-2	Matambo	Tete		Coal	2026	-										300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Tete Coal-3	Matambo	Tete		Coal	2034	-																		300	300	300	300	300	300	300	300	300
Tete Coal-4	Matambo	Tete		Coal	2038	-																						300	300	300	300	300
Mphanda Nkuwa	Mpanda Nkuwa	Tete		Hydro	2024	-								1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Cahora Bassa North	Songo	Tete		Hydro	2029	-													1,245	1,245	1,245	1,245	1,245	1,245	1,245	1,245	1,245	1,245	1,245	1,245	1,245	1,245
Lupata	Lupata	Tete		Hydro	2027	-											650	650	650	650	650	650	650	650	650	650	650	650	650	650	650	650
Taste	Mavuzi	Manica	Chimoio	Hydro	2025	-									50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Shell	Palma	Cabo Delgado	Palma	Gas	2027	-											80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
H50-1	Salamanga	Maputo	Matutuine	Hydro	2032	-																50	50	50	50	50	50	50	50	50	50	50
H50-2	Macomia	Cabo Delgado	Chiure	Hydro	2033	-																	50	50	50	50	50	50	50	50	50	50
H50-3	Marrupa Hydro	Cabo Delgado	Meluco	Hydro	2033	-																	50	50	50	50	50	50	50	50	50	50
H50-4	Chibabava	Inhambane	Govuro	Hydro	2034	-																		50	50	50	50	50	50	50	50	50
H50-5	Matambo	Tete	Changara	Hydro	2034	-																		50	50	50	50	50	50	50	50	50
H50-6	Caia(Chimuara)	Tete	Mutarara	Hydro	2035	-																			50	50	50	50	50	50	50	50
H50-7	Marrupa Hydro	Niassa	Mecula	Hydro	2035	-																			50	50	50	50	50	50	50	50
H50-8	Chibabava	Sofala	Chibabava	Hydro	2036	-																				50	50	50	50	50	50	50
H50-9	Macomia	Cabo Delgado	Chiure	Hydro	2036	-																				50	50	50	50	50	50	50
H50-10	Matambo	Tete	Changara	Hydro	2037	-																					50	50	50	50	50	50
H50-11	Marrupa Hydro	Niassa	Mecula	Hydro	2037	-																					50	50	50	50	50	50
H50-12	Metoro Hydro	Cabo Delgado	Chiure	Hydro	2038	-																						50	50	50	50	50
H50-13	Metoro Hydro	Cabo Delgado	Chiure	Hydro	2038	-																						50	50	50	50	50
H100-1	Metoro Hydro	Cabo Delgado	Chiure	Hydro	2035	-																			100	100	100	100	100	100	100	100
H100-2	Matangula Hydro	Niassa	Songa	Hydro	2037	-																					100	100	100	100	100	100
H100-3	Matangula Hydro	Niassa	Songa	Hydro	2039	-																							100	100	100	100
CCGT-1 (Temane)	Vilanculos	Inhambane		Gas	2033	-																	200	200	200	200	200	200	200	200	200	200
CCGT-2 (Rovuma)	Palma	Cabo Delgado		Gas	2036	-																				200	200	200	200	200	200	200
CCGT-3 (Maputo)	Ressano Garcia	Maputo		Gas	2037	-																					200	200	200	200	200	200
CCGT-4 (Temane)	Vilanculos	Inhambane		Gas	2039	-																							200	200	200	200
CCGT-5 (Rovuma)	Palma	Cabo Delgado		Gas	2040	-																								200	200	200
CCGT-6 (Maputo)	Ressano Garcia	Maputo		Gas	2040	-																								200	200	200
CCGT-7 (Temane)	Vilanculos	Inhambane		Gas	2041	-																									200	200
CCGT-8 (Rovuma)	Palma	Cabo Delgado		Gas	2042	-																										200
CCGT-9 (Maputo)	Ressano Garcia	Maputo		Gas	2042	-																										200
Coal-1	Nacala Velha	Nampula	Nacala	Coal	2041	-																									200	200
Coal-2	Nacala Velha	Nampula	Nacala	Coal	2042	-																										200
Mocuba	Mocuba	Zambezia	Mocuba	Solar	2018	-		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Metoro	Metoro	Cabo Delgado	Metoro	Solar	2019	-			40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Tofo	Lindela	Inhambane	Tofo	Wind	2023	-							30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Solar-1	Boane	Maputo	Boane	Solar	2024	-								30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Solar-2	Songo	Tete	Maravia	Solar	2025	-									30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Solar-3	Nacala Velha	Nampula	Nacala	Solar	2026	-										30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Solar-4	Beira	Sofala	Beira	Solar	2028	-												30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Solar-5	Caia(Chimuara)	Sofala	Caia	Solar	2029	-													30	30	30	30	30	30	30	30	30	30	30	30	30	30
Solar-6	Nampula	Nampula	Nampula	Solar	2030	-														30	30	30	30	30	30	30	30	30	30	30	30	30
Solar-7	Boane	Maputo	Boane	Solar	2032	-																30	30	30	30	30	30	30	30	30	30	30
Solar-8	Manica	Manica	Manica	Solar	2033	-																	30	30	30	30	30	30	30	30	30	30
Solar-9	Beira	Sofala	Beira	Solar	2034	-																		30	30	30	30	30	30	30	30	30
Solar-10	Quelimane	Zambezia	Quelimane	Solar	2036	-																				30	30	30	30	30	30	30
Solar-11	Alto Molocue	Zambezia	Alto-Molocue	Solar	2037	-																					30	30	30	30	30	30
Solar-12	Boane	Maputo	Boane	Solar	2038	-																						30	30	30	30	30
Solar-13	Manica	Manica	Manica	Solar	2040	-																								30	30	30
Solar-14	Beira	Sofala	Beira	Solar	2041	-																									30	30
Solar-15	Pemba	Cabo Delgado	Pemba	Solar	2042	-																										30
Wind-1	Boane	Maputo	Namaacha	Wind	2027	-											30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Wind-2	Beira	Sofala	Beira	Wind	2031	-															30	30	30	30	30	30	30	30	30	30	30	30
Wind-3	Marracuene	Maputo	Marracuene	Wind	2035	-																			30	30	30	30	30	30	30	30
Wind-4	Songo	Tete	Magoe	Wind	2039	-																							30	30	30	30
							1053	1379	1659	1779	2029	2489	3375	3913	3993	4323	5083	5113	6388	6418	6448	6528	6858	7288	7518	7848	8278	8708	9038	9468	9898	10528

Source: JICA Study Team

(5) Transmission line and substation expansion plan

Power system analysis in 2022, 2027, 2032 and 2042 was carried out using PSS/E, additional facilities needed to satisfy the design condition of the power system was listed and the investment cost was calculated. Transition of total investment cost is shown in Table 6.2-25 and Figure 6.2-12. And also, transmission and substation's additional facilities and investment cost are shown in Table 6.2-26 - Table 6.2-33 and system diagram of each year are shown in

Figure 6.2-13 -Figure 6.2-16. Investment cost was prorated in the construction period of each transmission line and substation (including transformer adding). The construction period was based on the expansion plan received from EDM. Investment cost of other expansion plans was prorated with a construction period of 4 years.

Total investment cost by 2042 become about 9,100MUSD, which is an increase of 3,300 MUSD compared to about 5,800 MUSD planned EDM. This increase is mainly due to equipment added to meet the N-1 criteria.

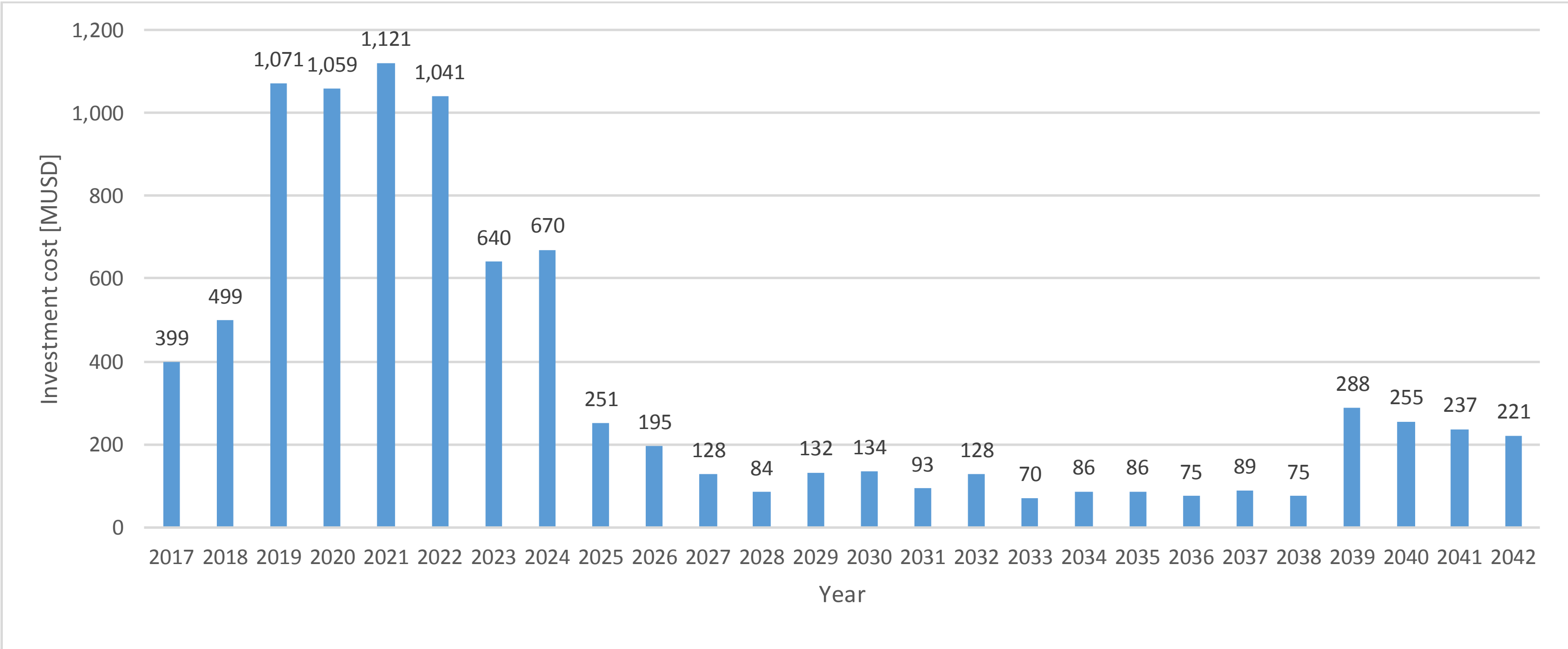
In addition, the investment cost by 2022 become 5,100 MUSD, which account for about 60% of the total investment cost by 2042. This is due to allocate the investment cost of the construction of the STE project scheduled to be sequentially commenced by 2024 and the Zambia interconnector, the Malawi interconnector, the MoZiSa project and to make the system satisfy the N-1 criteria

After 2022, extension of the distribution substations and load system transmission lines and substations (transformers) to cope with the increase in demand are accounted. In addition, as a result of the power system analysis, the second Zambian interconnector, which was planned to be introduced in 2024, will be canceled.

Table 6.2-25 power system plan (total investment cost)

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	total
T/L	106	162	435	513	558	515	326	331	157	103	51	28	44	54	26	37	21	21	21	10	10	0	81	81	81	81	3,851
S/S	292	337	636	546	563	526	314	339	94	92	77	57	89	80	67	92	49	66	66	65	78	75	208	175	156	140	5,277
Total cost	399	499	1,071	1,059	1,121	1,041	640	670	251	195	128	84	132	134	93	128	70	86	86	75	89	75	288	255	237	221	9,127

Source: JICA study team



Source: JICA study team

Figure 6.2-12 power system plan (total investment cost)

Table 6.2-26 Transmission line expansion plan (Northern and Central-Northern area)

[kUSD]

Voltage (kV)	bus number	from	bus number	to	area	length (km)	Conductor name	Construction start year	Commissioned year	Normal Rating (MVA)	Funding	Remarks	investment classification	unit cost [kUSD]	project cost [kUSD]	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	total
110	72511	Metoro	72711	Macomia	North	120	1xDove	2019	2022	99			2022 Analysis	123	14,760			3,690	3,690	3,690	3,690																					14,760
110	72711	Macomia	72811	Auasse	North	95	1xDove	2019	2022	99			2022 Analysis	123	11,685			2,921	2,921	2,921	2,921																					11,685
220	99022	Metoro	73613	Montepuez	North	115	2xCondor	2019	2024	477		Construction of a 220kV Metoro – Montepuez Line, Montepuez Substation and 110kV Line Montepuez – Marrupa	Long-term	205	23,575			3,929	3,929	3,929	3,929	3,929	3,929																			23,575
110	72511	Metoro	72611	Pemba	North	108	1xDove	2019	2022	99			2022 Analysis	123	13,284			3,321	3,321	3,321	3,321																					13,284
110	72511	Metro	72611	Pemba	North	100	1xDove	2020	2025	99		Construction of 100km of 110kV Line and 110 / 33kV Substation in Pemba for second power to the City.	Mid-term	123	12,300				2,050	2,050	2,050	2,050	2,050	2,050																		12,300
110	72511	Metoro	72611	Pemba	North	108	1xDove	2039	2042	99			2042 Analysis	123	13,284																							3,321	3,321	3,321	3,321	13,284
400	99020	Metoro	72131	Namialo	North	216	4xTern	2021	2026	2335		Tanzania interconnector	Mid-term	340	73,440					12,240	12,240	12,240	12,240	12,240	12,240																	73,440
400	99020	Metoro	99023	Mtwara(Tan)	North	484	4xTern	2021	2026	2335		Tanzania interconnector	Long-term	340	164,560					27,427	27,427	27,427	27,427	27,427	27,427																	164,560
400	99020	Metoro	99021	Palma	North	210	4xTern	2021	2026	2335		Construction of a Line of 220(400) kV Metoro-Palma and interconnection with SE Auasse	Mid-term	340	71,400					11,900	11,900	11,900	11,900	11,900	11,900																	71,400
220	73703	Metoro Hydropower	99022	Metoro	North	100	2xCondor	2032	2035	477			Hydropower	205	20,500																5,125	5,125	5,125	5,125								
220	73703	Metoro Hydropower	99022	Metoro	North	100	2xCondor	2032	2035	477			Hydropower	205	20,500																5,125	5,125	5,125	5,125								
220	73702	Marrupa Hydropower	73613	Montepuez	North	100	2xCondor	2030	2033	477			Hydropower	205	20,500														5,125	5,125	5,125	5,125										
220	73702	Marrupa Hydropower	73613	Montepuez	North	100	2xCondor	2030	2033	477			Hydropower	205	20,500														5,125	5,125	5,125	5,125										
220	72813	Palma	72814	Auasse	North	75	2xCondor	2025	2030	477		Construction of a Line of 220(400) kV Metoro-Palma and interconnection with SE Auasse	Long-term	205	15,375									2,563	2,563	2,563	2,563	2,563	2,563													15,375
110	73411	Cuamba	73611	Marrupa	North	215	1xDove	2017	2019	99			EDM plan	123	26,445	8,815	8,815	8,815																								26,445
110	73411	Cuamba	73611	Marrupa	North	215	1xDove	2019	2022	99			2022 Analysis	123	26,445			6,611	6,611	6,611	6,611																					26,445
110	73411	Cuamba	73611	Lichinga	North	235	1xDove	2019	2022	99			2022 Analysis	123	28,905			7,226	7,226	7,226	7,226																					28,905
220	73701	Matangula Hydropower	73513	Lichinga	North	100	2xCondor	2034	2037	477			Hydropower	205	20,500																		5,125	5,125	5,125	5,125						
220	73701	Matangula Hydropower	73513	Lichinga	North	100	2xCondor	2034	2037	477			Hydropower	205	20,500																		5,125	5,125	5,125	5,125						
110	73611	Marrupa	73614	Montepuez	North	97	1xDove	2019	2024	99		Construction of a 220kV Metoro – Montepuez Line, Montepuez Substation and 110kV Line Montepuez – Marrupa	Long-term	123	11,931			1,989	1,989	1,989	1,989	1,989	1,989																			11,931
110	73611	Marrupa	73614	Montepuez	North	97	1xDove	2019	2024	99			2032 Analysis	123	11,931			1,989	1,989	1,989	1,989	1,989	1,989																			11,931
220	72141	Namialo	71811	Nampula	North	90	2xCondor	2017	2022	477	IsDB, (AfDB,JICA)	Caia-Nacala	EDM plan	205	18,450	3,075	3,075	3,075	3,075	3,075	3,075																					18,450
110	72121	Namialo	72111	Nampula	North	90.78	1xDove	2039	2042	99			2042 Analysis	123	11,166																							2,791	2,791	2,791	2,791	
220	72141	Namialo	72421	Nacala Velha	North	100	2xCondor	2017	2022	477	IsDB, (AfDB,JICA)	Caia-Nacala	EDM plan	205	20,500	3,417	3,417	3,417	3,417	3,417	3,417																					20,500
110	72121	Namialo	72211	Nampula Center	North	90.45	1xDove	2029	2032	99			2032 Analysis	123	11,125													2,781	2,781	2,781	2,781											11,125
110	72121	Namialo	72211	Nampula Center	North	90.45	1xDove	2039	2042	99			2042 Analysis	123	11,125																							2,781	2,781	2,781	2,781	11,125
110	72121	Namialo	72311	Monapo	North	44.5	1xDove	2024	2027	99			2027 Analysis	123	5,474								1,368	1,368	1,368	1,368																5,474
110	72121	Namialo	72311	Monapo	North	44.5	1xDove	2039	2042	99			2042 Analysis	123	5,474																							1,368	1,368	1,368	1,368	5,474
110	72111	Nampula	72911	Moma	North	170	1xDove	2019	2022	99			2022 Analysis	123	20,910			5,228	5,228	5,228	5,228																					20,910
110	72111	Nampula	72911	Moma	North	170	1xDove	2029	2032	99			2032 Analysis	123	20,910													5,228	5,228	5,228	5,228											20,910
220	72111	Nampula	72911	Moma	North	170	2xCondor	2039	2042	477		110->220kV	2042 Analysis	205	34,850																							8,713	8,713	8,713	8,713	34,850
220	72111	Nampula	72911	Moma	North	170	2xCondor	2039	2042	477		110->220kV	2042 Analysis	205	34,850																							8,713	8,713	8,713	8,713	34,850
110	72111	Nampula	72915	Angoche	North	180	1xDove	2022	2025	99	Sinohydoro ou CCC		Mid-term	123	22,140						5,535	5,535	5,535	5,535																		22,140
110	72111	Nampula	72915	Angoche	North	180	1xDove	2022	2025	99			2027 Analysis	123	22,140						5,535	5,535	5,535	5,535																		22,140
110	72111	Nampula	72915	Angoche	North	180	1xDove	2039	2042	99			2042 Analysis	123	22,140																							5,535	5,535	5,535	5,535	22,140
110	72311	Monapo	72411	Nacala	North	64	1xDove	2024	2027	99			2027 Analysis	123	7,872								1,968	1,968	1,968	1,968																7,872
110	72422	Nacala Velha	72231	Vale	North	4	1xDove	2019	2022	99			2022 Analysis	123	492			123	123	123	123																					492
400	71721	Alto-Molocue	72131	Namialo	North	266	3xTern	2017	2022	1351	IsDB, (AfDB,JICA)	Caia-Nacala	EDM plan	340	90,440	15,073	15,073	15,073	15,073	15,073	15,073																					90,440
220	71711	Alto-Molocue	71618	Mocuba series	North	150.98	2xCondor	2039	2042	477			2042 Analysis	205	30,951																							7,738	7,738	7,738	7,738	30,951
110	73111	Alto-Molocue	73211	Uape	North	90	1xDove	2019	2022	99			2022 Analysis	123	11,070			2,768	2,768	2,768	2,768																					11,070
110	73111	Alto-Molocue	73311	Gurue	North	75.7	1xDove	2019	2022	99			2022 Analysis	123	9,311			2,328	2,328	2,328	2,328																					9,311
110	71614	Mocuba	71621	Pebane(Magiga/Caravela)	North	140	1xDove	2020	2025	99		Construction of a 110kV Line, 140km, between Mocuba and Magiga / Caravela, in Pebane and its 110 / 33kV Substation	Long-term	123	17,220				2,870	2,870	2,870	2,870	2,870	2,870																		17,220
110	71614	Mocuba	71621	Pebane(Magiga/Caravela)	North	140	1xDove	2020	2025	99			2027 Analysis	123	17,220				2,870	2,870	2,870	2,870	2,870	2,870																		17,220
110	71614	Mocuba	71622	Milange	North	120	1xDove	2020	2025	99		Construction of 120km of 110kV Line between Mocuba and Milange and its Substation in Milange	Long-term	123	14,760				2,460	2,460	2,460	2,460	2,460	2,460																		14,760
110	71614	Mocuba	71622	Milange	North	120	1xDove	2020	2025	99			2027 Analysis	123	14,760				2,460	2,460	2,460	2,460	2,460	2,460																		14,760
110	71614	Mocuba	71311	Nicoadala	North	108	1xDove	2024	2027	99			2027 Analysis	123	13,284								3,321	3,321	3,321	3,321																13,284
220	71311	Nicoadala	71411	Quelimane(Ceramica)	North	20	1xDove	2019	2022	99		Conversion of PS Nicoadala into SE Nicoadala and construction of second line Nicoadala-Ceramica at 220kV	Long-term 2022 Analysis	205	4,100			1,025	1,025	1,025	1,025																					4,100
400	71131	Chimuara	71721	Alto-Molocue	North	368	3xTern	2017	2022	1351	IsDB, (AfDB,JICA)	Caia-Nacala	EDM plan	340	125,120	20,853	20,853	20,853	20,853	20,853	20,853																					125,120
110	71111	Chimuara	71211	Marroumeu	North	90	1xDove	2019	2022	99			2022 Analysis	123	11,070			2,768	2,768	2,768	2,768																					11,070
110	71111	Chimuara	71211	Marroumeu	North	90	1xDove	2039	2042	99			2042 Analysis	123	11,070																							2,768	2,768	2,768	2,768	11,070
DC500	99018	Cataxa HVDC	99019	Maputo HVDC	Central-North	1276		2019	2024			STE Phase 1&2 HVDC	Long-term	342	436,392			72,732	72,732	72,732	72,732	72,732	72,732																			436,392
DC500	99018	Cataxa HVDC	99019	Maputo HVDC	Central-North	1276		2019	2024			STE Phase 1&2 HVDC	Long-term	342	436,392			72,732	72,732	72,732	72,732	72,732	72,732																			436,392
400	99014	Songo	99013	Cataxa	Central-North	53.7	4xTern	2019	2024	2335		STE Phase 1 HVAC	Long-term	340	18,258			3,043	3,043	3,043	3,043	3,043	3,043																			18,258
400	99013	Cataxa	99007	Matambo	Central-North	64.1	4xTern	2019	2024	2335		STE Phase 1 HVAC	Long-term	340	21,794			3,632	3,632	3,632	3,632	3,632	3,632																			21,794
400	99007	Matambo	99012	Lupata	Central-North	80.4	4xTern	2019	2024	2335		STE Phase 1 HVAC	Long-term	340	27,336			4,556	4,556	4,556	4,556	4,556	4,556																			27,336
400	99012	Lupata	99011	Macossa	Central-North	151.8	4xTern	2019	2024	2335		STE Phase 1 HVAC	Long-term	340	51,612			8,602	8,602	8,602	8,602	8,602	8,602																			51,612
400	99011	Macossa	82114	Inchope	Central-North	151.8	4xTern	2019	2024	2335		STE Phase 1 HVAC	Long-term	340	51,612			8,602	8,602	8,602	8,602	8,602	8,602																			51,612
400	99007	Matambo	99008	Moatize	Central-North	20	4xTern	2018	2021	2335		Malawi interconnector	Long-term	340	6,800		1,700	1,700	1,700	1,700																						6,800
400	99008	Moatize	9002	Phomebeya(Mal)	Central-North	218	4xTern	2018	2021	2335		Malawi interconnector	Long-term	340	74,120		18,530	18,530	18,530	18,530																						74,120
400	99007	Matambo	9001	Chipata West(Zam)	Central-North	368	4xTern	2020	2022	2335		Zambia interconnector	Long-term	340	125,120				41,707	41,707	41,707																					125,120
400	99008	Moatize	9001	Chipata West(Zam)	Central-North	370	4xTern	2019	2024	2335		2nd Zambia interconnector	Long-term	340	125,800																											0
400	99013	Cataxa	82114	Inchope	Central-North	360	4xTern	2020	2025	2335		MoZiSa Project	Long-term	340	122,400				20,400	20,400	20,400	20,400	20,400	20,400																		122,400
220	80111	Songo A	83211	Jindal	Central-North	19.97	2xCondor	2019	2022	477			2022 Analysis	205	4,094			1,023	1,023	1,023	1,023																					4,094
220	83111	Matambo A	83211	Jindal	Central-North	101.03	2xCondor	2019	2022	477			2022 Analysis	205	20,711			5,178	5,178	5,178	5,178																					20,711
66	83117	Matambo	83811	Benga	Central-North	30	1xDove	2019	2022	60			2022 Analysis	111	3,330			833	833	833	833																					3,330
66	83116	Matambo	83714	Vale	Central-North	40	1xDove	2019	2022	60			2022 Analysis	111	4,440			1,110	1,110	1,110	1,110																					4,440
66	83113	Matambo	83717	Guro	Central-North	90	1xDove	2018	2022	60		Construction of a 66kV Line, 90km between SE Matambo and Guro and its Substation in Guro	Long-term	111	9,990		1,998	1,998	1,998	1,998	1,998																					9,990
66	83113	Matambo	83717	Guro	Central-North	90	1xDove	2019	2022	60			2022 Analysis	111	9,990			2,498	2,498	2,498	2,498																					9,990
66	83113	Matambo	83511	Tete	Central-North	20	1xDove	2019	2022	60			2022 Analysis	111	2,220			555	555	555	555																					2,220
66	83113	Matambo	83511	Tete	Central-North	20	1xDove	2039	2042	60			2042 Analysis	111	2,220																							555	555	555	555	2,220
66	83511	Tete	83711	Movel Tete	Central-North	11.99	1xDove	2019	2022	60			2022 Analysis	111	1,331			333	333	333	333																					
66	83511	Tete	83711	Movel Tete	Central-North	11.99	1xDove	2039	2042	60			2042 Analysis	111	1,331																							333	333	333	333	
66	83711	Movel Tete	83611	Manje	Central-North	97.01	1xDove	2019	2022	60			2022 Analysis	111	10,768			2,692	2,692	2,692	2,692																					10,768
66	83514	Moatize	83515	Mussacama	Central-North	80	1xDove	2022	2023	60		Construction of 80 km of 66kV Moatize-Mussacama Line and its Substation in Mussacama	Long-term	111	8,880						4,440	4,440																				8,880
66	83514	Moatize	83515	Mussacama	Central-North	80	1xDove	2022	2023	60			2027 Analysis	111	8,880						4,440	4,440																				8,880
66	83514	Moatize	83515	Mussacama	Central-North	80	1xDove	2039	2042	60			2042 Analysis	111	8,880																							2,220	2,220	2,220	2,220	8,880
66	83515	Mussacama	83516	Ulongue	Central-North	80	1xDove	2022	2023	60		Construction of 80km of 66kV Mussacama Ulongue Line and its Substation in Ulongue	Long-term	111	8,880						4,440	4,440																				8,880

Source: JICA study team

Table 6.2-27 Transmission line expansion plan (Central area)

Voltage (kV)	bus number	from	bus number	to	area	length (km)	Conductor name	Construction start year	Commissioned year	Normal Rating (MVA)	Funding	Remarks	investment classification	unit cost [kUSD]	project cost [kUSD]	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	[kUSD] total
110	81211	Chimoio 2	81312	Gondola	Central	18.4	1xDove	2039	2042	99			2042 Analysis	123	2,263																							566	566	566	566	2,263
22	81213	Chimoio 1	81313	Gondola	Central	18.4	1xDove	2024	2027	60			2027 Analysis	111	2,042								511	511	511	511																2,042
110	81811	XigodoA	81911	E.Chicam	Central	5	1xDove	2019	2022	99			2022 Analysis	123	615			154	154	154	154																					615
110	81121	Messica	81911	E.Chicam	Central	12	1xDove	2019	2022	99			2022 Analysis	123	1,476			369	369	369	369																					1,476
110	81121	Messica	81221	Manica	Central	17	1xDove	2019	2022	99			2022 Analysis	123	2,091			523	523	523	523																					2,091
400	82114	Inchope	99002	Vilanculos	Central	352.2	4xTern	2019	2024	2335		STE Phase 2 HVAC	Long-term	340	119,748			19,958	19,958	19,958	19,958	19,958	19,958																			119,748
400	82114	Inchope	99024	Orange Grove(Zim)	Central	185	4xTern	2020	2025	2335		MoZiSa Project	Long-term	340	62,900				10,483	10,483	10,483	10,483	10,483	10,483																		62,900
110	82111	Inchope	82211	Nhamata A	Central	31.2	1xDove	2024	2027	99			2027 Analysis	123	3,838								959	959	959	959																3,838
110	82111	Inchope	82211	Nhamata A	Central	31.2	1xDove	2024	2027	99			2027 Analysis	123	3,838								959	959	959	959																3,838
110	82111	Inchope	82211	Nhamata A	Central	31.2	1xDove	2039	2042	99			2042 Analysis	123	3,838																							959	959	959	959	3,838
110	82111	Inchope	82211	Nhamata A	Central	31.2	1xDove	2039	2042	99			2042 Analysis	123	3,838																							959	959	959	959	3,838
110	82111	Inchope	81312	Gondola	Central	46.8	1xDove	2039	2042	99			2042 Analysis	123	5,756																							1,439	1,439	1,439	1,439	5,756
110	80212	Mavuzi	82212	Nhamata B	Central	80	1xDove	2024	2027	99			2027 Analysis	123	9,840								2,460	2,460	2,460	2,460																9,840
220	81111	Chibata	82813	Dondo	Central	170	2xCondor	2015	2017	197			EDM plan	205	34,850	11,617																										11,617
220	81111	Chibata	82813	Dondo	Central	170	2xCondor	2019	2022	477			2022 Analysis	205	34,850			8,713	8,713	8,713	8,713																					34,850
110	81112	Chibata	81211	Chimoio 2	Central	20	1xDove	2039	2042	99			2042 Analysis	123	2,460																							615	615	615	615	2,460
110	82212	Nhamata B	82411	Lamego	Central	10	1xDove	2019	2022	99			2022 Analysis	123	1,230			308	308	308	308																					1,230
110	82212	Nhamata B	82411	Lamego	Central	10	1xDove	2024	2027	99			2027 Analysis	123	1,230								308	308	308	308																1,230
110	82212	Nhamata B	82411	Lamego	Central	10	1xDove	2024	2027	99			2027 Analysis	123	1,230								308	308	308	308																1,230
110	82411	Lamego	82161	Buzi	Central	75	1xDove	2016	2019	99	Pinggao	Increased capacity of the 110kV Lines of the Center region including the reconstruction of the Lamego - Buzi Line for 110kV	Mid-term	123	9,225	2,306	2,306	2,306																								6,919
110	82411	Lamego	82161	Buzi	Central	75	1xDove	2019	2022	99			2022 Analysis	123	9,225			2,306	2,306	2,306	2,306																					9,225
110	82411	Lamego	82511	Muda	Central	26.4	1xDove	2024	2027	99			2027 Analysis	123	3,247								812	812	812	812																3,247
110	82411	Lamego	82511	Muda	Central	26.4	1xDove	2024	2027	99			2027 Analysis	123	3,247								812	812	812	812																3,247
110	82411	Lamego	82511	Muda	Central	26.4	1xDove	2039	2042	99			2042 Analysis	123	3,247																							812	812	812	812	3,247
110	82411	Muda	82611	Mafambis	Central	3.6	1xDove	2024	2027	99			2027 Analysis	123	443								111	111	111	111																443
110	82411	Muda	82611	Mafambis	Central	3.6	1xDove	2024	2027	99			2027 Analysis	123	443								111	111	111	111																443
110	82411	Muda	82611	Mafambis	Central	3.6	1xDove	2039	2042	99			2042 Analysis	123	443																							111	111	111	111	443
110	82611	Mafambis	82711	Nhessemb	Central	19	1xDove	2024	2027	99			2027 Analysis	123	2,337								584	584	584	584																2,337
110	82611	Mafambis	82711	Nhessemb	Central	19	1xDove	2039	2042	99			2042 Analysis	123	2,337																							584	584	584	584	2,337
110	82711	Nhessemb	82811	Dondo A	Central	15	1xDove	2024	2027	99			2027 Analysis	123	1,845								461	461	461	461																1,845
110	82711	Nhessemb	82811	Dondo A	Central	15	1xDove	2039	2042	99			2042 Analysis	123	1,845																							461	461	461	461	1,845
110	82221	Cimentos	82911	Beira	Central	13.6	1xDove	2019	2022	99			2022 Analysis	123	1,673			418	418	418	418																					1,673
110	82221	Cimentos	82811	Dondo A	Central	3.485	1xDove	2024	2027	99			2027 Analysis	123	429								107	107	107	107																429
110	82221	Cimentos	82811	Dondo A	Central	3.485	1xDove	2024	2027	99			2027 Analysis	123	429								107	107	107	107																429
110	82211	Hhamat A	82812	Dondo B	Central	74	1xDove	2024	2027	99			2027 Analysis	123	9,102								2,276	2,276	2,276	2,276																9,102
110	82211	Hhamat A	82812	Dondo B	Central	74	1xDove	2024	2027	99			2027 Analysis	123	9,102								2,276	2,276	2,276	2,276																9,102
110	82211	Hhamat A	82812	Dondo B	Central	74	1xDove	2039	2042	99			2042 Analysis	123	9,102																							2,276	2,276	2,276	2,276	9,102
220	82813	Dondo	82816	Manga	Central	89	2xCondor	2020	2022	477	Fedha Advisory	Construction of 20km of 220km line between Dondo and Manga and 8km of 110kV line between Manga and Airport. Construction of Substation and airport	Mid-term	205	18,245				6,082	6,082	6,082																					18,245
220	92813	Dondo	82816	Manga	Central	89	2xCondor	2019	2022	477			2022 Analysis	205	18,245			4,561	4,561	4,561	4,561																					18,245
110	82817	Manga	82818	Airport	Central	8	1xDove	2020	2022	99	Fedha Advisory	Construction of 20km of 220km line between Dondo and Manga and 8km of 110kV line between Manga and Airport. Construction of Substation and airport	Mid-term	123	984				328	328	328																					984
110	82817	Manga	82818	Airport	Central	8	1xDove	2019	2022	99			2022 Analysis	123	984			246	246	246	246																					984
110	82812	Dondo B	82921	Beira Cimentos	Central	15.47	1xDove	2019	2022	99			2022 Analysis	123	1,903			476	476	476	476																					1,903
110	82812	Dondo B	82921	Beira Cimentos	Central	15.47	1xDove	2019	2022	99			2022 Analysis	123	1,903			476	476	476	476																					1,903
110	82812	Dondo B	82921	Beira Cimentos	Central	15.47	1xDove	2019	2022	99			2022 Analysis	123	1,903			476	476	476	476																					1,903
110	82812	Dondo B	82921	Beira Cimentos	Central	15.47	1xDove	2024	2027	99			2027 Analysis	123	1,903								476	476	476	476																1,903
110	82812	Dondo B	82921	Beira Cimentos	Central	15.47	1xDove	2024	2027	99			2027 Analysis	123	1,903								476	476	476	476																1,903
110	82812	Dondo B	82921	Beira Cimentos	Central	15.47	1xDove	2039	2042	99			2042 Analysis	123	1,903																							476	476	476	476	1,903
110	82812	Dondo B	82921	Beira Cimentos	Central	15.47	1xDove	2039	2042	99			2042 Analysis	123	1,903																							476	476	476	476	1,903
110	82911	Beira	82921	Beira Cimentos	Central	1.53	1xDove	2019	2022	99			2022 Analysis	123	188			47	47	47	47																					188
110	82911	Beira	82921	Beira Cimentos	Central	1.53	1xDove	2019	2022	99			2022 Analysis	123	188			47	47	47	47																					188
110	82911	Beira	82921	Beira Cimentos	Central	1.53	1xDove	2019	2022	99			2022 Analysis	123	188			47	47	47	47																					188
110	82911	Beira	82921	Beira Cimentos	Central	1.53	1xDove	2029	2032	99			2032 Analysis	123	188													47	47	47	47											188
110	82911	Beira	82921	Beira Cimentos	Central	1.53	1xDove	2029	2032	99			2032 Analysis	123	188													47	47	47	47											188
110	82911	Beira	82921	Beira Cimentos	Central	1.53	1xDove	2024	2027	99			2027 Analysis	123	188								47	47	47	47																188
110	82911	Beira	82921	Beira Cimentos	Central	1.53	1xDove	2039	2042	99			2042 Analysis	123	188																							47	47	47	47	188
110	99003	Chibabava	99001	Vilanculos	Central	240	1xDove	2020	2022	99			EDM plan	123	29,520				9,840	9,840	9,840																					29,520
400	82923	Inhaminga	71131	Chimuara	Central	125	4xTern	2025	2030	2335		Construction of 400kV Chimuara Line - Inhaminga-Inchope, 400 / 220kV Substation in Inhaminga and interconnection Inhaminga - Dondo at 220kV	Long-term	340	42,500									7,083	7,083	7,083	7,083	7,083	7,083													42,500
400	82923	Inhaminga	82923	Inchope	Central	140	4xTern	2025	2030	2335		Construction of 400kV Chimuara Line - Inhaminga-Inchope, 400 / 220kV Substation in Inhaminga and interconnection Inhaminga - Dondo at 220kV	Long-term	340	47,600									7,933	7,933	7,933	7,933	7,933	7,933													47,600
400	82923	Inhaminga	99011	Macossa	Central	100	4xTern	2025	2030	2335		Construction of 400kV Chimuara Line - Inhaminga-Inchope, 400 / 220kV Substation in Inhaminga and interconnection Inhaminga - Dondo at 220kV	Long-term	340	34,000									5,667	5,667	5,667	5,667	5,667	5,667													34,000
220	82924	Inhaminga	82813	Dondo	Central	130	2xCondor	2025	2030	477		Construction of 400kV Chimuara Line - Inhaminga-Inchope, 400 / 220kV Substation in Inhaminga and interconnection Inhaminga - Dondo at 220kV	Long-term	205	26,650									4,442	4,442	4,442	4,442	4,442	4,442													26,650

Source: JICA study team

Table 6.2-28 Transmission line expansion plan (Southern area except Maputo city)

Voltage (kV)	bus number	from	bus number	to	area	length (km)	Conductor name	Construction start year	Commissioned year	Normal Rating (MVA)	Funding	Remarks	investment classification	unit cost [kUSD]	project cost [kUSD]	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	[kUSD] total
110	96711	Lindela	96713	Massinga	South	100	1xDove	2015	2017	99			EDM plan	123	12,300	4,100																										4,100
110	96713	Massinga	99001	Vilanculos	South	159.4	1xDove	2018	2020	99			EDM plan	123	19,606		6,535	6,535	6,535																							19,606
400	99002	Vilanculos	99006	Chibuto	South	339.5	4xTern	2018	2021	2335		STE Phase 1-1 HVAC	Long-term	340	115,430		28,858	28,858	28,858	28,858																						115,430
110	99001	Vilanculos	96713	Masinga	South	159.4	1xDove	2039	2042	99			2042 Analysis	123	19,606																							4,902	4,902	4,902	4,902	19,606
110	96311	Macia	96411	Chicumbane	South	49	1xDove	2039	2042	99			2042 Analysis	123	6,027																							1,507	1,507	1,507	1,507	6,027
110	96411	Chicumbane	96716	Chongoene	South	184.8	1xDove	2039	2042	99			2042 Analysis	123	22,730																							5,683	5,683	5,683	5,683	22,730
110	96611	Kuvaninga	96621	Mapai	South	237	1xDove	2019	2022	99			2022 Analysis	123	29,151			7,288	7,288	7,288	7,288																					29,151
400	99006	Chibuto	99005	New Marracuene	South	179.3	4xTern	2018	2021	2335		STE Phase 1-1 HVAC	Long-term	340	60,962		15,241	15,241	15,241	15,241																						60,962
400	5946	Maputo	99005	New Marracuene	South	43.6	4xTern	2018	2021	2335		STE Phase 1-1 HVAC	Long-term	340	14,824		3,706	3,706	3,706	3,706																						14,824
275	97411	Maputo A	97311	Matola A	South	15.4	2xBear	2029	2032	479			2032 Analysis	197	3,034													758	758	758	758											3,034
275	97411	Maputo A	97311	Matola A	South	15.4	2xBear	2029	2032	479			2032 Analysis	197	3,034													758	758	758	758											3,034
275	97411	Maputo A	99004	New Marracuene	South	50	2xBear	2016	2019	479	Eurico Ferreira	Construction of 50km of 275kV Line between SE Maputo and Marracuene and interconnection with STE, and Southern Region Network	Mid-term	197	9,850	2,463	2,463	2,463																								7,388
275	97411	Maputo A	97131	Beluluane	South	0.6	2xBear	2018	2020	479			EDM plan	197	118		39	39	39																							118
275	97412	Maputo B	97814	Salamanga	South	100	2xBear	2017	2019	479	Sinohydoro ou CCC	Construction of 100km of 275kV Line and 275/66/33kV Substation in Salamanga to feed Catembe and Ponta de Ouro	Mid-term	197	19,700	9,850	9,850																									19,700
275	97114	Ressano Garcia	97131	Beluluane	South	90	2xBear	2016	2018	479	Mochi	Construction of 90km of 275kV Line between Ressano Garcia and Beluluane and interconnection with the existing 275 & 66kV Network	Mid-term	197	17,730	5,910	5,910																									11,820
275	97114	Ressano Garcia	96000	Dzimbene	South	142	1xDove	2015	2017	479			EDM plan	197	27,974	9,325																										9,325
275	97114	Ressano Garcia	97111	Infulene	South	85	2xBear	2039	2042	479			2042 Analysis	197	16,745																							4,186	4,186	4,186	4,186	16,745
66	97611	Matola Rio T	97711	Boane	South	10.9	1xDove	2029	2032	60			2032 Analysis	111	1,210													302	302	302	302											1,210
66	97611	Matola Rio T	97711	Boane	South	10.9	1xDove	2029	2032	60			2032 Analysis	111	1,210													302	302	302	302											1,210
66	97711	Boane	97811	Salamanga	South	76.73	1xDove	2024	2027	60			2027 Analysis	111	8,517								2,129	2,129	2,129	2,129																8,517
275	97311	Matola A	97111	Infulene	South	16	2xBear	2029	2032	479			2032 Analysis	197	3,152													788	788	788	788											3,152
275	97311	Matola A	97111	Infulene	South	16	2xBear	2029	2032	479			2032 Analysis	197	3,152													788	788	788	788											3,152
66	97212	Matola A	95111	Cimentos T-off	South	2.7	1xDove	2019	2022	60			2022 Analysis	111	300			75	75	75	75																					300
66	97212	Matola A	95111	Cimentos T-off	South	2.7	1xDove	2029	2032	60			2032 Analysis	111	300													75	75	75	75											300
66	97212	Matola A	95111	Cimentos T-off	South	2.7	1xDove	2039	2042	60			2042 Analysis	111	300																							75	75	75	75	300
66	97212	Matola A	98111	CTM A	South	4.9	1xDove	2019	2022	60			EDM plan	111	544			136	136	136	136																					544
66	97312	Matola B	98111	CTM A	South	5	1xDove	2019	2022	60			EDM plan	111	555			139	139	139	139																					555
66	97312	Matola B	98111	CTM A	South	5	1xDove	2029	2032	60			2032 Analysis	111	555													139	139	139	139											555
66	97312	Matola B	97511	Machava	South	2.5	1xDove	2019	2022	60			2022 Analysis	111	278			69	69	69	69																					278
66	97312	Matola B	97511	Machava	South	2.5	1xDove	2019	2022	60			2022 Analysis	111	278			69	69	69	69																					278
66	97312	Matola B	97511	Machava	South	2.5	1xDove	2029	2032	60			2032 Analysis	111	278													69	69	69	69											278
66	97132	Beluluane	97911	Beluluane	South	5.5	2xDove	2019	2022	120			2022 Analysis	134	737			184	184	184	184																					737
66	97132	Beluluane	97911	Beluluane	South	5.5	2xDove	2024	2027	120			2027 Analysis	134	737								184	184	184	184																737
66	97132	Beluluane	97911	Beluluane	South	5.5	2xDove	2024	2027	120			2027 Analysis	134	737								184	184	184	184																737
66	97132	Beluluane	97911	Beluluane	South	5.5	2xDove	2039	2042	120			2042 Analysis	134	737																							184	184	184	184	737
66	97911	Beluluane	97913	Tchumene	South	3	1xDove	2017	2019	60		Construction of Beluluane Line-Tchumene and respective SE in Tchumene	Long-term	111	333	111	111	111																								333
66	97911	Beluluane	97913	Tchumene	South	3	1xDove	2019	2022	60			2022 Analysis	111	333			83	83	83	83																					333
66	97911	Beluluane	97913	Tchumene	South	3	1xDove	2039	2042	60			2042 Analysis	111	333																							83	83	83	83	333
66	97911	Beluluane	97711	Boane	South	10	2xDove	2039	2042	120			2042 Analysis	134	1,340																							335	335	335	335	1,340
275	96000	Dzimbene	96715	Chongoene	South	80	2xBear	2018	2021	479		Construction of 80 km of 275kV line between the new SE Macia and Chongoene, 275/110kV substation in Chongoene and interconnection with the existing 110&33kV network	Long-term	197	15,760		3,940	3,940	3,940	3,940																						15,760
110	96001	Dzimbene	96311	Macia	South	3.18	1xDove	2039	2042	99			2042 Analysis	123	391																							98	98	98	98	391
110	96001	Dzimbene	96311	Macia	South	3.18	1xDove	2039	2042	99			2042 Analysis	123	391																							98	98	98	98	391
275	99004	New Marracuene	99009	SE 11	South	14	2xBear	2017	2019	479			EDM plan	197	2,758	919	919	919																								2,758
275	99004	New Marracuene	99009	SE 11	South	14	2xBear	2039	2042	479			2042 Analysis	197	2,758																							690	690	690	690	2,758
66	97424	New Marracuene	98911	SE7-Baixa	South	56	1xDove	2016	2019	60	World Bank	Construction of 81km of 275 & 66kV line between SE Infulene-Marracuene-SE7 and new SE in the Maxaquene (Baixa)	Mid-term	111	6,216	1,554	1,554	1,554																								4,662
66	97424	New Marracuene	98321	SE 11	South	14	1xDove	2017	2019	60	World Bank		Emergency	111	1,554	518	518	518																								1,554
66	97424	New Marracuene	98321	SE 11	South	14	1xDove	2019	2022	60			2022 Analysis	111	1,554			389	389	389	389																					1,554
66	97424	New Marracuene	97421	Marracuene	South	3	1xDove	2017	2019	60	World Bank		Emergency	111	333	111	111	111																								333
66	97424	New Marracuene	97421	Marracuene	South	3	1xDove	2019	2022	60			2022 Analysis	111	333			83	83	83	83																					333
66	97424	New Marracuene	97421	Marracuene	South	3	1xDove	2039	2042	60			2042 Analysis	111	333																							83	83	83	83	333
66	97424	New Marracuene	97421	Marracuene	South	3	1xDove	2039	2042	60			2042 Analysis	111	333																							83	83	83	83	333
66	97421	Marracuene	97521	Manihca	South	37	1xDove	2019	2022	60			2022 Analysis	111	4,107			1,027	1,027	1,027	1,027																					4,107
66	97421	Marracuene	97521	Manihca	South	37	2xDove	2029	2032	60			2032 Analysis	134	4,958													1,240	1,240	1,240	1,240											4,958

Source: JICA study team

Table 6.2-29　Transmission line expansion plan (Southern area (Maputo city))

Voltage (kV)	bus number	from	bus number	to	area	length (km)	Conductor name	Construction start year	Commissioned year	Normal Rating (MVA)	Funding	Remarks	investment classification	unit cost [kUSD]	project cost [kUSD]	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	[kUSD] total
275	97111	Infulene	99004	New Marracuene	South	25	2xBear	2016	2019	479	World Bank	Construction of 81km of 275 & 66kV line between SE Infulene-Marracuene-SE7 and new SE in the Maxaquene (Baixa)	Mid-term	197	4,925	1,231	1,231	1,231																								3,694
110	96111	Infulene	97623	Moamba	South	50	1xDove	2017	2019	99		Construction of the SE 110 / 33kV in Moamba and interconnection with the existing network	Long-term	123	6,150	2,050	2,050	2,050																								6,150
110	96111	Infulene	97623	Moamba	South	50	1xDove	2019	2022	99			2022 Analysis	123	6,150			1,538	1,538	1,538	1,538																					6,150
110	96111	Infulene	97621	Coruma	South	92	1xDove	2019	2022	99			2022 Analysis	123	11,316			2,829	2,829	2,829	2,829																					11,316
110	96111	Infulene	96211	Xinavane	South	100	1xDove	2039	2042	99			2042 Analysis	123	12,300																							3,075	3,075	3,075	3,075	12,300
66	97113	Infulene I	97511	Machava(DL6)	South	7.5	2xDove	2017	2019	120		Rebuildng	EDM plan	134	1,005	335	335	335																								1,005
66	97113	Infulene I	97511	Machava(DL6)	South	7.5	2xDove	2029	2032	120			2032 Analysis	134	1,005													251	251	251	251											1,005
66	97113	Infulene I	97511	Machava(DL6)	South	7.5	2xDove	2029	2032	120			2032 Analysis	134	1,005													251	251	251	251											1,005
66	97113	Infulene I	97511	Machava(DL6)	South	7.5	2xDove	2039	2042	120			2042 Analysis	134	1,005																							251	251	251	251	1,005
66	97113	Infulene	97121	Matola Gare	South	14	1xDove	2019	2022	120			2022 Analysis	134	1,876			469	469	469	469																					1,876
66	97113	Infulene I	98124	SE 9 T	South	7.5	1xDove	2019	2022	60			2022 Analysis	111	833			208	208	208	208																					833
66	97113	Infulene I	98124	SE 9 T	South	7.5	1xDove	2029	2032	60			2032 Analysis	111	833													208	208	208	208											833
66	97113	Infulene I	98124	SE 9 T	South	7.5	1xDove	2029	2032	60			2032 Analysis	111	833													208	208	208	208											833
66	97113	Infulene I	98124	SE 9 T	South	7.5	1xDove	2039	2042	60			2042 Analysis	111	833																							208	208	208	208	833
66	97112	Infulene II	98811	SE 6(DL2)	South	5.9	2xDove	2017	2019	120	World Bank		Emergency	134	791	264	264	264																								791
66	97112	Infulene II	98111	CTM A(DL3)	South	7.5	2xDove	2017	2019	120	World Bank		Emergency	134	1,005	335	335	335																								1,005
66	97112	Infulene II	98113	CTM A T	South	4.5	2xDove	2029	2032	120			2032 Analysis	134	603													151	151	151	151											603
66	97112	Infulene II	98113	CTM A T	South	4.5	2xDove	2039	2042	120			2042 Analysis	134	603																							151	151	151	151	603
66	97112	Infulene II	98214	CTM B(DL4)	South	7.5	2xDove	2017	2019	120		Rebuildng	EDM plan	134	1,005	335	335	335																								1,005
66	97112	Infulene II	98214	CTM B(DL4)	South	4.5	2xDove	2039	2042	120			2042 Analysis	134	603																							151	151	151	151	603
66	97112	Infulene II	98215	CTM B T	South	4.5	2xDove	2029	2032	120			2032 Analysis	134	603													151	151	151	151											603
66	97112	Infulene II	98215	CTM B T	South	4.5	2xDove	2029	2032	120			2032 Analysis	134	603													151	151	151	151											603
66	97112	Infulene II	98215	CTM B T	South	4.5	2xDove	2039	2042	120			2042 Analysis	134	603																							151	151	151	151	603
66	98111	CTM A	98113	CTM A T	South	3	2xDove	2039	2042	120			2042 Analysis	134	402																							101	101	101	101	402
66	98113	CTM A T	98911	SE 7	South	7.9	1xDove	2029	2032	60			2032 Analysis	111	877													219	219	219	219											877
66	98113	CTM A T	98911	SE 7	South	7.9	1xDove	2039	2042	60			2042 Analysis	111	877																							219	219	219	219	877
66	98211	CTM B	98413	SE 2 T(DL19)	South	3.5	2xDove	2017	2019	120		Rebuildng	EDM plan	134	469	156	156	156																								469
66	98211	CTM B	98413	SE 2 T(DL19)	South	3.5	2xDove	2039	2042	120			2042 Analysis	134	469																							117	117	117	117	469
66	98211	CTM B	98511	SE 3(DL18)	South	5.4	2xDove	2017	2019	120		Rebuildng	EDM plan	134	724	241	241	241																								724
66	98211	CTM B	98511	SE 3(DL18)	South	5.4	2xDove	2039	2042	120			2042 Analysis	134	724																							241	241	241	241	965
66	98211	CTM B	98214	CTM B T	South	3	2xDove	2039	2042	120			2042 Analysis	134	402																							101	101	101	101	402
66	98214	CTM B T	98911	SE 7	South	7.9	1xDove	2039	2042	60			2042 Analysis	111	877																							219	219	219	219	877
66	98215	CTM B T	98811	SE 6	South	1.4	2xDove	2029	2032	120			2032 Analysis	134	188													47	47	47	47											188
66	98215	CTM B T	98811	SE 6	South	1.4	2xDove	2029	2032	120			2032 Analysis	134	188													47	47	47	47											188
66	98215	CTM B T	98811	SE 6	South	1.4	2xDove	2039	2042	120			2042 Analysis	134	188																							47	47	47	47	188
66	98215	CTM B T	98811	SE 6	South	1.4	2xDove	2039	2042	120			2042 Analysis	134	188																							47	47	47	47	188
66	98311	SE 1	98711	SE 5	South	6	1xDove	2017	2019	60	World Bank		Emergency	111	666	222	222	222																								666
66	98311	SE 1	98911	SE 7	South	3	1xDove	2017	2019	60	World Bank		Emergency	111	333	111	111	111																								333
66	98311	SE 1	98131	Facim	South	3	2xDove	2017	2019	120			EDM plan	134	402	134	134	134																								402
66	98413	SE 2 T	98411	SE2	South	0.2	1xDove	2019	2022	60			2022 Analysis	111	22				6	6	6																					17
66	98413	SE 2 T	98411	SE2	South	0.2	1xDove	2029	2032	60			2032 Analysis	111	22													6	6	6	6											22
66	98511	SE3	98911	SE7	South	2	1xDove	2019	2022	60			2022 Analysis	111	222			56	56	56	56																					222
66	98511	SE3	98911	SE7	South	2	1xDove	2019	2022	60			2022 Analysis	111	222			56	56	56	56																					222
66	98511	SE3	98911	SE7	South	2	1xDove	2029	2032	60			2032 Analysis	111	222													56	56	56	56											222
66	98511	SE3	98911	SE7	South	2	1xDove	2039	2042	60			2042 Analysis	111	222																							56	56	56	56	222
66	98511	SE3	98131	Facim	South	1.82	2xDove	2017	2019	120			EDM plan	134	244	81	81	81																								244
66	98611	SE 4	98711	SE 5	South	4.8	1xDove	2019	2022	60			2022 Analysis	111	533			133	133	133	133																					533
66	98611	SE 4	98711	SE 5	South	4.8	1xDove	2029	2032	60			2032 Analysis	111	533													133	133	133	133											533
66	98611	SE 4	98711	SE 5	South	4.8	1xDove	2029	2032	60			2032 Analysis	111	533													133	133	133	133											533
66	98611	SE 4	98811	SE 6	South	2.41	1xDove	2029	2032	60			2032 Analysis	111	268													67	67	67	67											268
66	98611	SE 4	98811	SE 6	South	2.41	1xDove	2029	2032	60			2032 Analysis	111	268													67	67	67	67											268
66	98611	SE 4	98811	SE 6	South	2.41	1xDove	2029	2032	60			2032 Analysis	111	268													67	67	67	67											268
66	98711	SE 5	98911	SE 7	South	4	1xDove	2019	2022	60			2022 Analysis	111	444			111	111	111	111																					444
66	98711	SE 5	98911	SE 7	South	4	1xDove	2029	2032	60			2032 Analysis	111	444													111	111	111	111											444
66	98711	SE 5	98221	SE 8	South	4.99	1xDove	2029	2032	60			2032 Analysis	111	554													138	138	138	138											554
66	98711	SE 5	98221	SE 8	South	4.99	1xDove	2029	2032	60			2032 Analysis	111	554													138	138	138	138											554
66	98711	SE 5	98321	SE 11	South	9	1xDove	2017	2019	60	World Bank		Emergency	111	999	333	333	333																								999
66	98711	SE 5	98321	SE 11	South	9	1xDove	2019	2022	60			2022 Analysis	111	999			250	250	250	250																					999
66	98711	SE 5	98321	SE 11	South	9	1xDove	2019	2022	60			2022 Analysis	111	999			250	250	250	250																					999
66	98711	SE 5	98321	SE 11	South	9	1xDove	2029	2032	60			2032 Analysis	111	999													250	250	250	250											999
66	98711	SE 5	98321	SE 11	South	9	1xDove	2039	2042	60			2042 Analysis	111	999																							250	250	250	250	999
66	98711	SE 5	98321	SE 11	South	9	1xDove	2039	2042	60			2042 Analysis	111	999																							250	250	250	250	999
66	98711	SE 5	98321	SE 11	South	9	1xDove	2039	2042	60			2042 Analysis	111	999																							250	250	250	250	999
66	98121	SE 9	98321	SE 11	South	8	1xDove	2039	2042	120			2042 Analysis	134	1,072																							268	268	268	268	1,072
66	97321	SE 10	98321	SE 11	South	11	1xDove	2017	2019	60	World Bank		Emergency	111	1,221	407	407	407																								1,221

Source: JICA study team

Table 6.2-30 Substation expansion plan (Northern area)

bus number	bus number	Substation	Area	Province	Voltage	Capacity	Quantity	Construction start year	Commissioned year	Funding	Remarks	investment classification	Unit cost [kUSD]	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	total
72611	72612	Pemba	North	Cabo Delgado	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
72611	72612	2nd Pemba	North	Cabo Delgado	110/33	40	1	2021	2024		Construction of 100km of 110kV Line and 110 / 33kV Substation in Pemba for second power to the City.	Mid-term	11,621					2,905	2,905	2,905	2,905																			11,621
72611	72612	3rd Pemba	North	Cabo Delgado	110/33	40	1	2029	2032		additional substation	2032 Analysis	11621													2905	2905	2905	2905											11,621
72611	72612	4th Pemba	North	Cabo Delgado	110/33	40	1	2035	2038		additional substation	2042 Analysis	11621																			2905	2905	2905	2905					11,621
72611	72612	5th Pemba	North	Cabo Delgado	110/33	40	1	2039	2042		additional substation	2042 Analysis	11621																							2905	2905	2905	2905	11,621
72711	72712	Macomia	North	Cabo Delgado	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
72711	72712	Macomia	North	Cabo Delgado	110/33	40	1	2038	2041		additional/replacement transformer	2042 Analysis	5203																						1301	1301	1301	1301		5,203
99020	99022	Metoro	North	Cabo Delgado	400/220	250	1	2021	2026		Tanzania interconnector	Mid-term	39,135					6,523	6,523	6,523	6,523	6,523	6,523																	39,135
99020	72511	Metoro	North	Cabo Delgado	400/110	250	2	2021	2026		Tanzania interconnector	Mid-term	17,087					5,696	5,696	5,696	5,696	5,696	5,696																	34,174
72511	72512	Metoro	North	Cabo Delgado	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
72814	72811	Auasse	North	Cabo Delgado	220/110	100	1	2021	2026		Construction of a Line of 220 (400) kV Metoro - Palma and interconnection with SE Auasse	Long-term	22,300					3,717	3,717	3716.67	3716.67	3716.67	3,717																	22,300
72811	72812	Ausse	North	Cabo Delgado	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
72811	72812	Ausse	North	Cabo Delgado	110/33	40	1	2026	2029		additional/replacement transformer	2022 Analysis	5203										1301	1301	1301	1301														5,203
73613	73614	Montepuez	North	Cabo Delgado	220/110	100	1	2019	2024		Construction of a 220kV Metoro - Montepuez Line, Montepuez Substation and 110kV Line Montepuez - Marrupa	Long-term	22,300			3,717	3,717	3,717	3,717	3,717	3,717																			22,300
73614	73615	Montepuez	North	Cabo Delgado	110/33	40	1	2019	2024				11,621			1,937	1,937	1,937	1,937	1,937	1,937																			11,621
99021	72813	Palma	North	Cabo Delgado	400/220	250	1	2021	2026		Construction of a Line of 220 (400) kV Metoro - Palma and interconnection with SE Auasse	Long-term	39,135					6,523	6,523	6522.5	6522.5	6522.5	6,523																	39,135
72813	72816	Palma	North	Cabo Delgado	220/33	40	1	2021	2026		Construction of a Line of 220 (400) kV Metoro - Palma and interconnection with SE Auasse	Long-term	17,350					2,892	2,892	2892	2892	2892	2,892																	17,350
73411	73412	Cuamba	North	Niassa	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
73411	73412	Cuamba	North	Niassa	110/33	40	1	2030	2033		additional/replacement transformer	2042 Analysis	5203														1301	1301	1301	1301										5,203
73513	73511	Lichinga	North	Niassa	200/110	100	1	2034	2037		Installation of Hydropower	Hydropower	22300																		5575	5575	5575	5575						22,300
73513	73511	Lichinga	North	Niassa	200/110	100	1	2034	2037		additional/replacement transformer	Hydropower	9792																		2448	2448	2448	2448						9,792
73511	72512	Lichinga	North	Niassa	110/66	40	1	2017	2019	World Bank	Installation of aditional transformer	Emergency	5203	1734	1734	1734																								5,203
73511	72512	Lichinga	North	Niassa	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
73511	72512	2nd Lichinga	North	Niassa	110/33	40	1	2024	2027		additional substation	2032 Analysis	11621								2905	2905	2905	2905																11,621
73511	72512	3rd Lichinga	North	Niassa	110/33	40	1	2036	2039		additional substation	2042 Analysis	11621																				2905	2905	2905	2905				11,621
73611	73612	Marrupa	North	Niassa	110/33	40	1	2017	2019		110kV Cuamba-Marrupa	EDM plan	11,621	3874	3874	3874																								11,621
72211	72212	Nampula Central	North	Nampula	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
72211	72212	2nd Nampula Central	North	Nampula	110/33	40	1	2021	2024		additional substation	2032 Analysis	11621					2905	2905	2905	2905																			11,621
72211	72212	3rd Nampula Central	North	Nampula	110/33	40	1	2032	2035		additional substation	2042 Analysis	11621																2905	2905	2905	2905								11,621
72211	72212	4th Nampula Central	North	Nampula	110/33	40	1	2039	2042		additional substation	2042 Analysis	11621																							2905	2905	2905	2905	11,621
71811	72111	Nampula	North	Nampula	220/110	100	1	2016	2018	AfDB	installation of additional transformer	Mid-term	9792	3264	3264																									6,528
71811	72111	Nampula	North	Nampula	220/110	100	1	2029	2032		additional/replacement transformer	2032 Analysis	9792													2448	2,448	2448	2448											9,792
72111	72118	Nampula	North	Nampula	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
72111	72118	2nd Nampula	North	Nampula	110/33	40	1	2019	2022		additional substation	2022 Analysis	11621			2905	2905	2905	2905																					11,621
72111	72118	3rd Nampula	North	Nampula	110/33	40	1	2029	2032		additional substation	2032 Analysis	11621													2905	2,905	2905	2905											11,621
72111	72118	4th Nampula	North	Nampula	110/33	40	1	2036	2039		additional substation	2042 Analysis	11621																				2905	2905	2905	2905				11,621
72911	72912	Moma	North	Nampula	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
72911	72912	2nd Moma	North	Nampula	110/33	40	1	2019	2022		additional substation	2022 Analysis	11621			2905	2905	2905	2905																					11,621
72911	72912	3rd Moma	North	Nampula	110/33	40	1	2022	2025		additional substation	2032 Analysis	11621						2905	2905	2905	2905																		11,621
72911	72912	4th Moma	North	Nampula	110/33	40	1	2032	2035		additional substation	2042 Analysis	11621																2905	2905	2905	2905								11,621
72911	72912	5th Moma	North	Nampula	110/33	40	1	2038	2041		additional substation	2042 Analysis	11621																						2905	2905	2905	2905		11,621
72911		Moma 220	North	Nampula	220/110	100	1	2039	2042		additional substation for 220kV	2042 Analysis	22300																							5575	5575	5575	5575	22,300
72311	72312	Monapo	North	Nampula	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
72311	72312	2nd Monapo	North	Nampula	110/33	40	1	2028	2031		additional substation	2032 Analysis	11621												2905	2905	2905	2905												11,621
72411	72412	Nacala	North	Nampula	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
72411	72412	2nd Nacala	North	Nampula	110/33	40	1	2022	2025		additional substation	2032 Analysis	11621						2905	2905	2905	2905																		11,621
72231	72232	Nacala Vale	North	Nampula	110/33	40	1	2018	2020		New substation	EDM plan	11621		3874	3874	3874																							11,621
72231	72232	2nd Nacala Vale	North	Nampula	110/33	40	1	2018	2020		additional substation	EDM plan	11621			2905	2905	2905	2905																					11,621
72131	72141	Namialo	North	Nampula	400/220	250	1	2018	2022	IsDB, (AfDB,JICA)	400kV Caia-Nacala	EDM plan	39,135		7827	7827	7827	7827	7827																					39,135
72121	72122	Namialo	North	Nampula	110/33	40	1	2018	2020	JICA	New substation	EDM plan	11621		3874	3874	3874																							11,621
72121	72122	2nd Namialo	North	Nampula	110/33	40	1	2021	2024		additional substation	2032 Analysis	11621					2905	2905	2905	2905																			11,621
72121	72122	3rd Namialo	North	Nampula	110/33	40	1	2032	2035		additional substation	2042 Analysis	11621																2905	2905	2905	2905								11,621
72121	72122	4th Namialo	North	Nampula	110/33	40	1	2039	2042		additional substation	2042 Analysis	11621																							2905	2905	2905	2905	11,621
72421	72422	Nacala valha	North	Nampula	220/110	100	1	2018	2022	IsDB, (AfDB,JICA)	400kV Caia-Nacala	EDM plan	22,300		4460	4460	4460	4460	4460																					22,300
72421	72422	Nacala valha	North	Nampula	220/110	100	2	2039	2042		additional/replacement transformer	2042 Analysis	9792																							4896	4896	4896	4896	19,584
72915	72919	Angoche	North	Nampula	110/33	40	1	2022	2025	Sinohydro ou CCC	Construction of 180km 110kV line between Nampula and Angoche and interconnection with the existing network	Mid-term	11,621						3873.7	3,874	3,874																			11,621
72915	72919	2nd Angoche	North	Nampula	110/33	40	1	2036	2039		additional substation	2042 Analysis	11621																				2905	2905	2905	2905				11,621
71711	73111	Alto Molocue	North	Zambezia	220/110	100	1	2019	2022		additional/replacement transformer	2022 Analysis	9792			2448	2448	2448	2448																					9,792
73111	73112	Alto Molocue	North	Zambezia	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
71617	71615	Mocuba	North	Zambezia	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
71617	71615	Mocuba	North	Zambezia	110/33	40	1	2037	2040		additional/replacement transformer	2042 Analysis	5203																					1301	1301	1301	1301			5,203
71411	71413	Ceramica	North	Zambezia	220/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	7755			1939	1939	1939	1939																					7,755
71411	71413	2nd Ceramica	North	Zambezia	220/33	40	1	2019	2022		additional substation	2022 Analysis	17350			4338	4338	4338	4338																					17,350
71411	71413	3rd Ceramica	North	Nampula	220/33	40	1	2025	2028		additional substation	2032 Analysis	17350									4338	4338	4338	4338															17,350
71411	71413	4th Ceramica	North	Nampula	220/33	40	1	2031	2034		additional substation	2042 Analysis	17350															4338	4338	4338	4338									17,350
71411	71413	5th Ceramica	North	Nampula	220/33	40	1	2036	2039		additional substation	2042 Analysis	17350																				4338	4338	4338	4338				17,350
73311	73312	Gurue	North	Nampula	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
71131	71111	Chimuara(Caia)	North	Zambezia	400/220	250	1	2018	2022	IsDB, (AfDB,JICA)	400kV Caia-Nacala	EDM plan	39,135		7827	7827	7827	7827	7827																					39,135
71111	71112	Chimuara	North	Zambezia	220/110	100	1	2019	2022		additional/replacement transformer	2022 Analysis	9792			2448	2448	2448	2448																					9,792
71111	71112	Chimuara	North	Zambezia	220/110	100	1	2029	2032		additional/replacement transformer	2032 Analysis	9792													2448	2448	2448	2448											9,792
71111	71112	Chimuara	North	Zambezia	220/110	100	1	2039	2042		additional/replacement transformer	2042 Analysis	9792																							2,448	2,448	2,448	2,448	9,792
71112	71117	Chimuara	North	Zambezia	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
71112	71117	Chimuara	North	Zambezia	110/33	40	1	2022	2025		additional/replacement transformer	2022 Analysis	5203						1301	1301	1301	1301																		5,203
71112	71117	2nd Chimuara	North	Zambezia	110/33	40	1	2036	2039		additional substation	2042 Analysis	11621																				2905	2905	2905	2905				11,621
73211	73212	Uape	North	Zambezia	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
73211	73212	Uape	North	Zambezia	110/33	40	1	2034	2037		additional/replacement transformer	2042 Analysis	5203																		1301	1301	1301	1301						5,203

Source: JICA study team

Table 6.2-31 Substation expansion plan (Central-Northern area and Central area)

bus number	bus number	Substation	Area	Province	Voltage	Capacity	Quantity	Construction start year	Commissioned year	Funding	Remarks	investment classification	Unit cost [kUSD]	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	total
99018		Cataxa HVDC	Central-North	Tete	/DC500			2019	2024		STE Pahse 1&2 HVDC	Long-term	597,870			99,645	99,645	99,645	99,645	99,645	99,645																			597,870
99014	83911	Songo	Central-North	Tete	400/220	250	1	2019	2024		STE Phase 1 HVAC	Long-term	39,135			6,523	6,523	6,523	6,523	6,523	6,523																			39,135
99014	83911	Songo	Central-North	Tete	400/220	250	2	2024	2027		additional/replacement transformer	2027 Analysis	17,087								8,544	8,544	8,544	8544																34,174
99013		Cataxa	Central-North	Tete	400		1	2019	2024		STE Phase 1 HVAC MoZiSa project	Long-term	39,135			6,523	6,523	6,523	6,523	6,523	6,523																			39,135
99012	98924	Lupata	Central-North	Tete	400/33	40	1	2019	2024		STE Phase 1 HVAC	Long-term	27,306			4,551	4,551	4,551	4,551	4,551	4,551																			27,306
99007	83111	Matambo	Central-North	Tete	400/220	250	1	2018	2021		STE Phase 1 HVAC Malawi interconnector Zambia interconnector	Long-term	39,135		9,784	9,784	9,784	9,784																						39,135
99007	83111	Matambo	Central-North	Tete	400/220	250	1	2024	2027		additional/replacement transformer	2027 Analysis	17,087								4,272	4,272	4,272	4272																17,087
83111	83116	Matambo	Central-North	Tete	220/66	100	1	2019	2022		additional/replacement transformer	2022 Analysis	9792			2448	2448	2448	2448																					9,792
83111	83116	Matambo	Central-North	Tete	220/66	100	1	2039	2042		additional/replacement transformer	2042 Analysis	9792																							2448	2448	2448	2448	9,792
83111	83114	Matambo	Central-North	Tete	220/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	7755			1939	1939	1939	1939																					7,755
83111	83114	Matambo	Central-North	Tete	220/33	40	1	2022	2025		additional/replacement transformer	2032 Analysis	7755						1939	1939	1939	1939																		7,755
83111	83114	2nd Matambo	Central-North	Tete	220/33	40	1	2038	2041		additional substation	2042 Analysis	17350																						4338	4338	4338	4338		17,350
83511	83512	Tete	Central-North	Tete	66/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	3735			934	934	934	934																					3,735
83511	83512	Tete	Central-North	Tete	66/33	40	1	2029	2032		additional/replacement transformer	2032 Analysis	3735													934	934	934	934											3,735
83712	83713	Movel Tete	Central-North	Tete	66/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	3735			934	934	934	934																					3,735
83712	83713	Movel Tete	Central-North	Tete	66/33	40	1	2032	2035		additional/replacement transformer	2042 Analysis	3735																934	934	934	934								3,735
83611	83612	Manje	Central-North	Tete	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
83211	83212	Jindal	Central-North	Tete	220/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	7755			3878	3878	3878	3878																					15,510
83714	83716	Vale	Central-North	Tete	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
83714	83716	2nd Vale	Central-North	Tete	66/33	40	1	2019	2022		additional substation	2022 Analysis	8171			2043	2043	2043	2043																					8,171
83112	83721	Canangola	Central-North	Tete	220/33	40	1	2016	2017	Danida, kfw, EIB	Construction of new substation	Short-term	17350	8675																										8,675
99008	83514	Moatize	Central-North	Tete	400/66	125	1	2018	2021		Malawi interconnector	Long-term	39135		9784	9784	9784	9784																						39,135
83514	83417	Moatize	Central-North	Tete	66/33	40	2	2018	2022		Construction of a Substation in Moatize from SE Vale	Long-term	8,171		3,268	3,268	3,268	3,268	3,268																					16,342
83514	83417	2nd Moatize	Central-North	Tete	66/33	40	1	2038	2041		additional substation	2042 Analysis	8171																						2043	2043	2043	2043		8,171
83515	83519	Mussacama	Central-North	Tete	66/33	40	1	2022	2023		Construction of 80km of Moatize - Mussacama 66kV Line and its Substation in Mussacama	Long-term	8,171						4,086	4,086																				8,171
83516	83520	Ulongue	Central-North	Tete	66/33	40	1	2022	2023		Construction of 80km of 66kV Mussacama - Ulongue Line and its Substation in Ulongue	Long-term	8,171						4,086	4,086																				8,171
71621	71623	Pebane(Magiga/Caravela)	Central	Zambezia	110/33	40	1	2020	2025		Construction of a 110kV Line, 140km, between Mocuba and Magiga / Caravela, in Pebane and its 110 / 33kV Substation	Long-term	11,621				1,937	1,937	1,937	1,937	1,937	1,937																		11,621
71622	71624	Milange	Central	Zambezia	110/33	40	1	2020	2025		Construction of 120km of 110kV Line between Mocuba and Milange and its Substation in Milange	Long-term	11,621				1,937	1,937	1,937	1,937	1,937	1,937																		11,621
81211	81212	Chimoio 1 22	Central	Manica	110/22	40	2	2016	2018	AfDB	Acquisition of new trasnformer and interconnection with Chimoio1 Urgent Rehabilitation project	Mid-term	5203	3469	3469																									6,937
81214	81215	Chimoio 1 6.6	Central	Manica	66/6.6	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
81214	81215	2nd Chimoio 1 6.6	Central	Manica	66/6.6	40	1	2034	2037		additional substation	2042 Analysis	8171																		2043	2043	2043	2043						8,171
81221	81222	Manica	Central	Manica	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
81221	81222	2nd Manica	Central	Manica	110/33	40	1	2038	2041		additional substation	2042 Analysis	11621																						2905	2905	2905	2905		11,621
81711	81713	Mavita	Central	Manica	110/22	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
81121	81123	Messica	Central	Manica	110/6.6	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
81223	81225	Catandica	Central	Manica	220/33	40	1	2016	2018	AfDB	Installation of additional transformer	Mid-term	7755	2585	2585																									5,170
81223	81225	Catandica	Central	Manica	220/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	7755			1939	1939	1939	1939																					7,755
81312	81313	Gondola	Central	Manica	110/22	40	1	2016	2018	AfDB	Installation of additional transformer	Mid-term	5203	1734	1734																									3,469
81312	81313	Gondola	Central	Manica	110/22	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
82114	82111	Inchope	Central	Manica	400/110	250	1	2019	2024		STE Pahse 1 HVAC MoZiSa project	Long-term	39,135			6,523	6,523	6,523	6,523	6,523	6,523																			39,135
82111	82114	Inchope	Central	Manica	400/110	250	1	2024	2027			2027 Analysis	17,087								4,272	4,272	4,272	4272																17,087
82111	82113	Inchope	Central	Manica	110/33	40	1	2016	2018	AfDB	Installation of additional transformer	Mid-term	5203	1734.3	1734.3																									3,469
82111	82113	Inchope	Central	Manica	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
83717	83718	Guro	Central	Manica	66/33	40	1	2018	2022		Construction of a 66kV Line, 90km between SE Matambo and Guro and its Substation in Guro	Long-term	8,171		1,634	1,634	1,634	1,634	1,634																					8,171
99011	83719	Macossa	Central	Manica	400/33	40	1	2019	2024		STE Phase 1 HVAC	Long-term	27,306			4,551	4,551	4,551	4,551	4,551	4,551																			27,306
82411	82413	Lamego	Central	Sofala	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
82411	82413	2nd Lamego	Central	Sofala	110/33	40	1	2036	2039		additional substation	2042 Analysis	11621																				2905	2905	2905	2905				11,621
82611	82612	Mafambisse	Central	Sofala	110/22	40	1	2016	2018	AfDB	Installation of additional transformer	Mid-term	5203	1734.3	1734.3																									3,469
82611	82612	Mafambisse	Central	Sofala	110/22	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
82611	82612	2nd Mafambisse	Central	Sofala	110/22	40	1	2020	2023		additional substation	2032 Analysis	11621				2905	2905	2905	2905																				11,621
82813	82815	Dondo	Central	Sofala	220/110	100	1	2017	2017		220kV Chibata-Dondo	EDM plan	22,300	22,300																										22,300
82813	82815	Dondo	Central	Sofala	220/110	100	1	2019	2022		additional/replacement transformer	2022 Analysis	9,792			2448	2448	2448	2448																					9,792
82813	82815	Dondo	Central	Sofala	220/110	100	1	2029	2032		additional/replacement transformer	2032 Analysis	9,792													2448	2,448	2,448	2,448											9,792
82814	82815	Dondo	Central	Sofala	110/22	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
82814	82815	2nd Dondo	Central	Sofala	110/22	40	1	2037	2040		additional substation	2042 Analysis	11621																					2905	2905	2905	2905			11,621
71211	71213	Marroumeu	Central	Sofala	110/22	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
71211	71213	2nd Marroumeu	Central	Sofala	110/22	40	1	2034	2037		additional substation	2042 Analysis	11621																		2905	2905	2905	2905						11,621
82161	82181	Buzi	Central	Sofala	110/22	40	2	2016	2019	Pinggao	Increased capacity of the 110kV Lines of the Center region including the reconstruction of the Lamego - Buzi Line for 110kV	Mid-term	5,203	2,602	2,602	2,602																								7,805
82221	82222	Cimentos	Central	Sofala	110/22	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
82221	82222	2nd Cimentos	Central	Sofala	110/22	40	1	2038	2041		additional substation	2042 Analysis	11621																						2905	2905	2905	2905		11,621
82911	82913	Beira 22	Central	Sofala	110/22	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
82911	82913	2nd Beira 22	Central	Sofala	110/22	40	1	2019	2022		additional substation	2022 Analysis	11621			2905	2905	2905	2905																					11,621
82911	82913	3rd Beira 22	Central	Sofala	110/22	40	1	2021	2024		additional substation	2032 Analysis	11621					2905	2905	2905	2905																			11,621
82911	82913	4th Beira 22	Central	Sofala	110/22	40	1	2027	2030		additional substation	2032 Analysis	11621											2905	2905	2905	2905													11,621
82911	82913	5th Beira 22	Central	Sofala	110/22	40	1	2032	2035		additional substation	2042 Analysis	11621																2905	2905	2905	2905								11,621
82911	82913	6th Beira 22	Central	Sofala	110/22	40	1	2036	2039		additional substation	2042 Analysis	11621																				2905	2905	2905	2905				11,621
82911	82916	2nd Beira 6.6	Central	Sofala	110/6.6	40	1	2021	2024		additional substation	2032 Analysis	11621					2905	2905	2905	2905																			11,621
82911	82916	3rd Beira 6.6	Central	Sofala	110/6.6	40	1	2027	2030		additional substation	2032 Analysis	11621											2905	2905	2905	2905													11,621
82911	82916	4th Beira 6.6	Central	Sofala	110/6.6	40	1	2032	2035		additional substation	2042 Analysis	11621																2905	2905	2905	2905								11,621
82911	82916	5th Beira 6.6	Central	Sofala	110/6.6	40	1	2036	2039		additional substation	2042 Analysis	11621																				2905	2905	2905	2905				11,621
82925	82935	Munhava 22	Central	Sofala	110/22	40	1	2016	2018	AfDB	Acquisition of new transformer Urgent Rehabilitation project	Mid-term	11621	3873.7	3873.7																									7,747
82925	82935	2nd Munhava 22	Central	Sofala	110/22	40	1	2019	2022		additional substation	2022 Analysis	11621			2905	2905	2905	2905																					11,621
82925	82937	Munhava 6.6	Central	Sofala	110/6.6	40	1	2016	2018	AfDB	Acquisition of new transformer Urgent Rehabilitation project	Mid-term	11621	3873.7	3873.7																									7,747
82925	82937	2nd Munhava 6.6	Central	Sofala	110/6.6	40	1	2032	2035		additional substation	2042 Analysis	11621																2905	2905	2905	2905								11,621
82921	82922	Beira Cimentos	Central	Sofala	110/22	40	1	2018	2020		New substation	EDM plan	11621		2905	2905	2905	2905																						11,621
82816	82817	Manga	Central	Sofala	220/110	100	1	2020	2022	Fedha Advisory	Construction of 20km of 220kV line between Dondo and Manga and 8km of 110kV line between Manga and Airport. Construction of Substations in Manga and airport	Mid-term	22,300				7433	7433	7433																					22,300
82817	80820	Manga	Central	Sofala	110/33	40	1	2020	2022		New substation	EDM plan	11621				3874	3874	3874																					11,621
82818	82828	Manga Airport	Central	Sofala	110/33	40	1	2020	2022	Fedha Advisory	Construction of 20km of 220kV line between Dondo and Manga and 8km of 110kV line between Manga and Airport. Construction of Substations in Manga and airport	Mid-term	11,621				3874	3874	3874																					11,621
99003	99010	Chibabava	Central	Sofala	110/33	40	1	2018	2022		110kV Chibabava-Vilanculos	EDM plan	11,621		2,324	2,324	2,324	2,324	2,324																					11,621
82923	82924	Inhaminga	Central	Sofala	400/220	250	1	2024	2030		400kV Inghaminga-Chimuara	Long-term	39,135								5,591	5,591	5,591	5,591	5,591	5,591	5,591													39,135
82924		Inhaminga	Central	Sofala	220/33	40	1	2024	2030		400kV Inghaminga-Chimuara	Long-term	17,350								2,479	2,479	2,479	2,479	2,479	2,479	2,479													17,350

Source: JICA study team

Table 6.2-32 Substation expansion plan (Southern area except Maputo City)

bus number	bus number	Substation	Area	Province	Voltage	Capacity	Quantity	Construction start year	Commissioned year	Funding	Remarks	investment classification	Unit cost [kUSD]	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	total
96711	96712	Lindela	South	Inhabane	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
96711	96712	Lindela	South	Inhabane	110/33	40	1	2021	2024		additional/replacement transformer	2032 Analysis	5203					1301	1301	1301	1301																			5,203
96711	96712	2nd Lindela	South	Inhabane	110/33	40	1	2034	2037		additional substation	2042 Analysis	11621																		2905	2905	2905	2905						11,621
96713	96714	Massinga	South	Inhambane	110/33	40	1	2017	2017		110kV Lindela-Massinga	EDM plan	11,621	11,621																										11,621
99002	99001	Vilanculos	South	Inhambane	400/110	250	1	2018	2021		STE Phase 1-1 HVAC	Long-term	39,135		9,784	9,784	9,784	9,784																						39,135
99001	96718	Vilanculos	South	Inhambane	110/33	40	1	2018	2020		110kV Massinga-Vilanculos	EDM plan	11,621		3,874	3,874	3,874																							11,621
96511	96512	Lionde	South	Gaza	110/33	40	1	2016	2018	AfDB	Installation of additional transformer	Mid-term	5203	1734.3	1734.3																									3,469
96511	96512	Lionde	South	Gaza	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
96311	96312	Macia	South	Gaza	110/33	40	1	2016	2018	AfDB	Installation of additional transformer	Mid-term	5203	1734.3	1734.3																									3,469
96311	96312	Macia	South	Gaza	110/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	5203			1301	1301	1301	1301																					5,203
96311	96312	2nd Macia	South	Gaza	110/33	40	1	2032	2035		additional substation	2042 Analysis	11621																2905	2905	2905	2905								11,621
96211	96212	Xinavane	South	Gaza	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
96211	96212	2nd Xinavane	South	Gaza	110/33	40	1	2027	2030		additional substation	2032 Analysis	11621											2905	2905	2905	2905													11,621
96211	96212	3rd Xinavane	South	Gaza	110/33	40	1	2039	2042		additional substation	2042 Analysis	11621																							2905	2905	2905	2905	11,621
96411	96412	Chicumbane(Xai-Xai)	South	Gaza	110/33	40	1	2016	2018	AfDB	Installation of additional transformer	Mid-term	5203	1734.3	1734.3																									3,469
96411	96412	2nd Chicumbane(Xai-Xai)	South	Gaza	110/33	40	1	2034	2037		additional substation	2042 Analysis	11621																		2905	2905	2905	2905						11,621
96621	96622	Mapai	South	Gaza	110/33	40	1	2017	2018			EDM plan	11621	5810.5	5810.5																									11,621
96715	96716	Chongoene	South	Gaza	275/110	250	1	2018	2021		Construction of 80km of 275kV line between new SE Macia and Chongoene, 275 / 110kV substation in Chongoene and interconnection with existing 110 & 33kV network	Long-term	30,811		7,703	7,703	7,703	7,703																						30,811
96716	96719	Chongoene	South	Gaza	110/33	40	1	2018	2021		Construction of 80km of 275kV line between new SE Macia and Chongoene, 275 / 110kV substation in Chongoene and interconnection with existing 110 & 33kV network	Long-term	11621		2,905	2,905	2,905	2,905																						11,621
96716	96719	2nd Chongoene	South	Gaza	110/33	40	1	2033	2036		additional substation	2042 Analysis	11621																	2905	2905	2905	2905							11,621
99006	96721	Chibuto	South	Gaza	400/33	40	1	2018	2021		STE Phase 1-1 HVAC	Long-term	27,306		6,827	6,827	6,827	6,827																						27,306
99019		Maputo HVDC	South	Maputo	DC500/			2019	2024		STE Pahse 1&2 HVDC	Long-term	597,870			99,645	99,645	99,645	99,645	99,645	99,645																			597,870
97111	96111	Infulene	South	Maputo	275/110	250	1	2024	2027		additional/replacement transformer	2027 Analysis	13,757								3,439	3,439	3,439	3439																13,757
97111	97113	Infulene	South	Maputo	275/66	250	1			JICA	T2 replacement transformer	EDM plan	13,757													3439	3439	3439	3439											13,757
97111	97113	Infulene	South	Maputo	275/66	250	3	2029	2032		additional/replacement transformer	2032 Analysis	13,757													10318	10318	10318	10318											41,271
97111	97112	Infulene	South	Maputo	275/66	250	2	2039	2042		additional/replacement transformer	2042 Analysis	13,757																							6,879	6,879	6,879	6,879	27,514
96111	97112	Infulene	South	Maputo	110/66	125	2	2029	2032		additional/replacement transformer	2032 Analysis	7,021													3511	3511	3511	3511											14,042
5946	97411	Maputo	South	Maputo	400/275	400	1	2029	2032		additional/replacement transformer	2032 Analysis	17087													4272	4272	4272	4272											17,087
5946	97411	Maputo	South	Maputo	400/275	400	1	2039	2042		additional/replacement transformer	2042 Analysis	17087																							4,272	4,272	4,272	4,272	17,087
5946	97412	Maputo	South	Maputo	400/275	400	1	2039	2042		additional/replacement transformer	2042 Analysis	17087																							4,272	4,272	4,272	4,272	17,087
97121	97123	Matola Gare A	South	Maputo	66/33	40	1	2016	2017	Danida, kfw, EIB	Installation of new transformer	Short-term	3735	1867.5																										1,868
97121	97123	Matola Gare A	South	Maputo	66/33	40	1	2022	2025		additional/replacement transformer	2032 Analysis	5203						1301	1301	1301	1301																		5,203
97121	97123	2nd Matola Gare A	South	Maputo	66/33	40	1	2026	2029		additional substation	2032 Analysis	8171										2043	2043	2043	2043														8,171
97121	97123	3rd Matola Gare A	South	Maputo	66/33	40	1	2039	2042		additional substation	2042 Analysis	8171																							2,043	2,043	2,043	2,043	8,171
97121	97122	Matola Gare B	South	Maputo	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
97121	97122	2nd Matola Gare B	South	Maputo	66/33	40	1	2035	2038		additional substation	2042 Analysis	8171																			2043	2043	2043	2043					8,171
97131	97132	Beluluane	South	Maputo	275/66	250	1	2016	2018	Mochi	Construction of 90km of 275kV Line between Ressano Garcia and Beluluane and interconnection with the existing 275 & 66kV Network	Mid-term	30,811	10,270	10,270																									20,541
97131	97132	Beluluane	South	Maputo	275/66	250	1	2039	2042			2042 Analysis	13,757																							3,439	3,439	3,439	3,439	13,757
97911	97912	Beluluane	South	Maputo	66/11	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
97911	97912	2nd Beluluane	South	Maputo	66/11	40	1	2021	2024		additional substation	2032 Analysis	8171					2043	2043	2043	2043																			8,171
97911	97912	3rd Beluluane	South	Maputo	66/11	40	1	2032	2035		additional substation	2042 Analysis	8171																2043	2043	2043	2043								8,171
97711	97712	Boane	South	Maputo	66/33	40	1	2016	2018	AfDB	Installation of additional transformer	Mid-term	3735	1245.0	1245.0																									2,490
97711	97712	Boane	South	Maputo	66/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	3735			934	934	934	934																					3,735
97711	97712	2nd Boane	South	Maputo	66/33	40	1	2019	2022		additional substation	2022 Analysis	8171			2043	2043	2043	2043																					8,171
97711	97712	3rd Boane	South	Maputo	66/33	40	1	2028	2031		additional substation	2032 Analysis	8171												2043	2043	2043	2043												8,171
97711	97712	4th Boane	South	Maputo	66/33	40	1	2037	2040		additional substation	2042 Analysis	8171																					2043	2043	2043	2043			8,171
97521	97522	Manhica	South	Maputo	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
97521	97522	2nd Manhica	South	Maputo	66/33	40	1	2030	2033		additional substation	2042 Analysis	8171														2043	2043	2043	2043										8,171
97511	97512	Machava	South	Maputo	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
97511	97512	2nd Machava	South	Maputo	66/33	40	1	2019	2022		additional substation	2022 Analysis	8171			2043	2043	2043	2043																					8,171
97511	97512	3rd Machava	South	Maputo	66/33	40	1	2019	2022		additional substation	2022 Analysis	8171			2043	2043	2043	2043																					8,171
97511	97512	4th Machava	South	Maputo	66/33	40	1	2021	2024		additional substation	2032 Analysis	8171					2043	2043	2043	2043																			8,171
97511	97512	5th Machava	South	Maputo	66/33	40	1	2026	2029		additional substation	2032 Analysis	8171										2043	2043	2043	2043														8,171
97511	97512	6th Machava	South	Maputo	66/33	40	1	2029	2032		additional substation	2032 Analysis	8171													2043	2043	2043	2043											8,171
97511	97512	7th Machava	South	Maputo	66/33	40	1	2033	2036		additional substation	2042 Analysis	8171																	2043	2043	2043	2043							8,171
97511	97512	8th Machava	South	Maputo	66/33	40	1	2036	2039		additional substation	2042 Analysis	8171																				2043	2043	2043	2043				8,171
97511	97512	9th Machava	South	Maputo	66/33	40	1	2039	2042		additional substation	2042 Analysis	8171																							2043	2,043	2,043	2,043	8,171
97814	97811	Salamanga	South	Maputo	275/66	250	1	2017	2019	Sinohydro ou CCC	Construction of 100km of 275kV Line and 275/66/33kV Substation in Salamanga to feed Catembe and Ponta de Ouro	Mid-term	30,811	10,270	27,591	10,270																								48,132
97811	97812	2nd Salamanga	South	Maputo	66/33	40	1	2017	2019	Sinohydro ou CCC	Construction of 100km of 275kV Line and 275/66/33kV Substation in Salamanga to feed Catembe and Ponta de Ouro	Mid-term	8171	2,724	27,591	2,724																								33,038
97811	97812	3rd Salamanga	South	Maputo	66/33	40	1	2037	2040		additional substation	2042 Analysis	8171																					2043	2043	2043	2,043			8,171
97811	97812	Salamanga	South	Maputo	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
97611	97612	Matola Rio	South	Maputo	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
97611	97612	2nd Matola Rio	South	Maputo	66/33	40	1	2026	2029		additional substation	2032 Analysis	8171										2043	2043	2043	2043														8,171
97611	97612	3rd Matola Rio	South	Maputo	66/33	40	1	2039	2042		additional substation	2042 Analysis	8171																							2,043	2,043	2,043	2,043	8,171
97421	97422	Marracuene	South	Maputo	66/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	3735			934	934	934	934																					3,735
99005	99004	New Marracuene	South	Maputo	400/275	250	1	2018	2021		STE Phase 1-1 HVAC	Long-term	39,135		9,784	9,784	9,784	9,784																						39,135
99005	99004	New Marracuene	South	Maputo	400/275	250	2	2039	2042		additional/replacement transformer	2042 Analysis	17,087																							8,544	8,544	8,544	8,544	34,174
99004	97424	New Marracuene	South	Maputo	275/66	250	1	2017	2019	World Bank	New substation	Emergency	30811	10270	10270	10270																								30,811
97424	97425	New Marracuene	South	Maputo	66/33	40	1	2017	2019	World Bank	New substation	Emergency	8171	2724	2724	2724																								8,171
97424	97425	2nd New Marracuene	South	Maputo	66/33	40	1	2037	2040		additional substation	2042 Analysis	8171																					2043	2043	2,043	2,043			8,171
97621	97622	Coruma	South	Maputo	110/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	5203			2602	2602	2602	2602																					10,406
97623	97624	Moamba	South	Maputo	110/33	40	1	2017	2019		Construction of the SE 110 / 33kV in Moamba and interconnection with the existing network	Long-term	11,621	3,874	3,874	3,874																								11,621
97623	97624	2nd Moamba	South	Maputo	110/33	40	1	2026	2029		additional substation	2032 Analysis	11621										2905	2905	2905	2905														11,621
97623	97624	3rd Moamba	South	Maputo	110/33	40	1	2039	2042		additional substation	2042 Analysis	11621																							2,905	2,905	2,905	2,905	11,621
97913	97916	Tchumene	South	Maputo	66/33	40	1	2016	2019		Construction of Beluluane Line - Tchumene and respective SE in Tchumene	Long-term	8,171	2,043	2,043	2,043																								6,128
97913	97916	2nd Tchumene	South	Maputo	66/33	40	1	2026	2029		additional substation	2032 Analysis	8,171										2043	2043	2043	2043														8,171
97913	97916	3rd Tchumene	South	Maputo	66/33	40	1	2039	2042		additional substation	2042 Analysis	8,171																							2,043	2,043	2,043	2,043	8,171
96000	96001	Dzimbene	South	Maputo	275/110	250	1	2017	2017		275kV Ressano Garcia-Dzimbebe		30,811	30,811																										30,811

Source: JICA study team

Table 6.2-33 Substation expansion plan (Southern area (Maputo City))

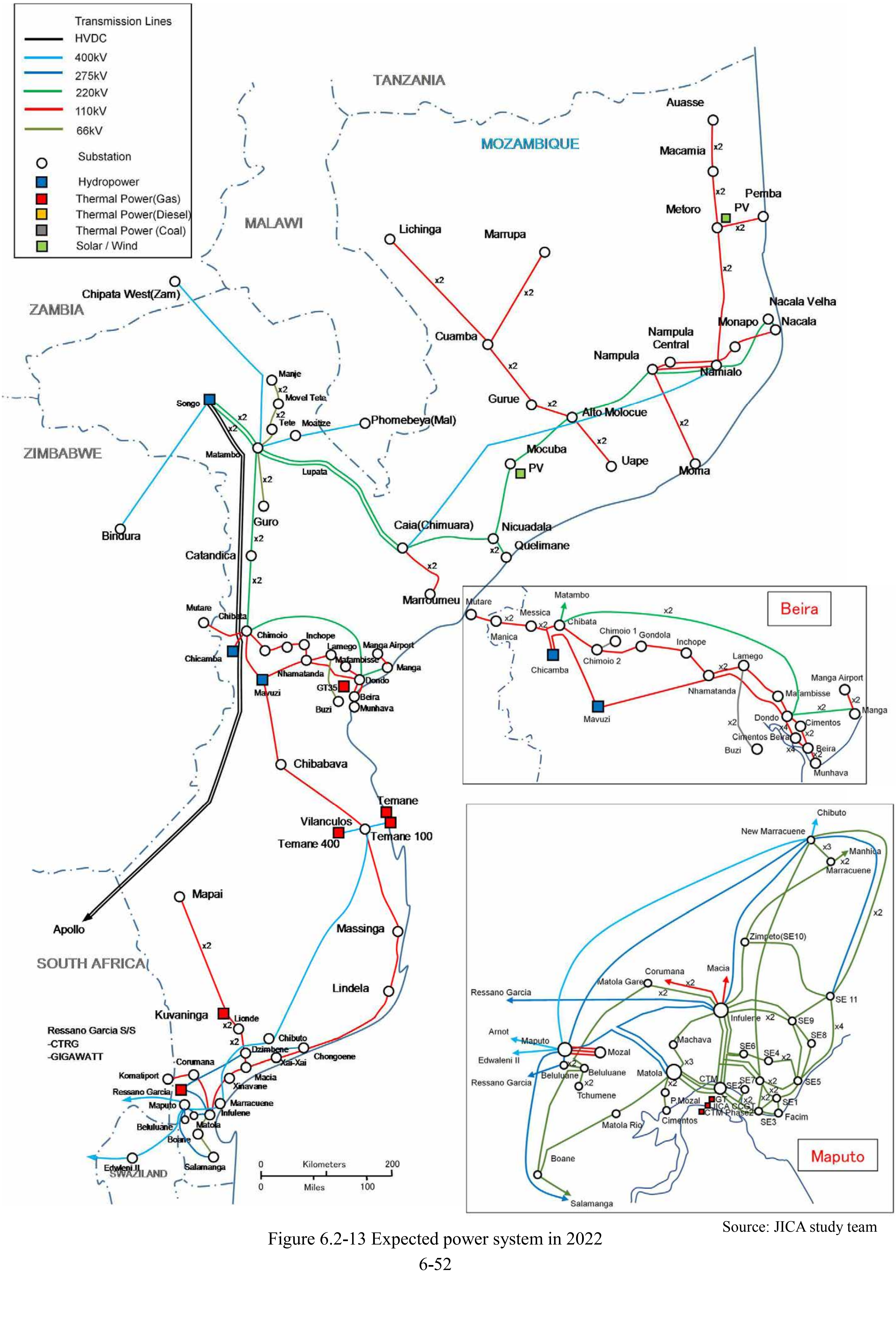
bus number	bus number	Substation	Area	Province	Voltage	Capacity	Quantity	Construction start year	Commissioned year	Funding	Remarks	investment classification	Unit cost [kUSD]	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	total
98111	98112	CTM A	South	Maputo City	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
98111	98112	2nd CTM A	South	Maputo City	66/33	40	1	2019	2022		additional substation	2022 Analysis	3735			934	934	934	934																					3,735
98111	98112	3rd CTM A	South	Maputo City	66/33	40	1	2025	2028		additional substation	2032 Analysis	8,171									2043	2043	2043	2043															8,171
98111	98112	4th CTM A	South	Maputo City	66/33	40	1	2032	2035		additional substation	2042 Analysis	8,171																2043	2043	2043	2043								8,171
98111	98112	5th CTM A	South	Maputo City	66/33	40	1	2037	2040		additional substation	2042 Analysis	8,171																					2043	2043	2043	2043			8,171
98211	98212	CTM B	South	Maputo City	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
98211	98212	2nd CTM B	South	Maputo City	66/33	40	1	2039	2042		additional substation	2042 Analysis	8,171																							2043	2043	2043	2043	8,171
98311	98312	SE 1	South	Maputo City	66/11	40	1	2017	2019	World Bank	Installation of aditional transformer	Emergency	3735	1245	1245	1245																								3,735
98311	98312	SE 1	South	Maputo City	66/11	40	1	2027	2030		additional/replacement transformer	2032 Analysis	3735											934	934	934	934													3,735
98311	98312	2nd SE 1	South	Maputo City	66/11	40	1	2032	2035		additional substation	2042 Analysis	8,171																2043	2043	2043	2043								8,171
98411	98412	SE 2	South	Maputo City	66/11	40	1	2017	2019	World Bank	Installation of aditional transformer	Emergency	3735	1245	1245	1245																								3,735
98411	98412	SE 2	South	Maputo City	66/11	40	1	2020	2023		additional/replacement transformer	2032 Analysis	3735				934	934	934	934																				3,735
98411	98412	2nd SE 2	South	Maputo City	66/11	40	1	2024	2027		additional substation	2032 Analysis	8,171								2043	2043	2043	2043																8,171
98411	98412	3rd SE 2	South	Maputo City	66/11	40	1	2036	2039		additional substation	2042 Analysis	8,171																				2043	2043	2043	2043				8,171
98511	98513	SE 3	South	Maputo City	66/11	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
98511	98513	2nd SE 3	South	Maputo City	66/11	40	1	2019	2022		additional substation	2022 Analysis	8171			2043	2043	2043	2043																					8,171
98511	98513	3rd SE 3	South	Maputo City	66/11	40	1	2025	2028		additional substation	2032 Analysis	8171									2043	2043	2043	2043															8,171
98511	98513	4th SE 3	South	Maputo City	66/11	40	1	2031	2034		additional substation	2042 Analysis	8171															2043	2043	2043	2043									8,171
98511	98513	5th SE 3	South	Maputo City	66/11	40	1	2036	2039		additional substation	2042 Analysis	8171																				2043	2043	2043	2043				8,171
98611	98612	SE 4	South	Maputo City	66/11	40	1	2017	2019	World Bank	Installation of aditional transformer	Emergency	3735	1245	1245	1245																								3,735
98611	98612	SE 4	South	Maputo City	66/11	40	1	2023	2026		additional/replacement transformer	2032 Analysis	3735							934	934	934	934																	3,735
98611	98612	2nd SE 4	South	Maputo City	66/11	40	1	2027	2030		additional substation	2032 Analysis	8171											2043	2043	2043	2043													8,171
98611	98612	3rd SE 4	South	Maputo City	66/11	40	1	2039	2042		additional substation	2042 Analysis	8171																							2043	2043	2043	2043	8,171
98711	98712	SE 5	South	Maputo City	66/11	40	2	2017	2019	World Bank	Installation of aditional transformer	Emergency	3735	2490	2490	2490																								7,470
98711	98712	2nd SE 5	South	Maputo City	66/11	40	1	2019	2022		additional substation	2022 Analysis	8171			2043	2043	2043	2043																					8,171
98711	98712	3rd SE 5	South	Maputo City	66/11	40	1	2025	2028		additional substation	2032 Analysis	8171									2043	2043	2043	2043															8,171
98711	98712	4th SE 5	South	Maputo City	66/11	40	1	2032	2035		additional substation	2042 Analysis	8171																2043	2043	2043	2043								8,171
98711	98712	5th SE 5	South	Maputo City	66/11	40	1	2037	2040		additional substation	2042 Analysis	8171																					2043	2043	2043	2043			8,171
98811	98812	SE 6 33	South	Maputo City	66/33	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
98811	98812	2nd SE 6 33	South	Maputo City	66/33	40	1	2024	2027		additional substation	2032 Analysis	8171								2043	2043	2043	2043																8,171
98811	98812	3rd SE 6 33	South	Maputo City	66/33	40	1	2036	2039		additional substation	2042 Analysis	8171																				2043	2043	2043	2043				8,171
98811	98813	SE 6 11	South	Maputo City	66/11	40	2	2019	2022		additional/replacement transformer	2022 Analysis	3735			1868	1868	1868	1868																					7,470
98811	98813	2nd SE 6 11	South	Maputo City	66/11	40	1	2019	2022		additional substation	2022 Analysis	8171			2043	2043	2043	2043																					8,171
98811	98813	3rd SE 6 11	South	Maputo City	66/11	40	1	2035	2038		additional substation	2042 Analysis	8171																			2043	2043	2043	2043					8,171
98911	98912	SE 7	South	Maputo City	66/11	40	1	2017	2019	World Bank	Installation of aditional transformer	Emergency	3735	1245	1245	1245																								3,735
98911	98912	SE 7	South	Maputo City	66/11	40	1	2023	2026		additional/replacement transformer	2032 Analysis	3735							934	934	934	934																	3,735
98911	98912	2nd SE 7	South	Maputo City	66/11	40	1	2028	2031		additional substation	2032 Analysis	8171												2043	2043	2043	2043												8,171
98221	98222	SE 8	South	Maputo City	66/11	40	1	2017	2019	World Bank	Installation of aditional transformer	Emergency	3735	1245	1245	1245																								3,735
98221	98222	SE 8	South	Maputo City	66/11	40	1	2019	2022		additional/replacement transformer	2022 Analysis	3735			934	934	934	934																					3,735
98221	98222	2nd SE 8	South	Maputo City	66/11	40	1	2021	2024		additional substation	2032 Analysis	8171					2043	2043	2043	2043																			8,171
98221	98222	3rd SE 8	South	Maputo City	66/11	40	1	2032	2035		additional substation	2042 Analysis	8171																2043	2043	2043	2043								8,171
98221	98222	4th SE 8	South	Maputo City	66/11	40	1	2039	2042		additional substation	2042 Analysis	8171																							2043	2043	2043	2043	8,171
98121	98122	SE 9 33	South	Maputo City	66/33	40	1	2016	2017	Danida, kfw, EIB	Installation of transformer	Short-term	3735	1867.5																										1,868
98121	98122	SE 9 33	South	Maputo City	66/33	40	1	2025	2028		additional/replacement transformer	2032 Analysis	3735									934	934	934	934															3,735
98121	98122	2nd SE 9 33	South	Maputo City	66/33	40	1	2029	2032		additional substation	2032 Analysis	8171													2043	2043	2043	2043											8,171
98121	98123	SE 9 11	South	Maputo City	66/11	40	1	2019	2022		additional/replacement transformer	2022 Analysis	3735			934	934	934	934																					3,735
98121	98123	SE 9 11	South	Maputo City	66/11	40	1	2021	2024		additional/replacement transformer	2032 Analysis	3735					934	934	934	934																			3,735
98121	98123	2nd SE 9 11	South	Maputo City	66/11	40	1	2025	2028		additional substation	2032 Analysis	8171									2043	2043	2043	2043															8,171
98121	98123	3rd SE 9 11	South	Maputo City	66/11	40	1	2037	2040		additional substation	2042 Analysis	8171																					2043	2043	2043	2043			8,171
97321	97322	SE 10	South	Maputo City	66/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	3735			934	934	934	934																					3,735
97321	97322	2nd SE 10	South	Maputo City	66/33	40	1	2025	2028		additional substation	2032 Analysis	8171									2043	2043	2043	2043															8,171
97321	97322	3rd SE 10	South	Maputo City	66/33	40	1	2037	2040		additional substation	2042 Analysis	8171																					2043	2043	2043	2043			8,171
98321	98322	SE 11	South	Maputo City	66/33	40	1	2019	2022		additional/replacement transformer	2022 Analysis	3735			934	934	934	934																					3,735
98321	98322	SE 11	South	Maputo City	66/33	40	1	2031	2034		additional/replacement transformer	2022 Analysis	3735															934	934	934	934									3,735
98131	98132	Facim	South	Maputo City	66/11	40	1	2017	2019		new substation	EDM plan	8,171	2,724	2,724	2,724																								8,171
98131	98132	2nd Facim	South	Maputo City	66/11	40	1	2032	2035		additional substation	2042 Analysis	8171																2043	2043	2043	2043								8,171
98913	98929	Baixa	South	Maputo City	66/33	40	1	2016	2019	World Bank		Mid-term	8,171	2,043	2,043	2,043																								6,128
98913	98929	2nd Baixa	South	Maputo City	66/33	40	1	2028	2031		additional substation	2032 Analysis	8171												2043	2043	2043	2043												8,171
		New mobile transformer			110/22	10	1	2016	2018	AfDB	Acquisition of mobile substation for the national electrical network of 110 / 22kV, 10MVA and 66 / 33kV, 16MVA and 110 / 33kV, 16MVA. Urgent Rehabilitation project	Mid-term	5267	1755.7	1755.7																									3,511
					66/33	16	1	2016	2018	AfDB	Acquisition of mobile substation for the national electrical network of 110 / 22kV, 10MVA and 66 / 33kV, 16MVA and 110 / 33kV, 16MVA. Urgent Rehabilitation project	Mid-term	5267	1755.7	1755.7																									3,511
					110/33	16	1	2016	2018	AfDB	Acquisition of mobile substation for the national electrical network of 110 / 22kV, 10MVA and 66 / 33kV, 16MVA and 110 / 33kV, 16MVA. Urgent Rehabilitation project	Mid-term	5267	1755.7	1755.7																									3,511

Source: JICA study team

Table 6.2-34 Substation expansion plan (Reactive compensator)

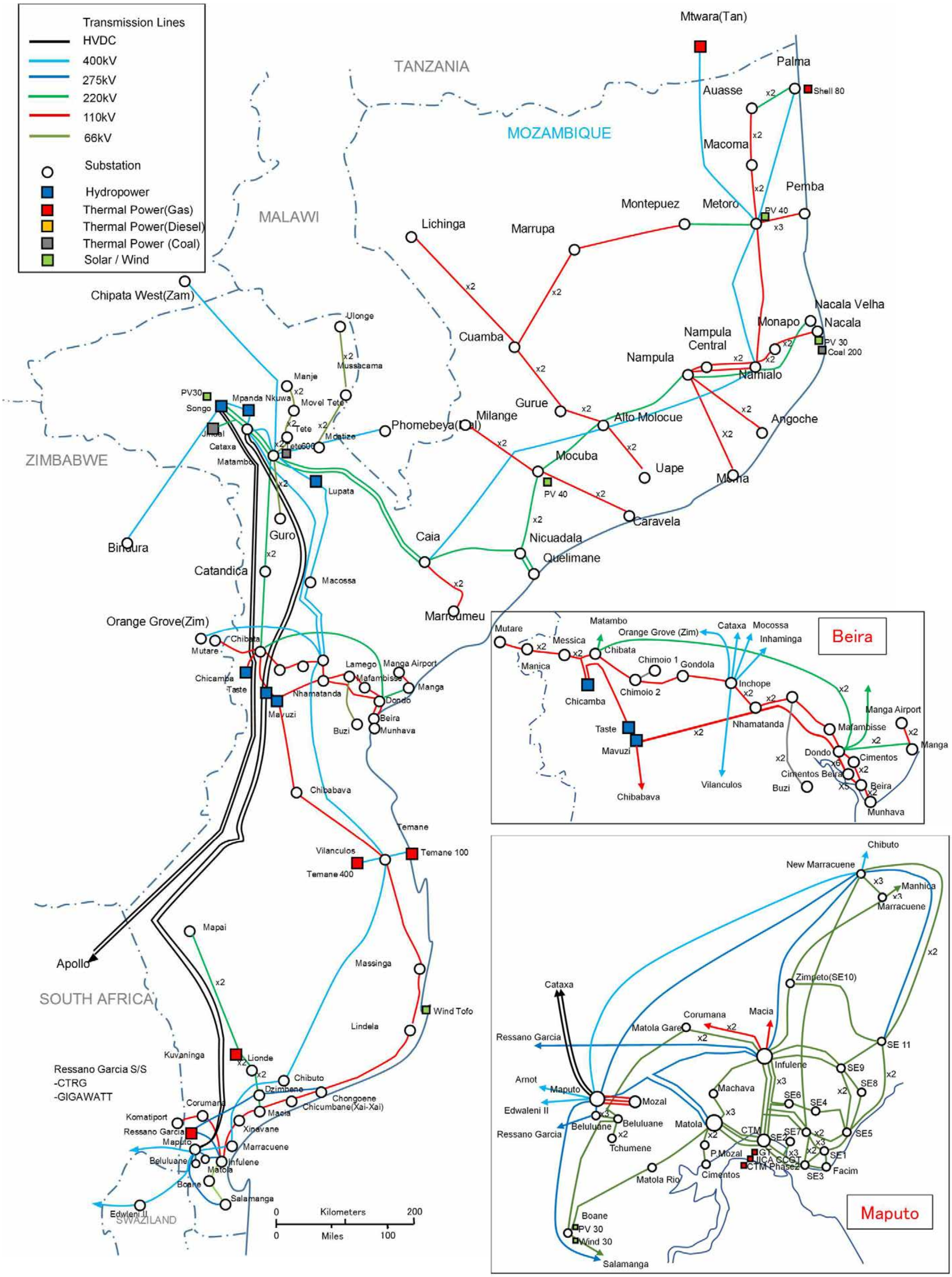
bus number	bus number	Substation	Area	Province	Voltage	Capacity	Quantity	Construction start year	Commissioned year	Funding	Remarks	investment classification	Unit cost [kUSD]	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	total
		Pemba(STATCOM)			15MVAr			2017	2019	World Bank		Emergency	9000	3000	3000	3000																								9,000
		Nacala(Shunt Capacitor)			15MVAr			2017	2019	World Bank		Emergency	9000	3000	3000	3000																								9,000
		Munhava/Dondo(STATCOM)						2016	2017	Fedha Advisory	STATCOM installation of 40MVAr, 110/22kV in Munhava/Dondo	Mid-term	19,000	19,000																										19,000
		Lindela(STATCOM)						2017	2019				12,045	4,015	4,015	4,015																								12,045
82114		Inchope(ShR)				150	1	2024	2027				3,308								827	827	827	827																3,308
82411		Lamego(ShR)				80	1	2024	2027				3,308								827	827	827	827																3,308
72111		Nampula(ShR)				110	1	2029	2032				3,308													827	827	827	827											3,308
71311		Nicoadal(ShR)				60	1	2029	2032				3,308													827	827	827	827											3,308
73411		Cuamba(ShR)				20	1	2029	2032				1,873													468	468	468	468											1,873
72121		Namialo(ShR)				140	1	2029	2032				3,308													827	827	827	827											3,308
73411		Cuamba(SW shunt)				3*50	1	2019	2022				36,145			9,036	9,036	9,036	9,036																					36,145
82911		Beira(SW shunt)				3*50	1	2019	2022				36,145			9,036	9,036	9,036	9,036																					36,145
72813		Palma(ShR)				50	1	2029	2032				3,308													827	827	827	827											3,308
99020		Metoro(ShR)				20	1	2029	2032				1,873													468	468	468	468											1,873
72911		Moma(ShC)				30	1	2029	2032				329													82	82	82	82											329
73511		Lichinga(ShC)				30	1	2029	2032				329													82	82	82	82											329
83611		Manue(ShC)				10	1	2029	2032				164													41	41	41	41											164
83516		Ulonge(ShC)				10	1	2029	2032				164													41	41	41	41											164
82611		Mafambis(ShC)				10	1	2029	2032				164													41	41	41	41											164
99004		New Marracuene(ShC)				150	1	2029	2032				657													164	164	164	164											657
97111		Infulene(ShC)				60	1	2029	2032				657													164	164	164	164											657
97711		Boane(ShC)				60	1	2029	2032				657													164	164	164	164											657
97711		Manhica(ShC)				10	1	2029	2032				164													41	41	41	41											164
81111		Chibata(ShR)				80	1	2029	2032				3,308													827	827	827	827											3,308
82816		Manga(ShR)				30	1	2029	2032				1,873													468	468	468	468											1,873
97621		Coruma(ShR)				20	1	2029	2032				1,873													468	468	468	468											1,873
96111		Infulene(ShR)				200	1	2029	2032				3,308													827	827	827	827											3,308
97911		Beluluane(SW shunt)				3*50	1	2039	2042				36,145																							9,036	9,036	9,036	9,036	36,145
98311		SE1(SW shunt)				3*50	1	2039	2042				36,145																							9,036	9,036	9,036	9,036	36,145
98711		SE5(SW shunt)				3*50	1	2039	2042				36,145																							9,036	9,036	9,036	9,036	36,145
97512		Manica				3*50	1	2039	2042				36,145																							9,036	9,036	9,036	9,036	36,145
83516		Ulonge				3*50	1	2039	2042				36,145																							9,036	9,036	9,036	9,036	36,145
83611		Manje				3*50	1	2039	2042				36,145																							9,036	9,036	9,036	9,036	36,145
83511		Tete				3*50	1	2039	2042				36,145																							9,036	9,036	9,036	9,036	36,145
99001		Vilanculous(ShR)				90	1	2039	2042				3,308																							827	827	827	827	3,308
82161		Buzi(ShR)				10	1	2039	2042				1,873																							468	468	468	468	1,873
73703		Metoro Hydro(ShR)				70	1	2039	2042				3,308																							827	827	827	827	3,308
72422		Nacala Velha(ShR)				20	1	2039	2042				1,873																							468	468	468	468	1,873
73411		Cuamba(ShR)				50	1	2039	2042				3,308																							827	827	827	827	3,308
73701		Matangula Hydro(ShR)				50	1	2039	2042				3,308																							827	827	827	827	3,308
71111		Chimuara(ShR)				30	1	2039	2042				1,873																							468	468	468	468	1,873
72611		Pemba(ShC)				20	1	2039	2042				329																							82	82	82	82	329
97111		Infulene(ShC)				20	1	2039	2042				329																							82	82	82	82	329
97623		Moamba(ShC)				30	1	2039	2042				329																							82	82	82	82	329
																																								0
		Maputo and/or Quelimane (Dispach Center)						2017	2020	MOCHI	Construction of National dispatch center	Mid-term	76,000	19,000	19,000	19,000	19000																							76,000
		Quelimane(Ceramica)	Central	Zambezia				2017	2018	World Bank	Replacement of obsolete panels in all substations of the LCN including assembly of one MiniSCADA at Quelimane	Emergency	27000	13500	13500																									27,000
		Mafambisse, Manica	Central	Sofala	110/66		1	2017	2019	Alstom, GE	Rehabilitation of LCN Substations including Mafambisse and Manica	Mid-term	150,000	50,000	50,000	50,000																								150,000

Source: JICA study team



Source: JICA study team

Figure 6.2-13 Expected power system in 2022



Source: JICA study team

Figure 6.2-14 Expected power system in 2027

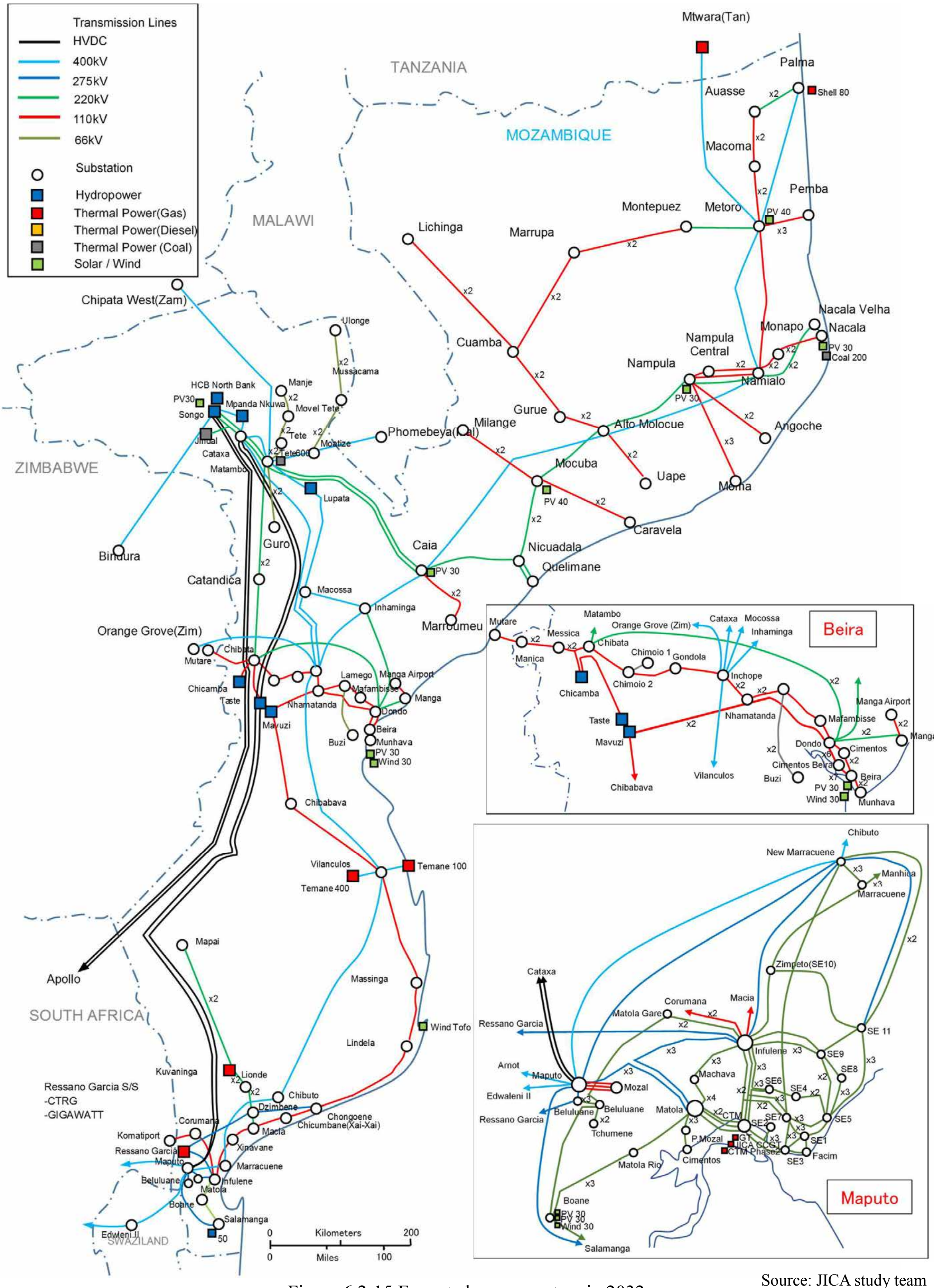
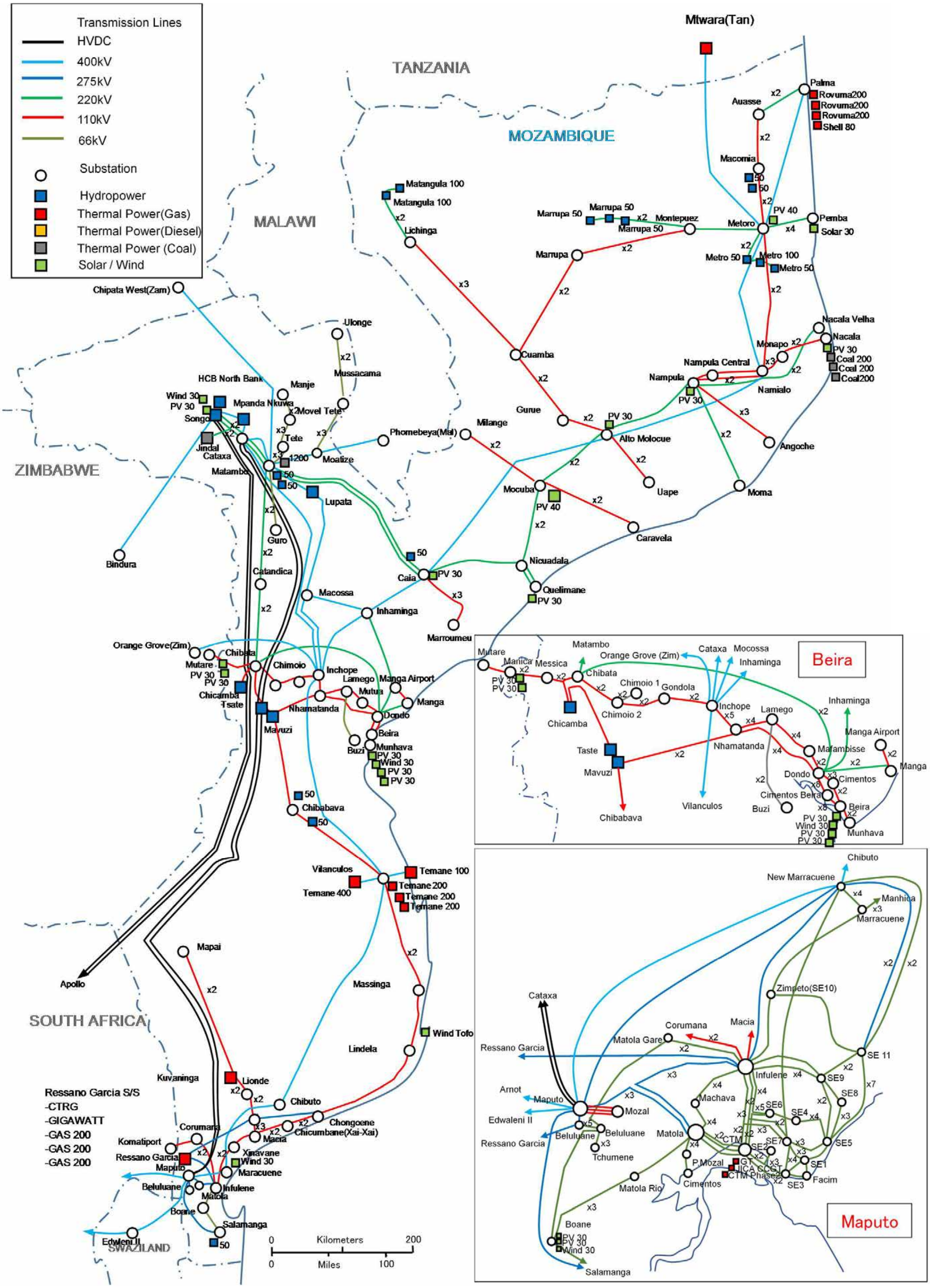


Figure 6.2-15 Expected power system in 2032

Source: JICA study team



Source: JICA study team

Figure 6.2-16 Expected power system in 2042

(6) Short circuit current

Three phase short circuit current will be exceeded allowable short circuit current of 31.5kA by 2032 because the power system is configured with loop system in Mozambique.

Therefore, we suggest that 66kV system at Maputo province is changed to radial system for decrease the short circuit current. Figure A shows system model at Maputo province in 2032 and 2042 with 66kV radial/loop system, respectively.

1. Calculation result of three phase short circuit current at 66kV Maputo power system

Table A shows three phase short circuit current at all 66kV substation in Maputo province in cases of 66kV radial/loop system in 2027, 2032, and 2042 by PSS/E. In 2027, all of three phase short circuit current are within 31.5kA in Maputo province, but some of these currents will be exceeded the allowable short circuit current by 2032. In order to decrease short circuit current, 66kV system at Maputo province have to be changed to loop system by 2032.

Table 6.2-35 Three phase short current of 66kV power system at Maputo province

2027

Bus number	Substation	Short circuit current [kA]	Bus number	Substation	Short circuit current [kA]
		66kV Loop			66kV Loop
95111	T-OFF CIMENT	23.1	97913	TCHUMENE	14.0
95112	MOZAL	23.1	98111	C.T.M.A	29.5
95113	CIMENT	23.1	98211	C.T.M.B	29.2
97112	INFULENE II	29.2	98131	SE FACIM	22.6
97113	INFULENE I	31.4	98311	SE1	25.1
97212	MATOLA A	29.0	98411	SE2	22.7
97312	MATOLA B	29.0	98511	SE3	26.4
97421	MARRACUENE	22.6	98611	SE4	24.2
97424	NEW MARRACUE	27.0	98711	SE5	29.6
97511	MACHAVA	27.4	98811	SE6	26.1
97521	MANHICA	5.9	98911	SE7	27.7
97611	T-MATOLA RIO	7.5	98221	SE8	19.7
97711	BOANE	10.1	98121	SE9	25.1
97811	SALAMANGA	12.3	97321	ZIMPETO SE10	18.4
97911	BELULUANE	17.7	98321	SE 11	30.2

2032

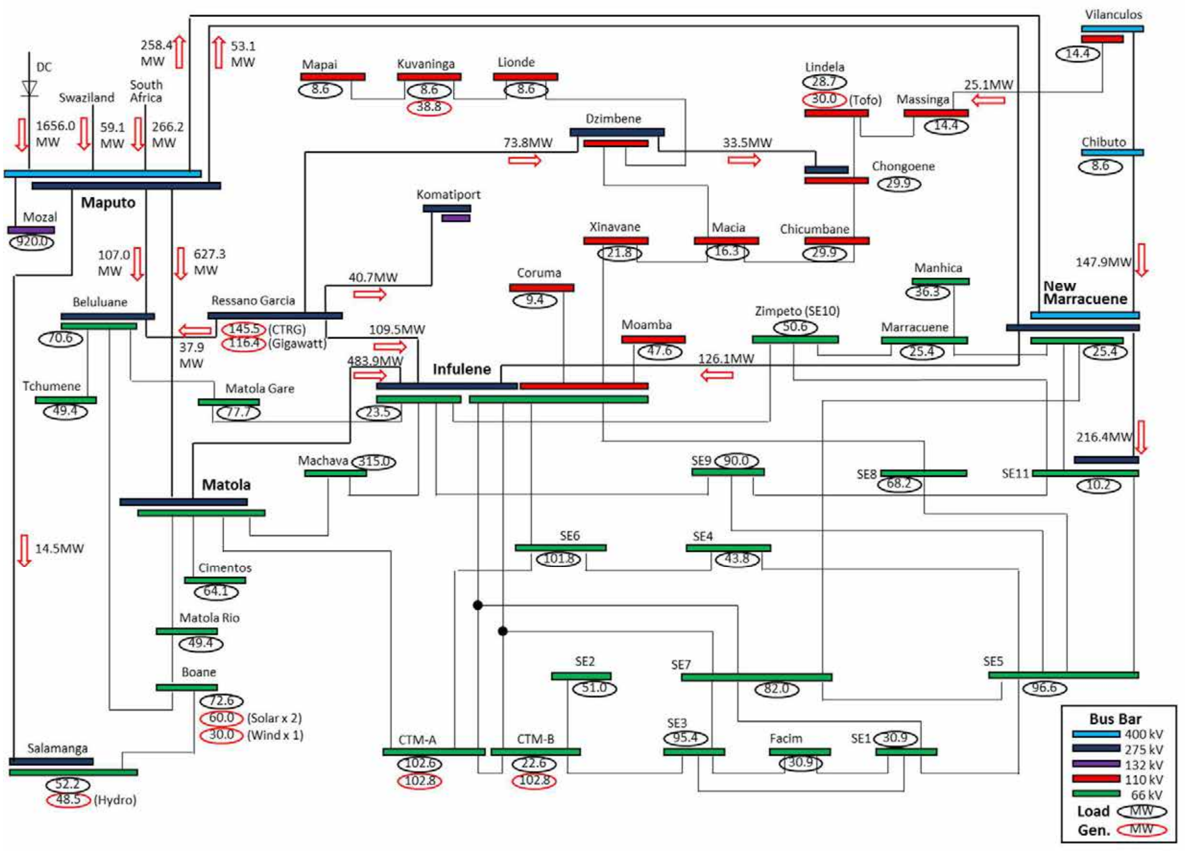
Bus number	Substation	Short circuit current [kA]		Bus number	Substation	Short circuit current [kA]	
		66kV Radial	66kV Loop			66kV Radial	66kV Loop
95111	T-OFF CIMENT	12.8	25.7	97913	TCHUMENE	10.3	14.7
95112	MOZAL	12.8	25.7	98111	C.T.M.A	12.5	33.6
95113	CIMENT	12.8	25.7	98211	C.T.M.B	15.2	33.1
97112	INFULENE II	24.1	33.8	98131	SE FACIM	8.6	24.8
97113	INFULENE I	27.8	39.1	98311	SE1	9.9	27.7
97212	MATOLA A	14.5	33.4	98411	SE2	13.7	24.9
97312	MATOLA B	14.5	33.4	98511	SE3	15.1	29.7
97421	MARRACUENE	16.9	20.8	98611	SE4	16.2	29.5
97424	NEW MARRACUE	20.2	27.0	98711	SE5	13.9	32.9
97511	MACHAVA	19.2	32.6	98811	SE6	18.6	30.8
97521	MANHICA	5.3	5.5	98911	SE7	15.4	31.1
97611	T-MATOLA RIO	5.7	7.2	98221	SE8	11.6	23.6
97711	BOANE	7.3	9.8	98121	SE9	16.3	28.6
97811	SALAMANGA	10.9	11.6	97321	ZIMPETO SE10	5.5	18.9
97911	BELULUANE	12.3	19.1	98321	SE 11	18.0	31.6

2042

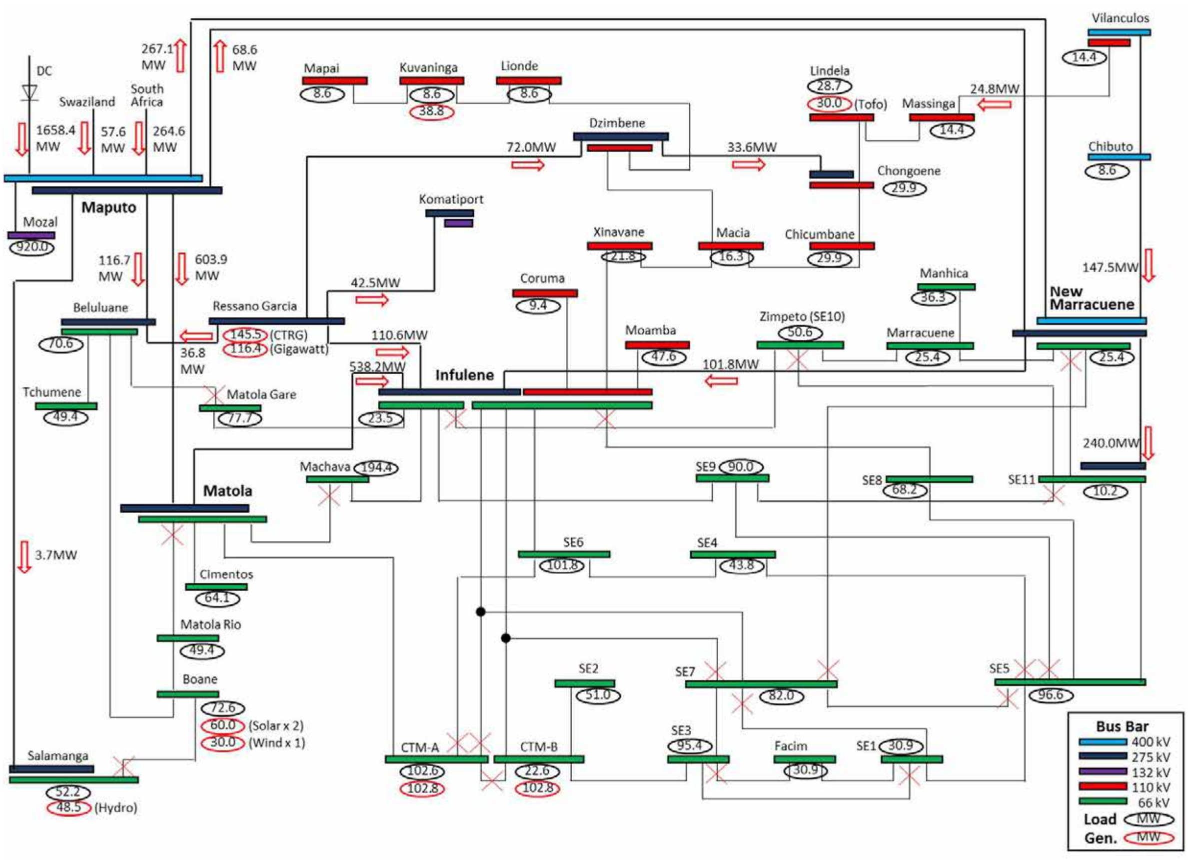
Bus number	Substation	Short circuit current [kA]		Bus number	Substation	Short circuit current [kA]	
		66kV Radial	66kV Loop			66kV Radial	66kV Loop
95111	T-OFF CIMENT	13.8	32.2	97913	TCHUMENE	20.7	23.8
95112	MOZAL	13.8	32.2	98111	C.T.M.A	13.1	44.2
95113	CIMENT	13.8	32.2	98211	C.T.M.B	17.8	43.7
97112	INFULENE II	31.1	47.4	98131	SE FACIM	11.7	30.9
97113	INFULENE I	31.2	47.6	98311	SE1	14.2	35.3
97212	MATOLA A	15.3	41.4	98411	SE2	15.2	33.7
97312	MATOLA B	15.3	41.4	98511	SE3	14.6	39.2
97421	MARRACUENE	19.6	26.1	98611	SE4	19.4	36.8
97424	NEW MARRACUE	23.1	30.8	98711	SE5	19.8	43.0
97511	MACHAVA	22.8	40.4	98811	SE6	22.4	39.4
97521	MANHICA	5.2	5.8	98911	SE7	16.7	41.0
97611	T-MATOLA RIO	9.6	10.4	98221	SE8	15.4	28.0
97711	BOANE	14.8	16.9	98121	SE9	19.7	37.4
97811	SALAMANGA	11.2	12.1	97321	ZIMPETO SE10	5.7	20.8
97911	BELULUANE	26.2	31.4	98321	SE 11	25.3	43.3

Note: Hatching shows over 31.5kA of three phases short circuit current

Source: JICA Study Team

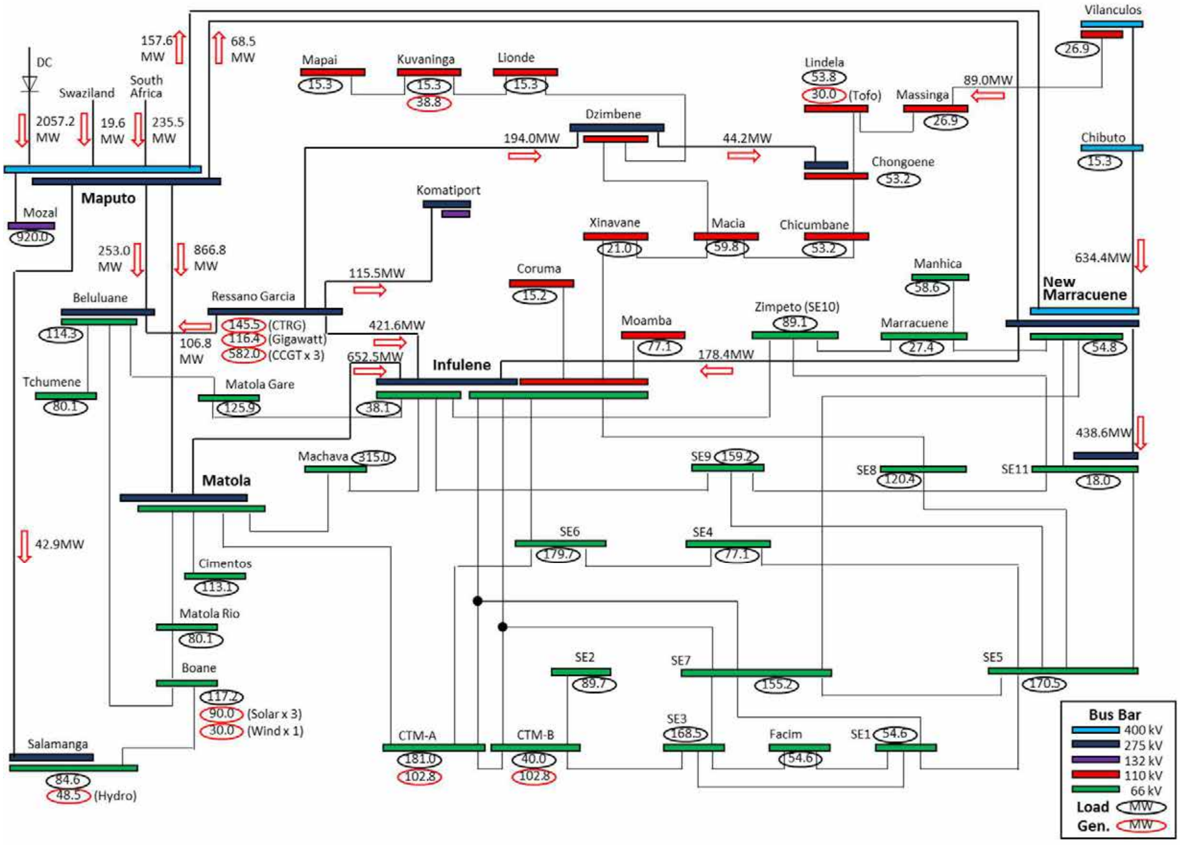


a. 66kV loop configuration

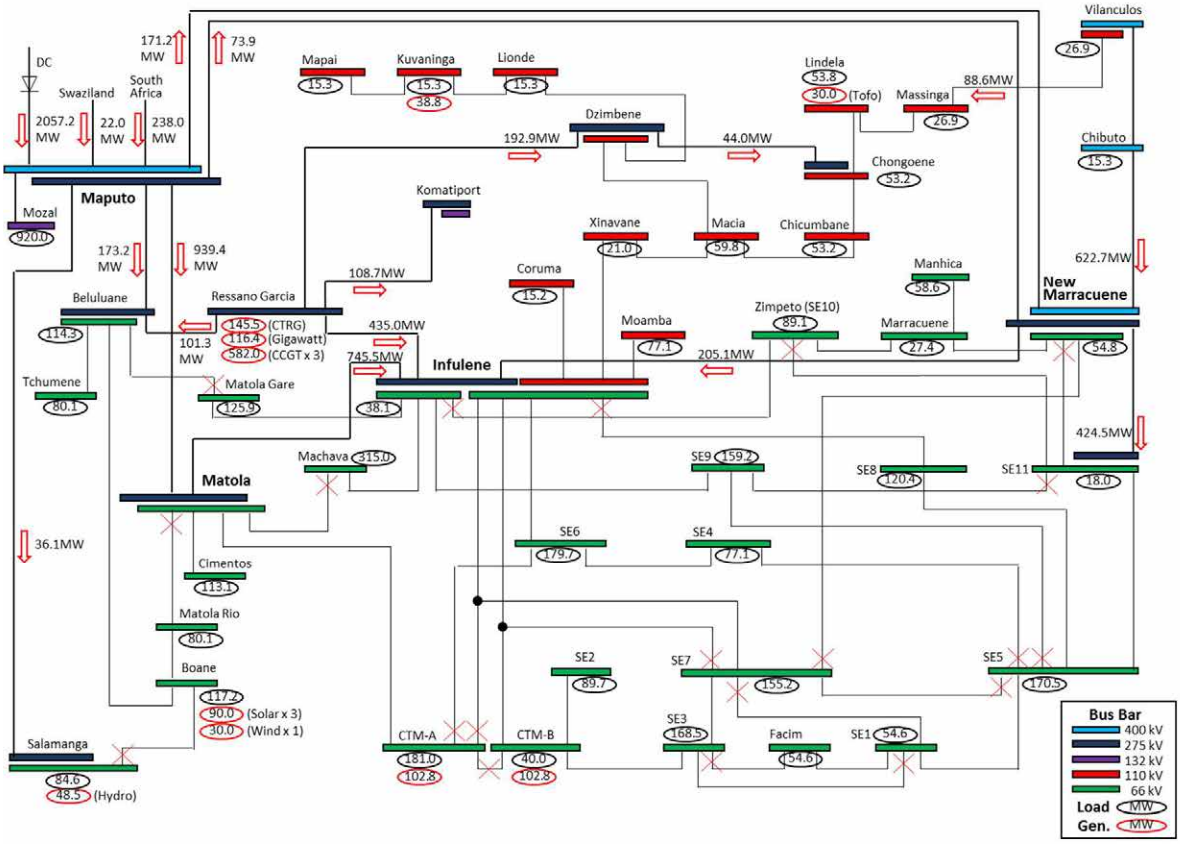


b. 66kV radial configuration

Figure 6.2-17 System model at Maputo province in 2032



a. 66kV loop configuration



b. 66kV radial configuration : Source: JICA Study Team

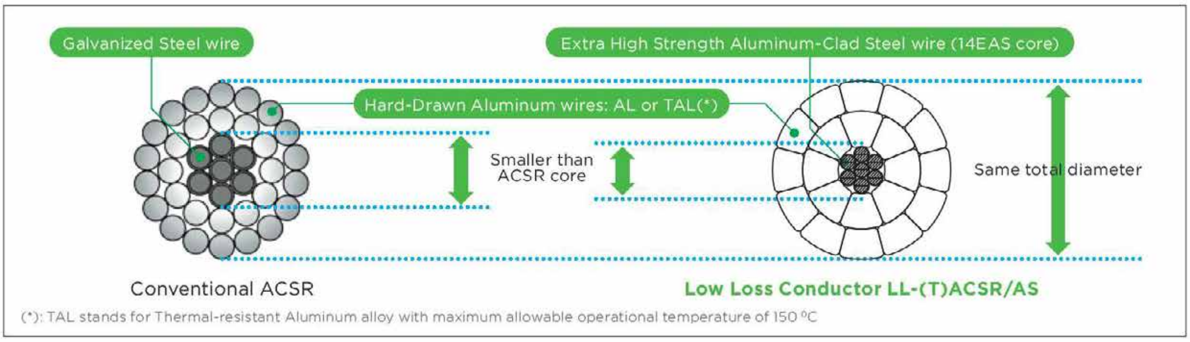
Figure 6.2-18 System model at Maputo province in 2042

6.2.6 Introduction impact of Low loss conductor

In "Plano de Actividades e Orcamento2016/2017 CRESCIMENTO SUSTENTÁVEL COM QUALIDADE", the transmission and distribution loss reported 19% in 2016. And target transmission and distribution loss is set 15% in 2017.
The distribution sector loss accounts for a large loss, but the transmission rate account for 5%.
Therefore, reduction of transmission line loss is also important.
In this survey, we examined the effect of introducing a low-loss conductor, which are effective in reducing transmission loss to the 400kV trunk transmission line[16].

(1) Feature of low loss conductor

The basic design concept of low loss conductor is "keeping the same diameter and the same rated tensile strength ACSR, while having a DC resistance lower than ACSR". To have lower DC resistance, low loss conductor apply trapezoidal shaped wires in its conductive layers, as well as extra-high strength aluminum-clad steel wire in the conductor core. The structure of the low loss conductor is shown in Figure XX.



Source: Technical data of wire manufacture

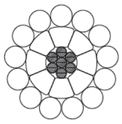
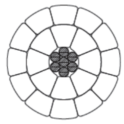
Figure 6.2-19 Structure of the low loss conductor

(2) Specification of low loss conductor and cost calculation

The low loss electric is wire used for this study is the same diameter as the 4 conductors of Tern which is standard in the Mozambique for 400 kV transmission line.
There are two design types for low loss conductor. One is a Type 1 conductor that has the same outer diameter and weight as ACSR Tern. The other is a Type 2 conductor that has the same outer diameter as the ACSR Tern and all of the aluminum wires are trapezoidal shaped wires, and the aluminum cross-sectional area is maximized. Type 2 conductor increases in weight compared to ACSR Tern, so it becomes larger than the steel tower designed with ACSR Tern. Over view of Type 1 and type 2 low loss conductors are shown in table XX. And each conductor specification are shown in table XX.

16 As a low loss conductor, there is also an ACCC using a carbon rod for conductor core. In this study, low loss conductor made of steel core and trapezoidal shaped aluminum wire with excellent reliability and workability are used.

Table 6.2-36 Overview of type 1 and type 2 low loss conductors

Type 1	Type 2
Use AL(TAL) round and trapezoidal shaped wires:  **Same diameter** **Same weight** No tower load increase	All aluminum wires are trapezoidal shaped wires:  **Same diameter** **Have maximum aluminum area** Achieve highest power saving
Reduce power loss by **roughly 10~15%** No sag increase No need to reinforce nor to modify the existing towers Recommended for re-conductoring of existing lines, or for new lines construction	Reduce power loss by **roughly 20~25%** Slight sag increase (because of slight weight increase) Tower reinforcement or modification may be necessary Recommended for construction of new lines

Source: Technical data of wire manufacture

Table 6.2-37 Specification of low loss conductors

		Unit	ACSR Tern	LL-ACSR/AS	
				420SQ (Type 1)	500SQ (Type 2)
Diameter		mm	27.01	25.95	27.0
Cross section area	AL	mm^2	402.8	420.0	500.2
	Core	mm^2	27.83	23.11	21.99
Rated tensile strength		kN	98.1	98.0	106.6
Nominal weight		kg/km	1333	1331	1546
DC resistance at 20°C		W/km	0.07168	0.0683	0.0575
maximum current capacity		A	852 at 90°C	863 at 90°C	950 at 90°C
Coefficient of linear expansion		$1/°Cx10^{-6}$	20.8	21.6	21.8
Modulus of elasticity		N/mm^2	71100	67400	66400
Transmission loss at 852A		kW/km	15.6	13.3	11.8
Sag at 852A (for span length of 400m)		m	15.70m at 90°C	15.73m at 88.8°C	17.39m at 81.5°C
Max sag (for span length of 400m)		m		15.78m at 90°C	17.69m at 90°C
Price ratio (assumed ACSR as 1.0)			1.0	approx. 1.5 - 1.8	approx. 1.7 - 2.0

Source: Technical data of wire manufacture

The total cost calculation condition are shown in below.

✓ Calculation condition for current carrying capacity

-Ambient Temperature: 40℃

-Wind Velocity: 0.5 m/s

-Wind Direction: 0 degree (Right andle to conductor)

-Solar Radiation 0.1 w/cm^2

-Absorptivity of conductor surface: 0.6

✓ Calculation condition for sag

1) Maximum working tension: Not exceed 50% RTS of ACSR Tern under 35m/s wind and conductor temperature 5℃

2) Everyday tension: Not exceed 20% RTS of ACSR Tern at 30℃ no wind

Critical condition is 1) or 2) severer

Span Length 400m

✓ Other calculation condition

-Line voltage: 400kV

-Number of circuit: 1

-Bundle: 4 conductor/phase

-Load factor: 0.6

-Route length: 200km

-Generation cost: 0.087 USD/kWh

-Current value: 200A, 400A, 600A, 900A

The calculation formulas are shown in below.

Transmission loss (P) [kW/cct]

$P=3\times R_{ac}\times I2\times 10^{-3}\times L\times n_c$

Here, Rac : A.C. resistance at Max. Load current (ohm/km)

I : Max. load current

L : Route length

n_c : Nos. of bundled conductor

Annual cost (C) of transmission loss [USD/year]

C=1cct.×P×LF×24hr. ×365days×c

Here, LF : Loss factor ($0.3f+0.7f^2$) Empirical formula

f : Load factor (=average load current/max. load current)

c : Price of electricity generation

The calculation results are shown in figure XX-XX and table XX.

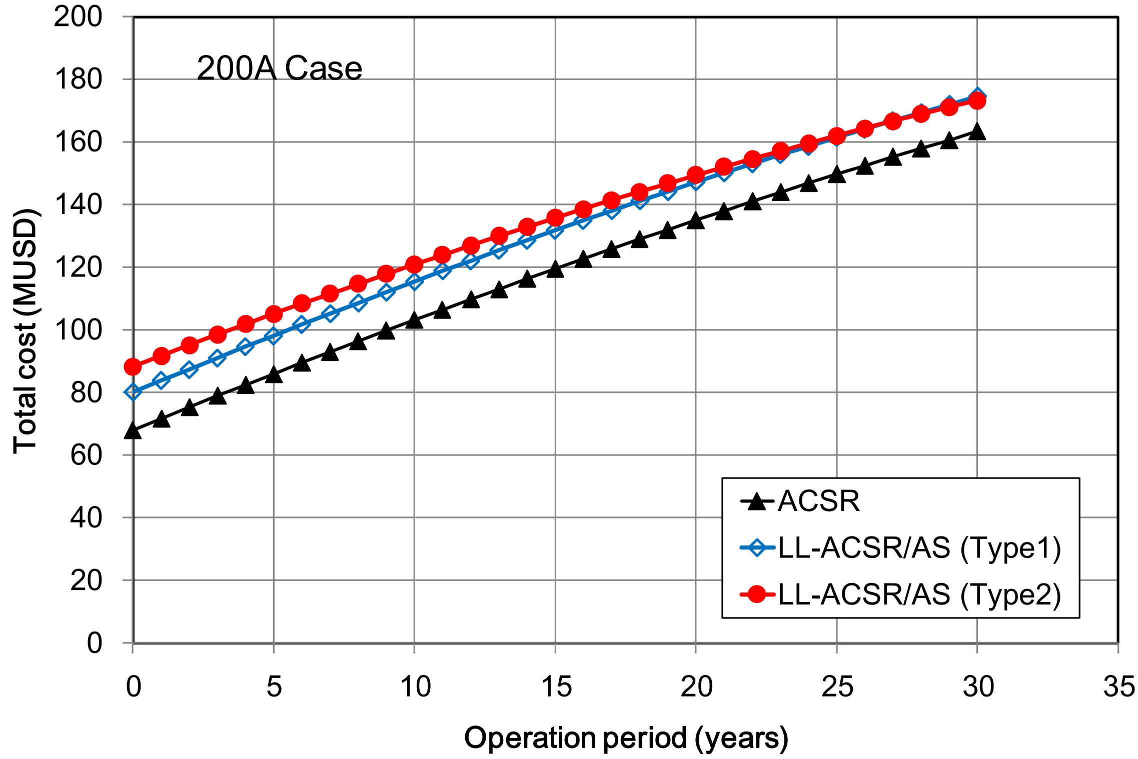
In the case for 200A, low loss conductor can not recover the difference of initial cost.

In the case for 400A, Type 2 low loss conductor can recover the difference of initial cost in 11 years.

In the case for 600A, Type 2 can recover the difference of initial cost in 5 years. And Type 1 loss loss conductor can recover the difference of initial cost in 11 years.

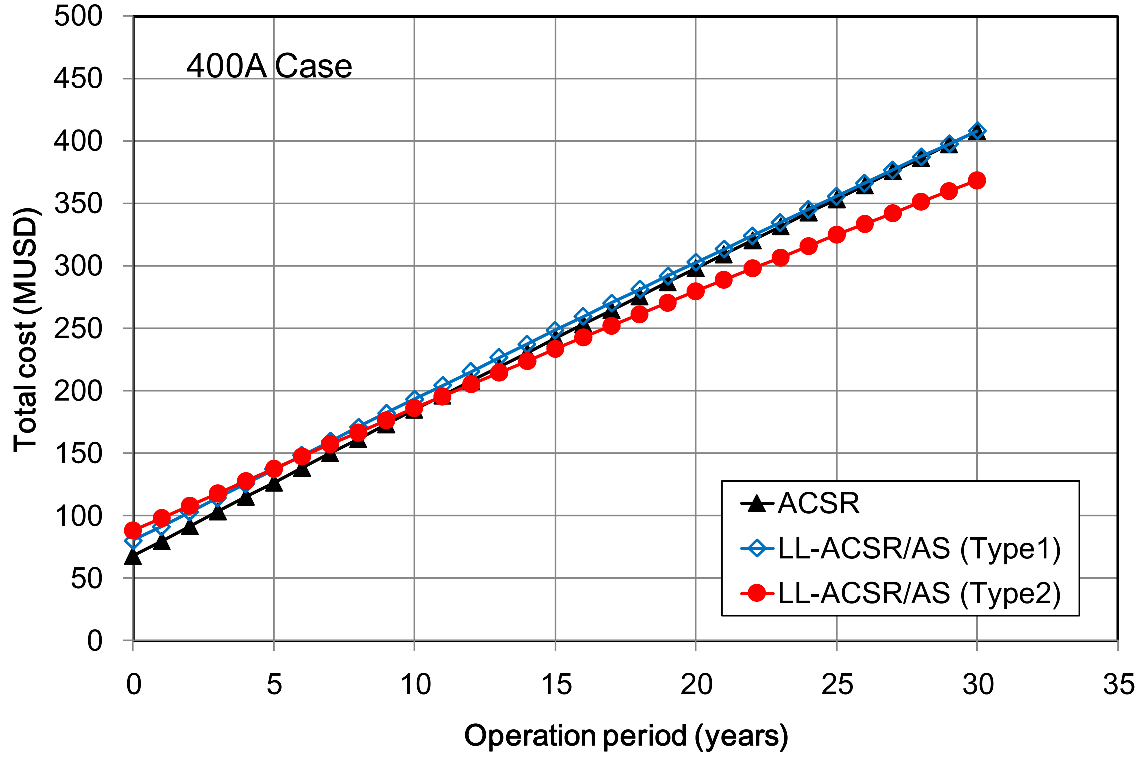
In the case for 900A, Type 2 can recover the difference of initial cost in 2years. And Type 1 low loss conductor can recover the difference of initial cost in 5 years.

In this way, for transmission line with large amount of current, investment cost differences between ACSR transmission line and low loss conductor transmission line can be recovered at an early stage by adopting low loss conductor, and by using for a long time, the total cost is lower than that of ACSR transmission lines. Also, Type 2 can be recovered investment cost different in short time than Type 1.



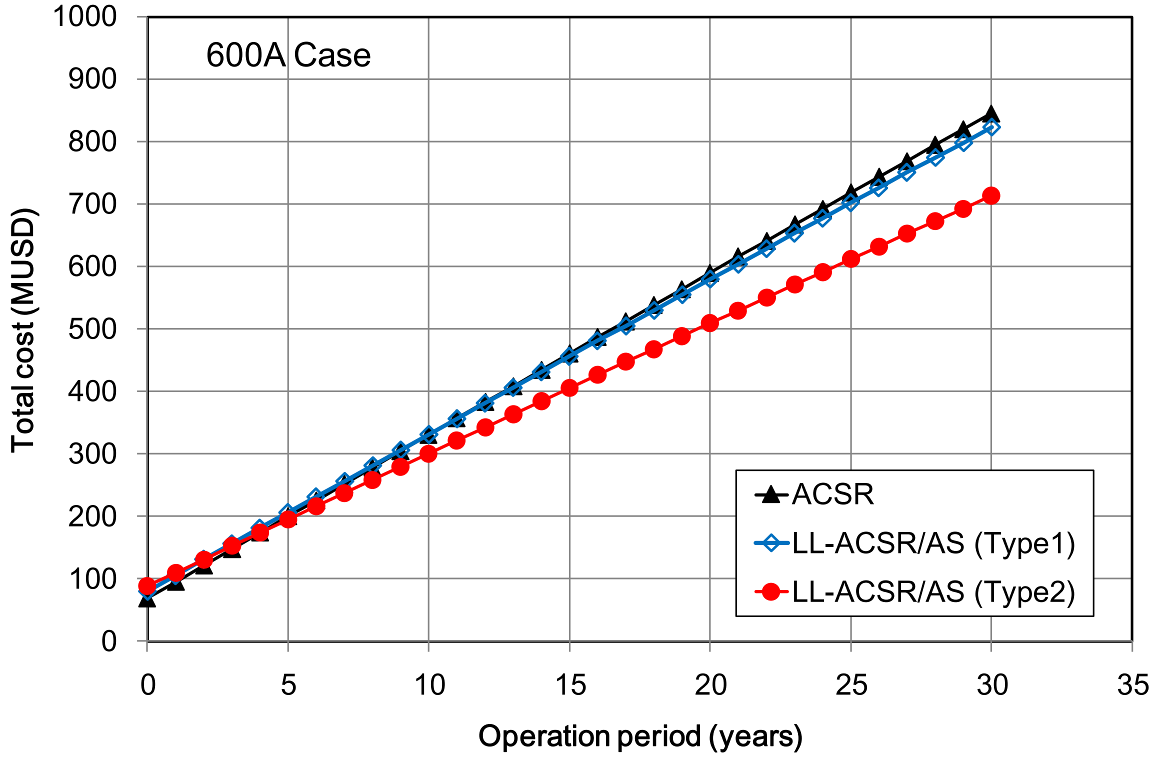
Source: Technical data of wire manufacture

Figure 6.2-20 Comparison for 200A operation



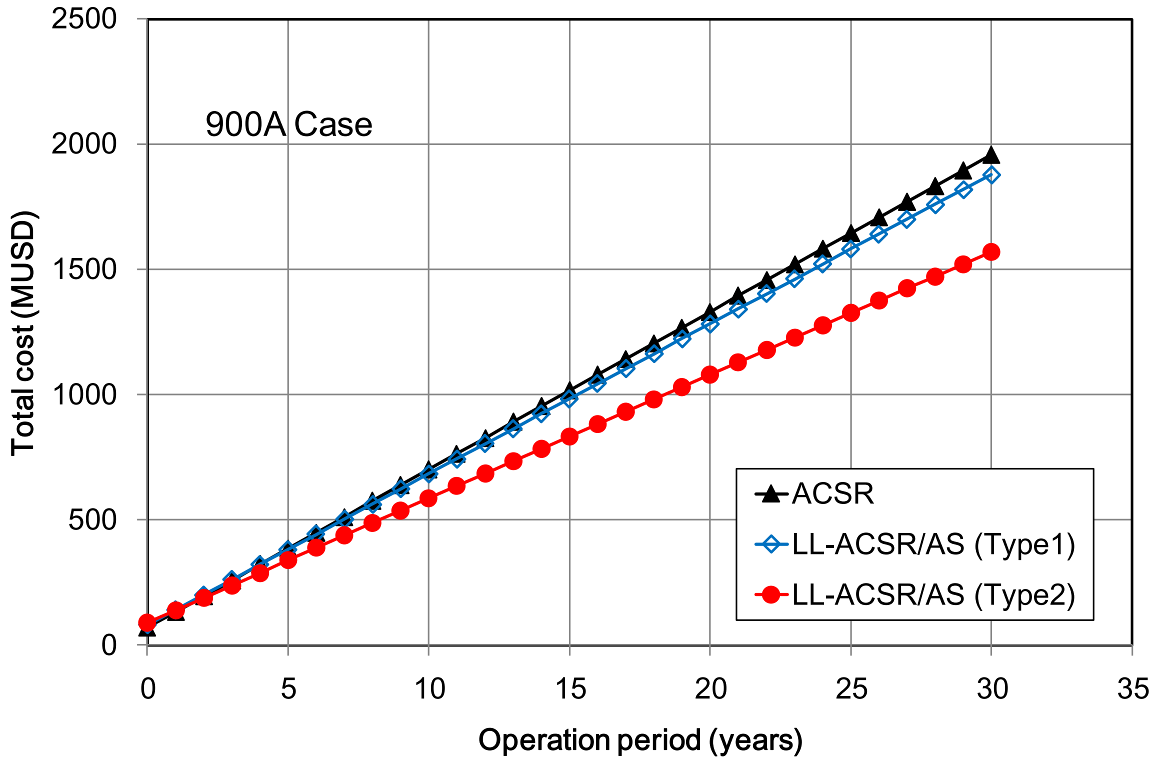
Source: Technical data of wire manufacture

Figure 6.2-21 Comparison for 400A operation



Source: Technical data of wire manufacture

Figure 6.2-22 Comparison for 600A operation



Source: Technical data of wire manufacture

Figure 6.2-23 Comparison for 900A operation

Table 6.2-38 Total cost comparison

[unit MUSD]

Current A	OP Years	ACSR Tern	LL-ACSR/AS	
			420SQ (Type 1)	500SQ (Type 2)
200	0	68.0 (100 %)	80.0 (118 %)	88.3 (130 %)
	10	103.1	115.4	120.9
	20	135.0	147.1	149.4
	30	163.3 (100 %)	174.6 (107 %)	173.3 (106 %)
400	0	68.0 (100 %)	80.0 (118 %)	88.3 (130 %)
	10	184.7	193.2	186.0
	20	298.2	302.7	279.7
	30	408.1 (100 %)	408.0 (100 %)	368.6 (90 %)
600	0	68.0 (100 %)	80.0 (118 %)	88.3 (130 %)
	10	330.4	331.5	300.8
	20	589.7	579.3	509.1
	30	845.4 (100 %)	822.8 (97 %)	712.8 (84 %)
900	0	68.0 (100 %)	80.0 (118 %)	88.3 (130 %)
	10	701.0	683.2	586.4
	20	1330.9	1282.7	1080.3
	30	1957.1 (100 %)	1878.0 (96 %)	1569.6 (80 %)

Source: Technical data of wire manufacture

6.3 Power system operation

6.3.1 Current power system operation and its surrounding circumstances

(1) Current power system operation

a. Operation of domestic power system

The power system operation in Mozambique is composed by southern system, north-central and northern systems.

(a) Southern system

The southern system is under control by the centralized remote supervision and control system in the National Control Centre (NCC) attached to the CTM in Maputo[17].

NCC has two operators regularly to supervise the power system under its jurisdiction. There are total of 10 operators who are divided into five groups of two operators each and they work in two shifts from 6:00 to 18:00 and from 18:00 to 6:00 of the following day.

The operators are mainly responsible for supervision and operation of the southern system that includes switching the system in cases of failures[18].

Television in center displays the current grid's diagram. The operators in the cockpits are supervising the grid condition. The clock, frequency and display enabling to display the fault messages are set on the wall

Source: JICA Study Team

Figure 6.3-1 Full view of NCC control room

[17] However, supervised and controlled power stations are not unmanned operation with staff allocated for facility maintenance and backup operation.

[18] The supply and demand plan in consideration of power generation output system and power interchange is made by the market operator in a different entity from NCC. The power source in the southern system area is in currently constant output operation and thus NCC does not give command of output adjustment of power generators in the area.

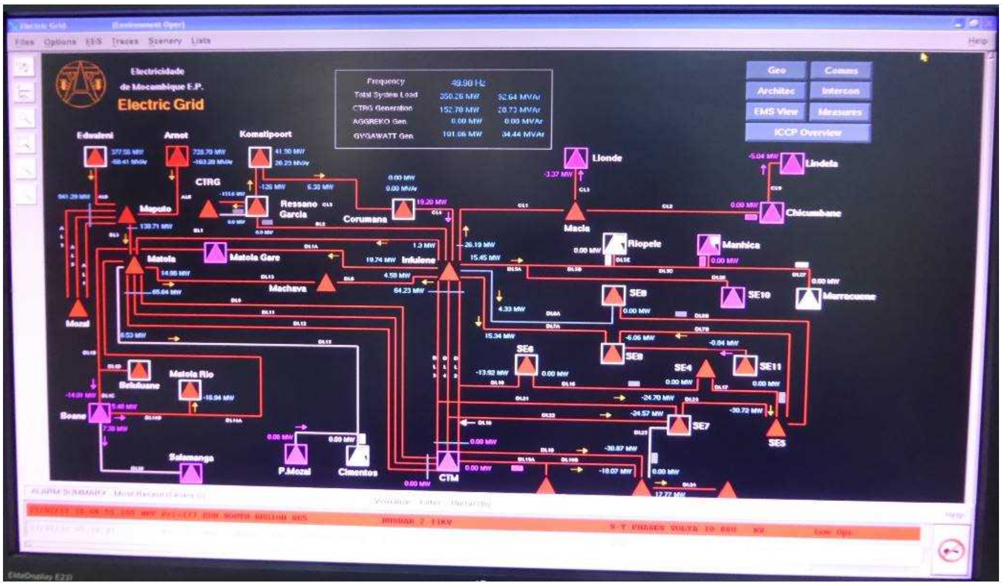
Important data such as frequency, real-time demand, generation output of main fleets are displayed on the diagram

Source: JICA Study Team

Figure 6.3-2 Aggregated Display of System Current Chart

As shown in the southern system current chart in Figure 6.3-3, NCC can check the system condition of only southern system, but cannot check central, northcentral and northern systems.

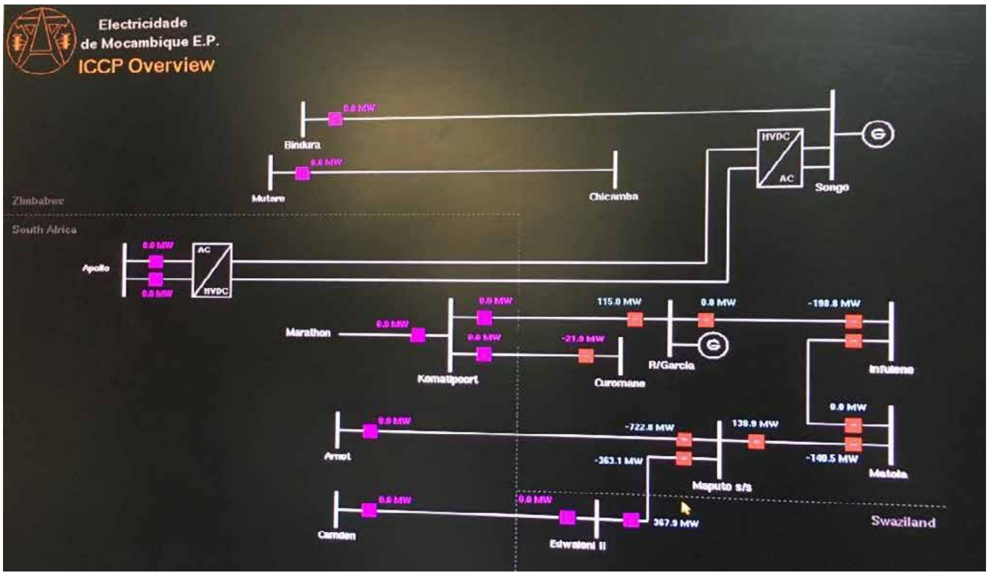
NCC also receives and displays interconnection current to SAPP in the domestic power system and information on interconnection point facility using the Inter-Control Center Communications Protocol (ICCP[19]) (See Figure 6.3-4).



Source: JICA Study Team

Figure 6.3-3 NCC SCADA surface (the southern grid real-time diagram)

[19] Communication protocol (IEC60870-6) that provides rules of transmission of necessary information (contact point condition, interconnection passing power, etc.) between load dispatching centers.



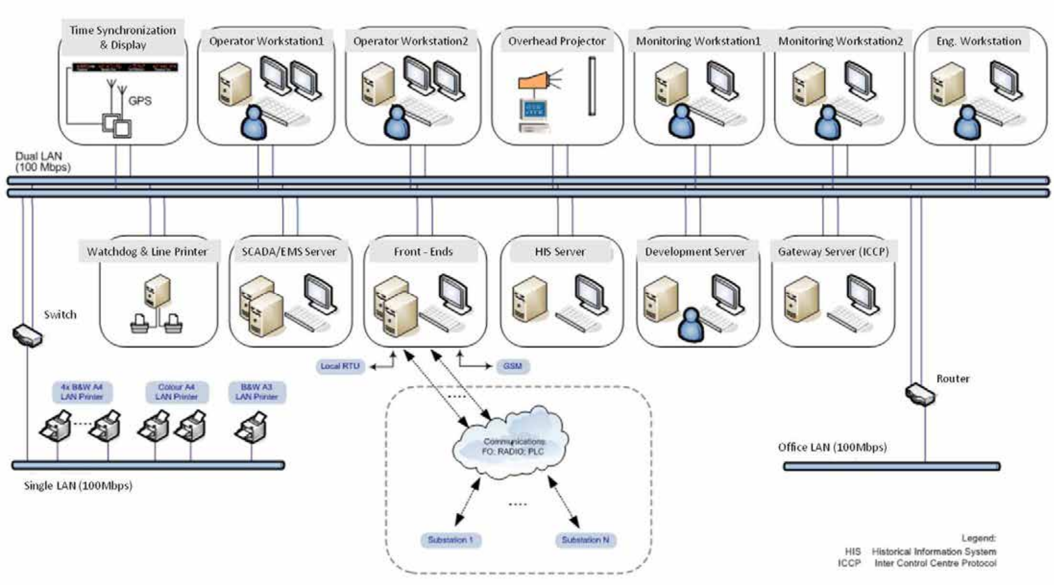
Source: JICA Study Team

Figure 6.3-4 Ultra-high voltage interconnector diagram (ICCP)

The Supervisory Control and Data Acquisition (SCADA) installed at NCC was developed with grant aid and began its operation in September 2010. It has enabled supervision of three international interconnection lines--the transmission line to Komatipoort substation that is an international interconnection line with South Africa, the transmission line between Edwaleni substation and Camden power plant that is an interconnection line with MOTRACO and the transmission line to Arnot power station—and remote supervision and control of over 30 power stations in the southern power system. The SCADA construction was launched in 2005 and it took five years to begin operation as it had difficulty in incorporating the data system of power stations. Although the SCADA is equipped with a variety of functions[20], utilized functions are limited to recording, remote supervision of power stations and separate operation of power facilities.

Physical structure and specifications of NCC SCADA are provided in the Figure 6.3-5 and Table 6.3-1.

[20] An example is the condition estimation function of current of power stations that are yet to be incorporated and current of transmission lines based on the information on power stations incorporated in SCADA (SV, TM).



Source: Produced by JICA Study Team based on materials from efacec

Figure 6.3-5 Structure of SCADA installed at NCC

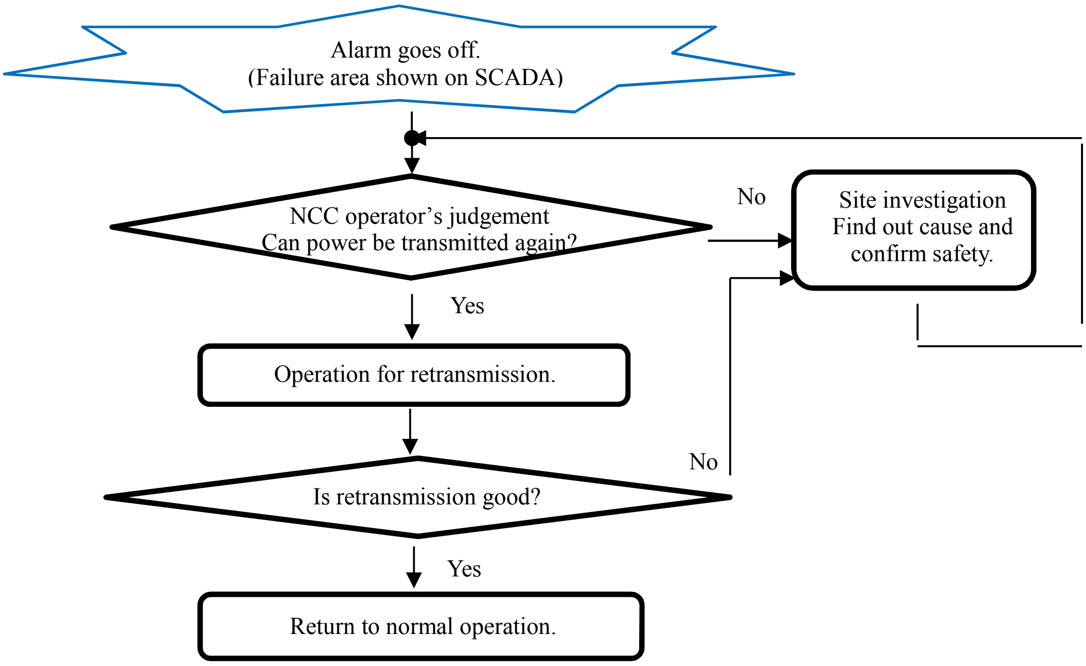
Table 6.3-1 Specifications of Installed SCADA

SCADA Component	Specifications	Manufacturer
Operating system (OS)	Red Hat Enterprise Linux ES 4	Red Hat
Computer	HP Proliant ML370 G5	HP
Installed SCADA software	ScateX 13.2.1	efacec

Source: Produced by JICA Study Team based on interview with EDM

NCC that mainly conducts system supervision assumes failures in the operation system and examines the recovery policy and takes responsive action to contingencies.

NCC response to ordinary failures is shown in Figure 6.3-6. It takes the action in line with the basics of recovering the system while checking the site.



Source: Produced by JICA Study Team based on interview with NCC

Figure 6.3-6 NCC's Response Process to Failures

Failures and recovery are communicated in electronic data as a preliminary report and the detailed report is sent to relevant organizations in print form[21].

The power system that is operated on a regular basis is often changed[22] due to facility inspections. Therefore, identification of suspended facility and suspension period based on the coordination with the facility maintenance department is an important duty.

Plans of inspections that require facility suspension (power outage) are annual and monthly plans. The annual plan is made from October to November for suspension plan from February to October in the following year. The monthly plan is to confirm and coordinate the work of the following month. The system structure is decided based on the result of the coordination. The period from November to January is designated as a heavy load period and no facility suspension is to be conducted unless it is urgently needed.

NCC that supervises the southern system works in collaboration with MOTRACO for operating Maputo substation. Specifically, it has a hotline (telephone) with MOTRACO and urgent matters are communicated on the phone and non-urgent matters are communicated by email. MOTRACO facility is controlled at Eskom's control center[23].

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[21] The rule on the deadline of the preliminary report (within one hour after the occurrence of failure, for example) was not clarified.

[22] It is referred to as extraordinary system.

[23] It is situated in Johannesburg in South Africa.

(b) Central, North-central and Northern systems

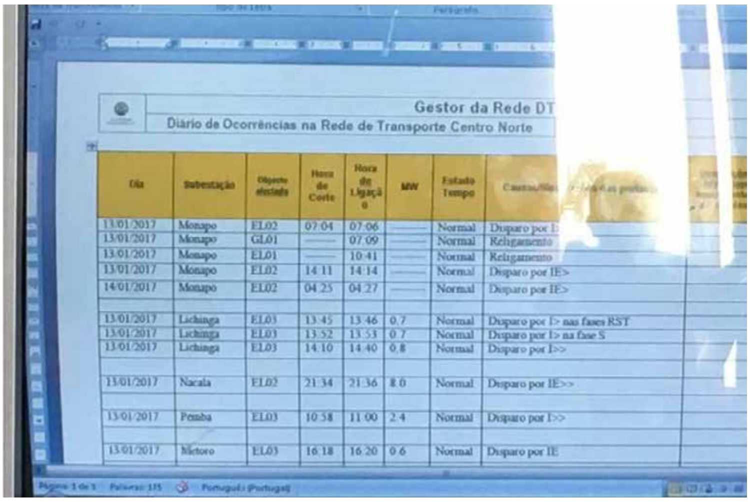
Central, north-central and northern systems have no remote centralized supervision unlike the southern system. The remote supervision is performed[24] locally with mini-SCADA only at Metoro substation in the northern system. Remote supervision is being introduced with mini-SCADA in line with the system expansion based on assistance for the region and electrification projects[25].

The operation recording system shown in Figure 6.3-7 is used to record everyday operation results at each substation. As SCADA is installed, the operation record can be automatically compiled by linking data from SCADA, which enables labor-saving.

The operation recording system is managed as a daily report with electric energy of each feeder recorded every hour and as a monthly report of failure record with electric energy of each feeder recorded at midnight every day, switch-on and off time. Operators of the substation enter information recorded in print form in the system and report the compiled information to Direcção da rede de transporte (Transmission Directorate: DRT) of EDM head office by email. The operation record aggregated at DRT is shared not only by technical division that include Direcção de Planeamento de Sistemas (System Planning Directorate: DPS) but across the company. The technical division of system planning and distribution planning share information on the peak demand, power outage time and causes of failures provided by all substations and discuss future development plans.

[24] Mini-SCADA was introduced to Macomia and Mocimboa in Cabo Delgado Province in the regional electrification project (2014) with assistance from the Royal Norwegian Embassy. As a result, mini-SCADA is installed in Metoro, Auassa and Macomia and that at each location can be controlled at the master station in Metoro.

[25] It is described later.

	Control room of Nampula220 substation The opertion recording system is placed on the desk.
	Display of the operation recording system Actual hourly current of each transmission line and transformer is input and managed.
	Operation recording system The record of equipment operatin and recovery from failures is input and managed.

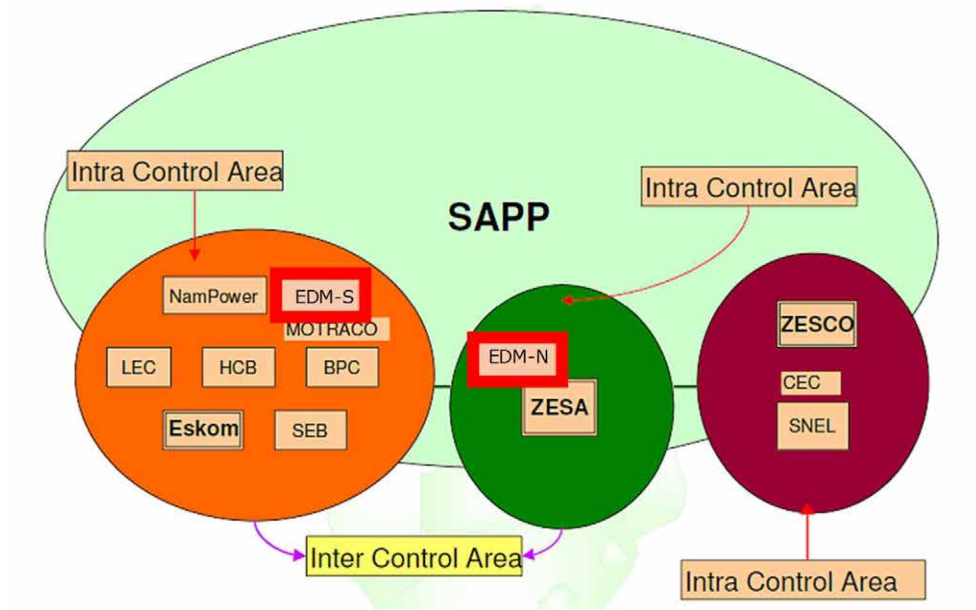
Source: JICA Study Team

Figure 6.3-7 Operation Record of Nampula220 Substation

b. Wide area system operation

Mozambique, a member country of the Southern African Development Community (SADC), participates in the Southern African Power Pool (SAPP) that aims at concerted development by connecting member counties with ultra-high voltage transmission lines[26] and operating power pool and EDM, HCB and MOTRACO are active from their own standing in the SAPP[27].

Different from other SAPP member countries or power utility, EDM belongs to the interrupted control area as the southern system is not connected with central, north-central or northern systems as shown in the Figure 6.3-8 and thus it is forced to conduct different operation from other member countries.



Source: Transmission and ancillary services access and pricing in SAPP (2010), SAPP

Figure 6.3-8 Division of SAPP Control Area

SAPP is divided into three control areas as shown in Figure 6.3-8. Each control area is called Eskom control area, ZESA control area and ZESCO control area, named after their host operator. As for Mozambique, the central, central-north and northern systems and southern system belong to the control area under the jurisdiction of Zimbabwe's ZESA and South African Eskom, respectively.

As guest members in each intra control area are supposed to comply with the system operation rules provided by the host operator in relation to international interconnection, the southern system of Mozambique obeys Eskom rules and the northern system there complies with ZESA rules. The host operator in an intra control area manages output of power generators, frequency and current of the interconnection line for load frequency control. It is also familiar with the interconnection utilization

[26] 400kV transmission line is applied the interconnector, regularly.

[27] EDM and HCB are participating as operation members as power utility and as an independent power producer (IPP), respectively. Motraco is participating as an independent transmission company (ITC) as an observer.

schedule by power exchange as power market operation and supervises transmittable capacity including vacant capacity and system operation control on a regular basis.

The operation of each inter control area is directly performed by both relevant control areas and SAPP office supervises it.

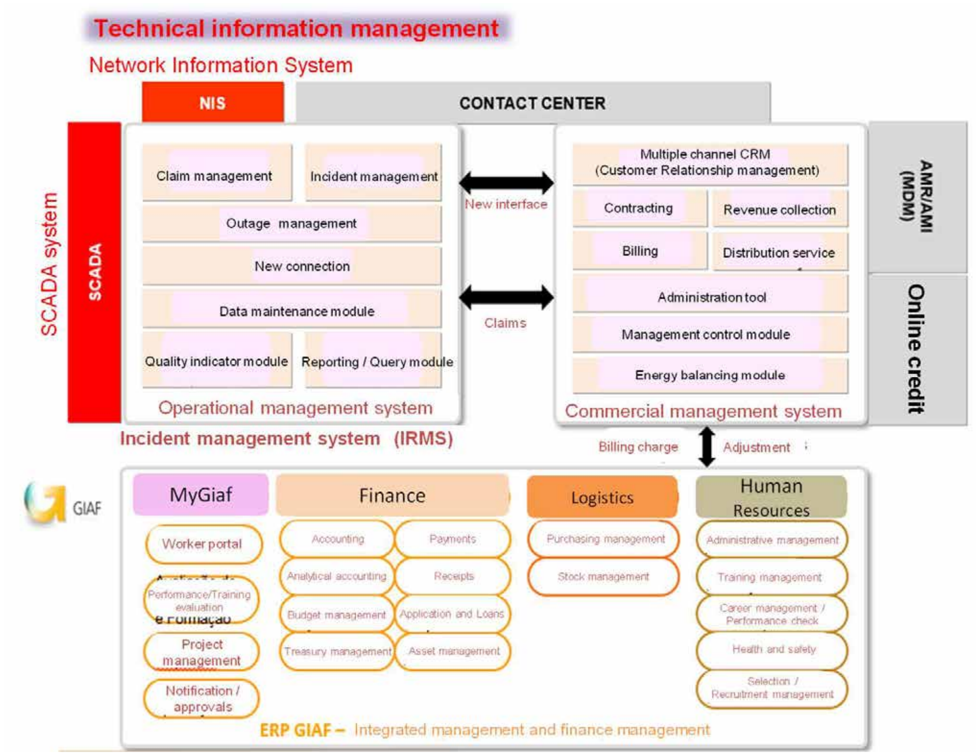
(2) Environment surrounding system operation

a. Sistema Integrado de Gestão da Electricidade de Moçambique (SIGEM)

The business model of centralized management of information on all processes of production, distribution and sales, more efficient business operation and creation of a variety of services for EDM that is a vertically integrated company that produces, distributes and sells electricity is becoming a global trend. Integrated business core system development in a project that aims at the business model development in the end is promoted with assistance from the WB. As the first phase construction of the system, a power charge collection system was completed in 2016.

Because EDM did not conduct centralized management of all customers before the system was developed, it was impossible to promptly find out the total number of customers, total sold power or uncollected power charges. The customer management and power charge collection system of SIGEM is an epoch-making internal innovation that guarantees solidity of charge collection and EDM profits[28] (management component in the upper right side in Figure 6.3-9).

[28] SIGEM has moved to the next development step and it mainly conducts repair to secure stable operation.



Source: The Study Team revised the material received by EDM

Figure 6.3-9 SIGEM's Business Management Components

EDM that is a vertically integrated company that produces, distributes and sells electricity aims to make SIGEM capable of managing information in all processes described above and conduct business operation and promotion more efficiently as its ultimate goal. To this end, it is essential to accumulate and disclose technical information on power systems through connection with SCADA and Network Information System (NIS[29]). A wide range of information should be accumulated through the connection with SCADA and SIGEM. Part of the information is listed in the below table.

Table 6.3-2 Information that Should be Linked between SCADA and SIGEM and its Example Utilization

Information to be Linked	Utilization
Electric energy in transmission line (transmission and receiving ends), electric energy of transformer	System loss calculation
Bus Voltage at substation, bus voltage at power plant	Power quality management
Failure and recovery	Failure statistics and identification of repair facilities

Source: JICA Study Team

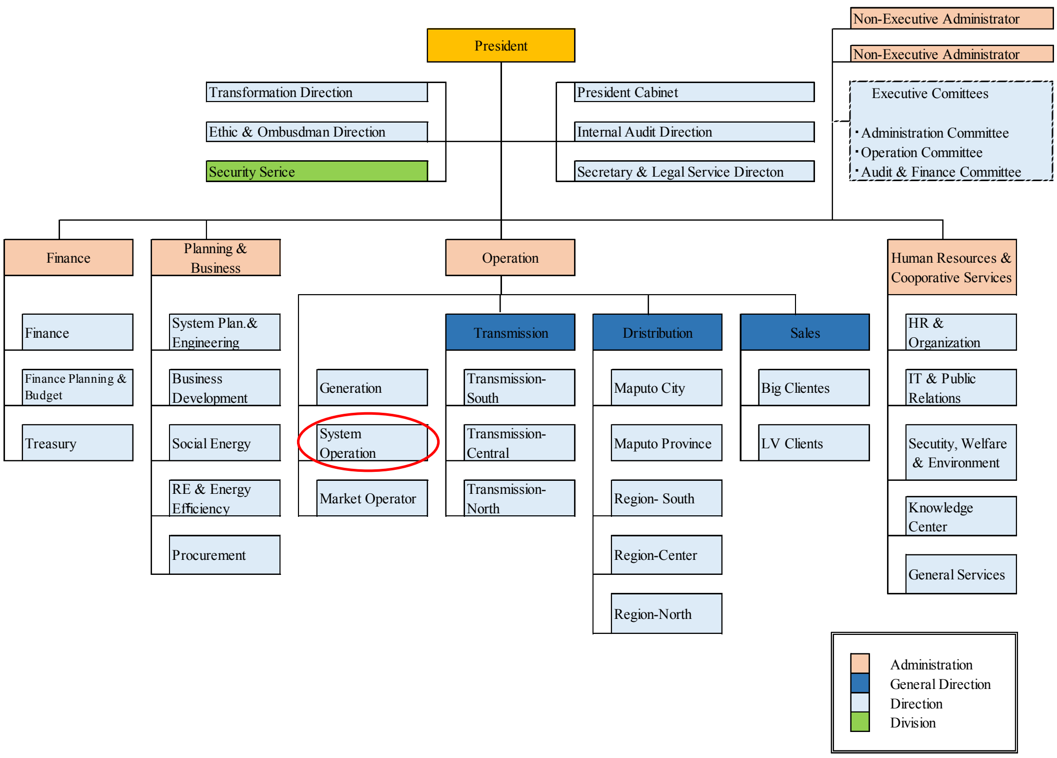
[29] NIS manages facility information and positional information together by drawing power facilities on the geographic information system (GIS). Addition and sharing failure information and on-site dispatch on the system enables active operation of each division in EDM.

b. EDM reorganization

EDM conducted reorganization and established the system operation direction in May 2017. As a result, the system operation that had been limited to basic operation that includes system supervision and failure recovery was upgraded into a foundation for advancing system operation more systematically.

The advancement means more sophisticated system supervision and control in line with system expansion across Mozambique and realization of international power interchange with SAPP member countries or third countries including neighboring nations together with supply and demand response to domestic demand.

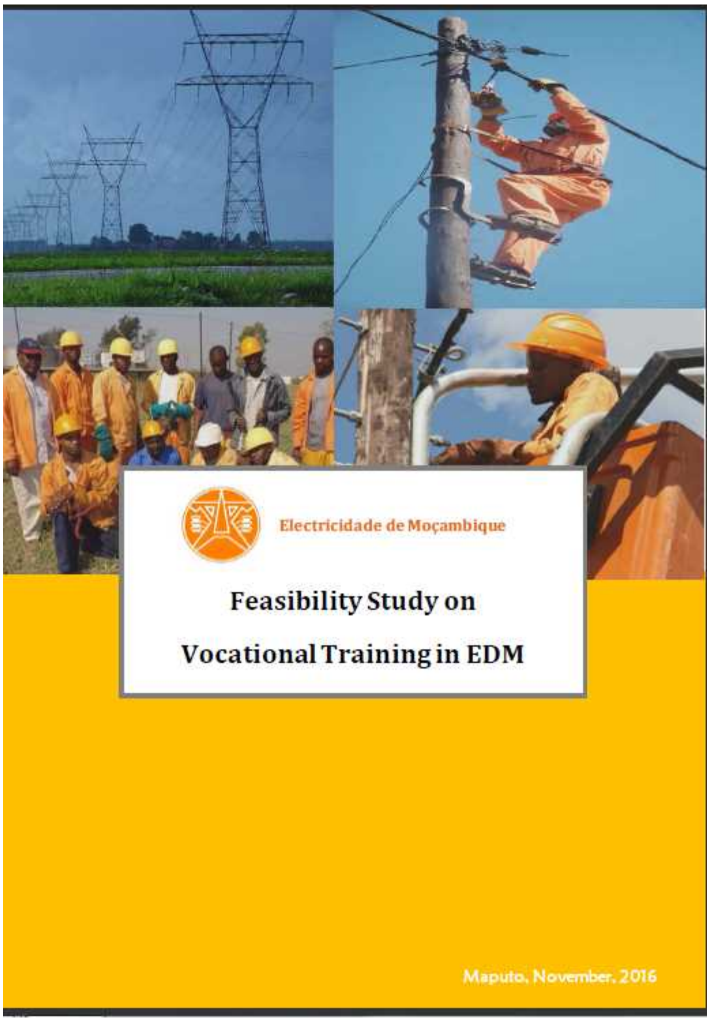
Figure 6.3-10 New EDM Organization



Source: Produced by JICA Study Team based on Ordem de Serviço N°, 006/CA/2017

c. Establishment of EDM human resource development program

EDM is engaged in major organizational reform. Abovementioned two measures for a realization of high-revel organization at the company and making the revenue base solid are part of the organizational reform. In addition, it also intends to focus on employee capacity development.



Source: Feasibility Study on Vocational Training in EDM (2016) – EDM

Figure 6.3-11 Feasibility Report on EDM HR Development Plan

With recognition that improvement of performance as a power company, including reduction of power loss and better facility utilization rate is a priority issue, EDM examined comprehensive HR development that includes development of English communication skills and other skills managers should be equipped with in addition to the development of skills related to electric power facilities and disclosed it in the form of feasibility report in November 2016[30]. Development of system operation skills also needs to be planned in line with the framework.

EDM plans development of forum to promote understanding of local residents concerning electric power and coexistence with them based on an idea that EDM's group education can be also shared with ordinary citizens as an upper-level thought of studying the HR development.

[30] Implementation of specific HR development programs described in the report is promoted with assistance from AFD.

(3) Assistance for system operation

The assistance for system operation from relevant organizations are listed below.

Table 6.3-3 Assistance for System Operation from Relevant Organizations

Donor	Project Title	Duration	Target	Specific Assistance
SIDA	EDM KPI Capacity Building Project	2014-18	EDM	Enhancement of business process skills through formulation of key performance indicators (KPI) of EDM
USAID	The Supporting the Policy Environment for Economic Development (SPEED+)	2016-20	MIREME, EDM, FUNAE, ARENE	Enhancement of EDM skills that contribute to Grid Code revision and Grid Code insertion of new technology requirement
WB	Evaluation of recent study, namely "National Control Centre and Northern, Central-northern, Central regions Control Centers Project FS"	2017-18	EDM	Introduction of SCADA/EMS and its efficient operation
WB	Power Efficiency and Reliability Improvement Project (PERIP)	2018-23	EDM, MIREME, ARENE	Improvement of distribution facility of trunk substations Remote supervision and control of trunk substations in northern region Enhancement of business process and stabilized operation of business management system

Source: Compiled by JICA Study Team based on its materials

As shown above, the WB actively supports EDM in the form of direct assistance for its system operation. In particular, it has proposed concrete assistance as below in PERIP.

- Remote supervision and control of trunk substations in northern region (Matambo, Chimuara, Mocuba, Alto-Molocue and Nampula) with mini-SCADA and replacement of their protective control units
- Replacement of transmission and substation facilities of trunk substations including Maputo, Matola, Nacala, Pemba and Lichinga substations.

6.3.2 Challenges related to system operation

There are a variety of challenges in the current system operation. Some challenges are mutually linked. The challenges are summarized in the below table and they are described in detail.

Table 6.3-4 Short-Term Challenges related to System Operation

Short-Term (Urgent) Challenge		Main Cause
1	No capacity of NCC SCADA maintenance	There is no EDM employee who is familiar with SCADA operation and maintenance.
2	No approved system operation guidelines	There was no control of system operation organization as a company
3	Unclear HR development program related to system operation	Although HR development program was formulated, much time is spent to prevail.

Source: JICA Study Team

Table 6.3-5 Mid- to Long-Term Challenges related to System Operation

Mid- to Long-Term Challenge		Direct Approach related to Solution
A	Establishment of system operation guidelines in accord with facility operation	・ Selection of automatic control device and sophistication of facility operation method ・ Introduction of facility on site that reduces operation load
B	Familiarity with supply and demand control in line with system enhancement	・ Formulation of setup method of automatic generation control (AGC) ・ Finalization of control area ・ Careful examination of EDM’s internal business process ・ Formulation of HD development program
C	Introduction of supply and demand control function and SCADA system that reduces load on system operator	・ Decision of NCC and backup control center ・ Construction of communication network
D	Development of key business management system incorporating system operation information	・ Formulation of business model ・ Provision of new services

Source: JICA Study Team

(1) Short term challenges

Short-term challenges are determined to be the below three issues. These can be also seen as urgent challenges and fundamental ones necessary for solving mid- to long-term challenges.

I. No capacity of NCC SCADA maintenance

Although the operation of SCADA installed at NCC began in 2010, its construction was launched in 2005 and the computer was manufactured in 2005, which means that its lifetime has already ended. In the case of NCC's SCADA, when the computer fails, EDM is supposed to acquire another one in the market and it is impossible to acquire currently working computer that is no longer manufactured. This means NCC's SCADA function may be lost when it fails and stops working.

To avoid such a situation, EDM has EFACEC[31] that is NCC SCADA software manufacturer dispatch its engineer on a regular basis for SCADA maintenance. It is under a contract of dispatch of engineers from EFACEC to be stationed at NCC on a regular basis as EDM has no employee who is familiar with SCADA, and another contract on response to on-call[32] on software issues to have EFACEC engineers in Portugal conduct primary response. As the maintenance contract expires in 2018, a new contract needs to be concluded. However, a fundamental measure needs to be taken as NCC SCADA may not have the manufacturer agree on a new maintenance contract[33] as the current contract is already a maintenance contract for lifecycle extension.

The problem is caused mainly because EDM has no employee who is familiar with SCADA. Familiarity with general knowledge on computer systems, various knowledge on SCADA software, data maintenance, and how to collect information when a failure occurs and determine whether the computer system operation can be continued is needed[34].

II. No approved system operation guidelines

Although NCC is equipped with operation guidelines with descriptions of system operation methods as internal rules, the descriptions are basic and not approved officially as EDM rules. It is a serious problem for a power utility that the operation rules are not approved. The problem has not come to the surface probably because it is capable of performing basic recovery from failures with the current system capacity and limited number of transmission lines and transformers, etc.

However, currently, due to the failure of transformer No. 2 of Infulene substation in the southern system, an extraordinary system is arranged radially (See Box 1). However, the facility is originally formed in a manner to enable free system arrangement with multiple supply routes to substations for loading and power sources are installed in the load system near Maputo including CTM in addition to

[31] Portugal-based heavy electric machinery manufacturer. Its computer systems are equipped with human interface in Portuguese as standard.

[32] When a failure occurs, the primary fault association is performed by making a phone call.

[33] As standard behavior of software and computer system sector, support for aged software and computer systems tend to be discontinued.

[34] Interview results with EDM revealed that it intends to study the possibility of introduction of new SCADA by 2019.

the system structure of 66kV transmission lines of southern system with non-uniform transmission capacity. Thus, support from SCADA for system operators is needed for the selection of optimal system structure.

The unavailability of no guidelines in EDM is due insufficient control as an organization regarding who writes, evaluates and approves the guidelines.

Further, these guidelines should be established by the formal rules, given by Mozambican regulator and/or relevant formal organizations. The fact of no formal rules cause this situation.

III. Unclear HR development program related to system operation

The challenge of no approved guidelines in II also resulted in no prevalence of HR development programs based on concrete rules. The Feasibility Study on Vocational Training in EDM contains the direct HR development program related to system operation as shown below. The programs are all two-week duration which is a long period and it is believed to enable participants to improve their skills with fulfilled syllabus. However, the program title also suggests that they focus on how to use SCADA, in spite that the most needed theme of HR development is to acquire SCADA utilization skills of the business process, namely: how to operate the distribution and power generation facilities, what kind of events to be communicated and when, to whom to communicate and report.

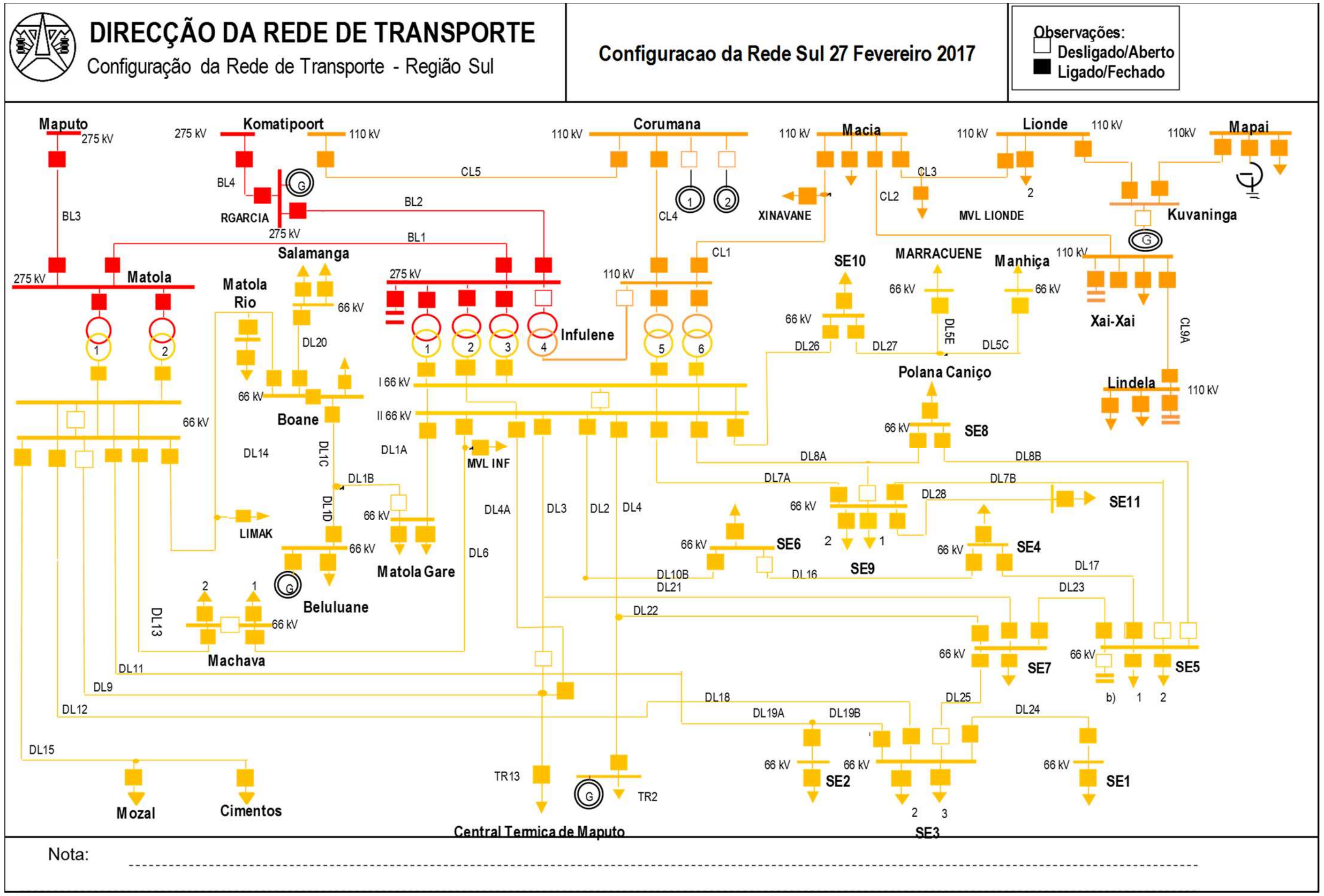
Table 6.3-6 Report on EDM HR Development Plan (extract)

Program	Durartion (Weeks)
SCADA System Management	2
Advanced SCADA Management	2
Operation based on SCADA Control	2

Source: Feasibility Study on Vocational Training in EDM (2016) – EDM

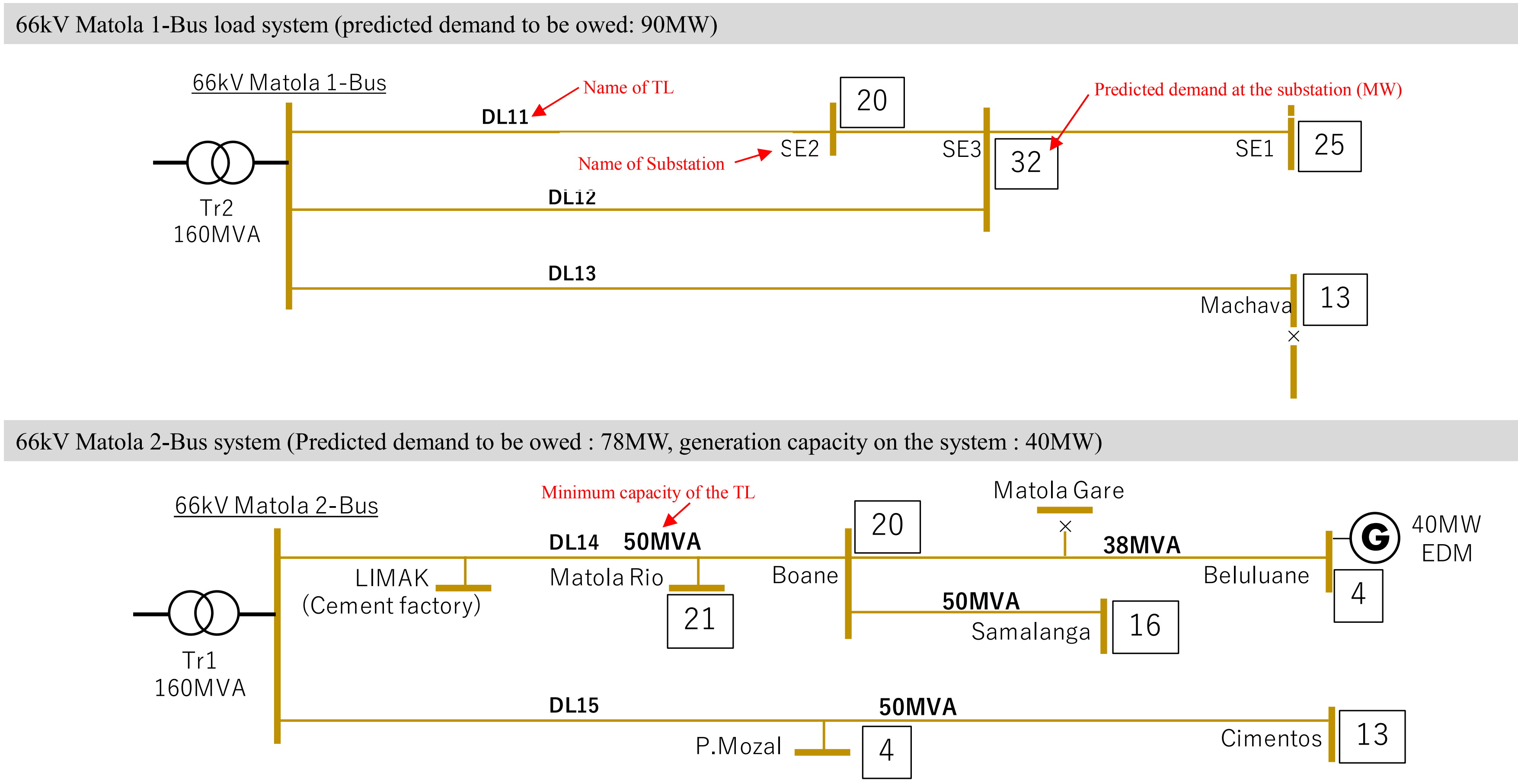
Box 1　Extraordinary system structure due to failure of transformer No. 2 at Infulene substation
Maputo area is one of the biggest power consumers in Mozambique and has two substations, Infulene and Matola substations, as power supply sources. However, both substations are dependent on South Africa power sources and they have a risk of having major supply failures caused by failures of interconnection line with South Africa. A special system structure is currently taken due to failure of transformer No. 2 at Infulene substation (See Figure 6.3-12). The 66kV transmission lines that supply Maputo are basically operated in radial system and the balance is taken using connecting lines to each radial system based on the maximum load of each 66kV substation including SE1. Operation of transformer No. 2 at Infulene substation is restricted to be 50VMA due to performance degradation and an extraordinary system is arranged with the transformer as the supply source for its effective use to have system structure to have good balance with other sound transformers (See Figure 6.3-13 to Figure 6.3-15). Although the load does not exceed the capacity of the transformer in either system structure, the transmission capacity of each 66kV transmission line is not standardized as shown in Figure 6.3-13 and thus the NCC system operator has a heavy burden related to system operation as there are various measures of recovery from failures with an example of the concern over excessive load on DL14 66kV transmission lines in an occurrence of failure of a power generator[35].

[35] Small transmission capacity of 66kV transmission lines for which NCC operator is responsible is planned to be increased and standardized to 120MVA with WB assistance.



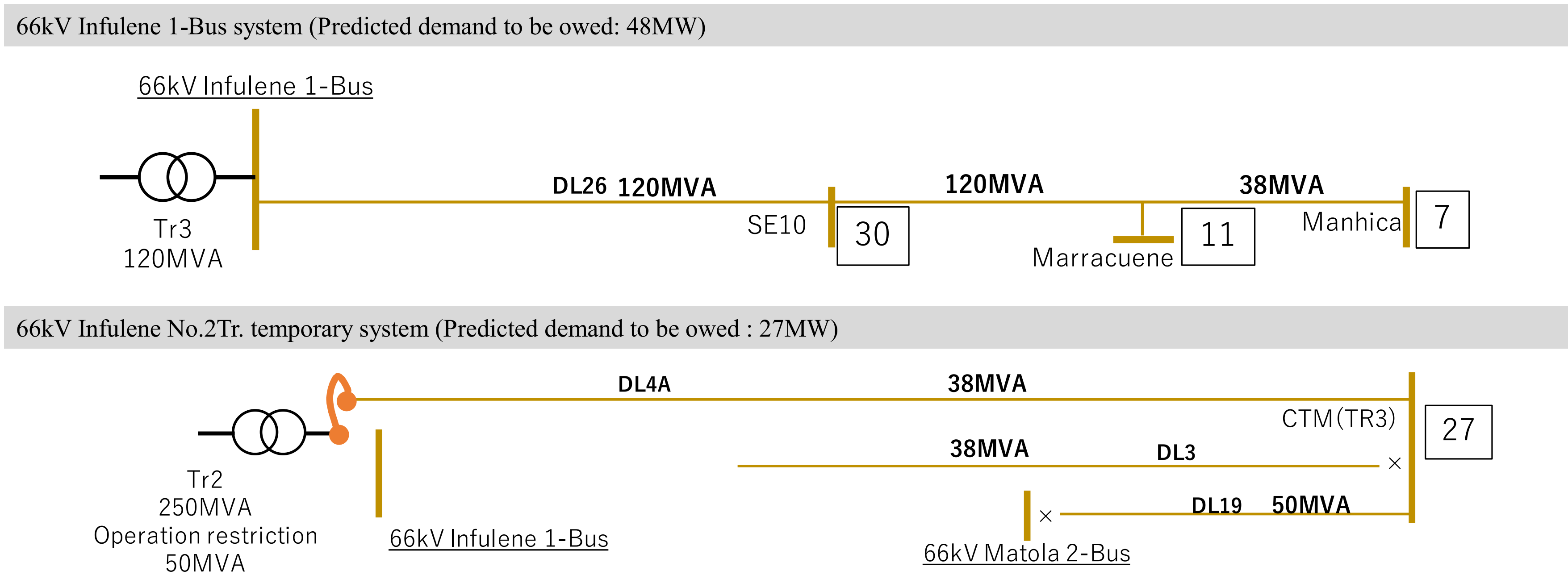
Source：EDM（2017）

Figure 6.3-12　The southern grid result diagram (27 Feb, 2017)



Source : Study Team, based on the information from EDM (2017)

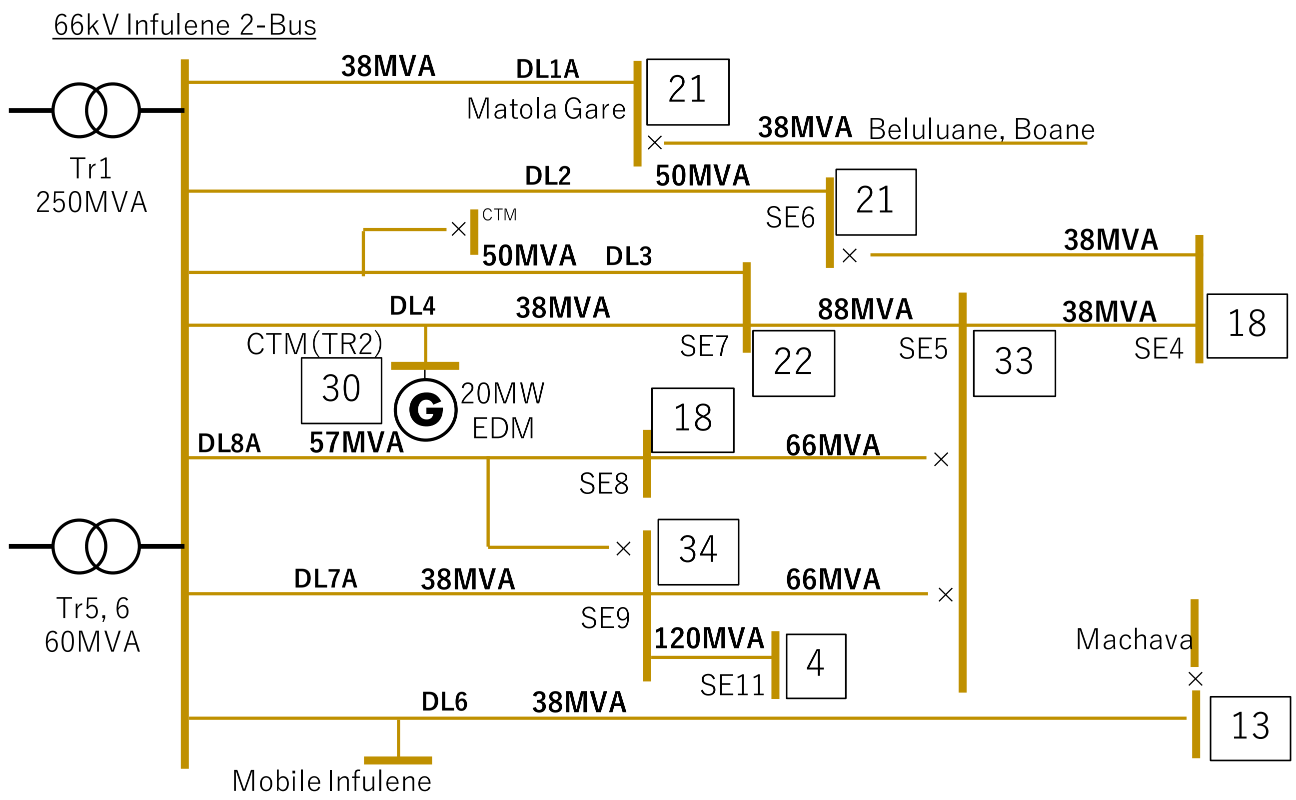
Figure 6.3-13 Matola 66kV 1-Bus system and Matola 66kV 2-Bus system



Source : Study Team, based on the information from EDM (2017)

Figure 6.3-14 66kV Infulene 1-Bus system and 66kV Infulene No.2 Tr temporary system

66kV Infulene 2-Bus system (Predicted demand to be owed : 214MW, generation capacity on the system : 20MW)



Source : Study Team, based on the information from EDM (2017)

Figure 6.3-15 66kV Infulene 2-Bus system

(2) Mid to Long term challenges

Mid- to long-term challenges focused on sophistication of system operation business in line with future system expansion and how the system operation should be performed in line with the business model EDM should aim at.

IV. Establishment of system operation guidelines in accord with facility operation

The facilities that should be supervised and controlled and current supervision points and voltage supervision points that should be grasped will increases significantly in line with future system expansion and system capacity increase. Installation of many international interconnection lines will also increase supervision of power exchange. System expansion will also increase events of failure of site facilities and operators are required to promptly handle failures caused by congestion.

Based on the assumption, it is necessary to establish matters related to system operation to be handled as system operation regulations, particularly system operation methods and sophistication of operation of site facilities to reduce the burden of operators.

Needless to say, formal rules to be established by the regulator and/or relevant organization must be disclosed as soon as possible.

V. Familiarity with supply and demand control in line with system enhancement

EDM that does not control the supply and demand balance in the supply area needs to establish the work of forecasting the demand and estimating supply to meet it. As for the demand forecast and supply estimation (calculation of supply capacity), the output distribution of power generators is adjusted and controlled while examining the system structure by using the Energy Management System (EMS) as supply and demand control.

A period for trainees to become familiar with the series of task needs to be set to acquire the skills in a planned manner to be prepared for the operation of expanded system in the future.

VI. Introduction of supply and demand control function and SCADA that reduces load on system operator

In relation to IV and V, functions SCADA/EMS should be equipped with are identified based on the formulated system operation guidelines and supply and demand control task. SCADA/EMS is basically a packaged software and there are functions that can be applied without any alternation to system operation that EDM aims at as well as functions with a certain level of insufficiency of alternation. It is a critical future issue to decide the scale of introduction of software to reduce the burden of system operators and prevent errors by improving work efficiency.

VII. Development of key business management system incorporating power system operation information

As described above, SIGEM which EDM is constructing is believed to benefit EDM business operation significantly through data linkage with SCADA/EMS. SCADA/EMS is a packaged software and data linkage with other computer systems requires separate development of additional functions. It is meaningful to examine the functions future SIGEM can offer and its business model by sorting out data to be linked.

6.3.3 Solutions to challenges

(1) Solutions to short-term challenges

a. Solutions to Challenge I: No capacity of NCC SCADA maintenance

The below is a summary of how to handle NCC SCADA that has difficulty in performing maintenance work.

Table 6.3-7 Solutions to Concerns of NCC SCADA

	Solution 1 (replacement)	Solution 2 (replacement)	Solution 3 (lifecycle extension)	Solution 4 (lifecycle extension)
Specific Method	Acquisition and replacement of SCADA with new supply and demand control function	Acquisition and replacement of SCADA for maintaining current functions	Conclusion of a maintenance contract with manufacturer's responsibility for supplying used hardware	Lifecycle extension of existing SCADA with virtualization technology
Restrictions	・The lead time for the replacement needs to be handled with Solution 2. ・Requirements for next SCADA need to be decided urgently.	・The lead time for the replacement needs to be handled with Solution 2.	・The manufacturer may not agree on the contract. ・EDM may become responsible for preparing used hardware.	・Requirements of system to be virtualized may require application of virtualization technology by the manufacturer (vendor lock-in)
Evaluation	△ (Satisfactory)	○ (Good)	◎ (Very good)	○ (Good)

Source: JICA Study Team

The solutions to NCC SCADA are largely divided into replacement with new SCADA and lifecycle extension of existing one.

The most reasonable solution is to request the SCADA manufacturer to agree on continuation of the maintenance contract while acquiring used hardware in Solution 3 in the market. Because the production of computers to be replaced has been already discontinued, the least expensive solution is to acquire used ones as stock to be prepared for contingencies. The parts of computers that are most likely to fail are fan and hard-disc that are mechanism elements and thus just preparing parts compatible with currently used computers is an adequate solution.

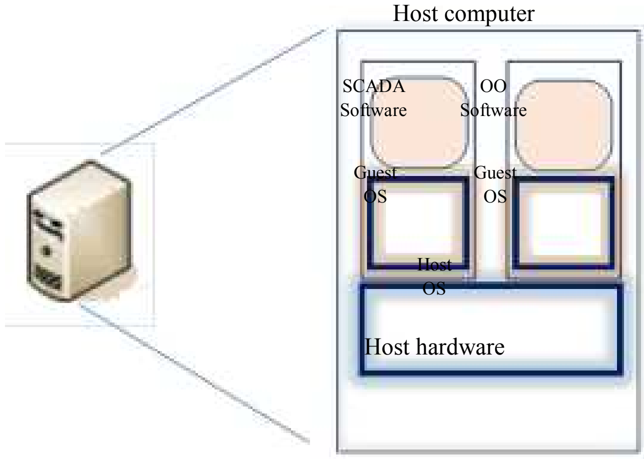
Another lifecycle extension solution is the application of virtualization technology in Solution 4. The virtualization technology is capable of logical integration and division of server and other hardware resources (CPU, memory and hard-disc) irrespective of physical structure. Application of the technology enables logical division of one physical server into multiple servers (logical server) and running operating system and software on each server. The table below are specifications of existing SCADA.

Table 6.3-8　Specifications of Existing SCADA (same as Table 6.3-1)

SCADA Component	Specifications	Manufacturer
Operating system (OS)	Red Hat Enterprise Linux ES 4	Red Hat
computer	HP Proliant ML370 G5	HP
Installed SCADA software	ScateX 13.2.1	EFACEC

Source: Produced by Study Team based on interview with EDM

Although the support period of the OS has already expired[36], the license of the existing OS can be used continuously and the virtualization technology is applicable to it. When the existing OS is used as guest OS[37], it can be set up as full virtualization[38].



Source: JICA Study Team

Figure 6.3-16　Computer Virtualization Technology

However, the application of virtualization technology requires computer system replacement although it is a small scale and SCADA function is lost for a certain period[39] and thus RTU, etc., needs to be shifted to the new system. However, because the power station in NCC has full-time EDM maintenance workers capable of back-up operation and virtualization technology will become a mainstream technology as computer technology, it is a good opportunity for EDM to improve their skills.

The most basic solution is acquisition and replacement of SCADA as listed in Solutions 1 and 2.

In September 2017, EDM launched review of the Feasibility Study of National Control Center formulated by EDF in 2013 with WB assistance[40]. This study is to comprehensively examine the establishment of NCC with supply and demand control function as EDM and regional control centers (RCCs) and associated organizations, facilities and technology to be applied. EDM hopes to include the new NCC and RCC construction in the

[36] The extension support expired on March 31, 2017. (http://jp-redhat.com/rhel4-eol/)
[37] OS of logical server
[38] It is full virtualization of complete emulation of hardware and the image is to access hardware directly from the guest OS. Another virtualization technology is quasi-virtualization and its image is to access virtual hardware on host OS and the OS accesses hardware.
[39] It is assumed to take three to five days based on the SCADA scale. The total work period is assumed to be two to four weeks.
[40] The consultant is EDF that is the same as the previous project and it is scheduled take three months.

investment plan officially based on the review result.

However, it is difficult to purchase SCADA software and decide the system structure under the situation where EDM is equipped with no work process and there is a risk of no realization of truly necessary functions with the system.

Before purchasing SCADA software, fit & gap analysis is performed to check whether the software meets buyer's needs and it is modified or it is also confirmed whether it is possible to conduct additional development when it does not meet them. If EDM does not have internal work process or flow that are finalized to some degree, the development may be delayed.

Thus, it is necessary to choose whether to replace the system while maintaining the current function until the supply and demand function becomes necessary or acquire new SCADA under the situation where necessary functions are presented with a certain degree of finalization of EDM work process.

When SCADA is acquired and replaced in either cases of Solutions 1 or 2, it takes at least two years to begin operation if the acquisition process is started now. Thus, it is essential to be prepared for contingencies by concluding a maintenance contract in Solution 3.

b. Solutions to Challenge II: No approved system operation guidelines

No internally approved system operation guidelines that are concrete operation method processed from the Grid Code means that it may result in the situation where operation standards against power project investment by the private sector cannot be clarified in addition to the incapability to control of the system operation as EDM.

The guidelines can be in the form where the basic policy of power system facility formation and its system operation to respond to the Grid Code[41] as their core and operational decisions can be added later. They can also include SAPP Operating Guidelines.

c. Solutions to Challenge III: Unclear HR development program related to system operation

As described earlier, the HR development programs concerning system operation are mainly consisting of SCADA utilization method. EDM's HR development programs do not clarify who should take them, which may be because the rank/title scheme as the organization of the system operation is not finalized.

(a) Required skills

Duties the system operation direction needs to be responsible for and skills necessary to perform them are summarized in the below table.

[41] The Grid Code is issued in Portuguese as government approved official document. However, it is also necessary to compile an English version to promote private investment including that from foreign capital to express government's aggressive attitude.

Table 6.3-9 Business Areas System Operation Direction should be Responsible for and Required Skills

Duties	Skill
Supply and demand planning and operation	Skills necessary for supply and demand operation in EDM control area and that in international interconnection
System operation	Skills necessary for dispatching, operation control and power facility operation
Study of system technology	Skills necessary for system protection and system analysis and power quality
Computer/software technology	Skills necessary for computer operation to operate SCADA/EMS
Communication technology	Skills necessary for communication network construction and operation

Source: JICA Study Team

Supply and demand planning and operation requires the skill of studying and planning the output system of power generators that can follow the daily demand fluctuations and actually performing control and operation in line with the plan.

System operation requires the skill of studying a system structure to transport electricity efficiently from power generators decided by those engaged in supply and demand planning and operation and performing operation based on the Grid Code and rules on system operation specified in operation guidelines.

Study of system technology requires the skill of studying and deciding the permanent operation value of protective relay of power facilities as well as the skill to study actual failures regarding whether the it was correct performance or not based on the operation of the protective relay and whether a new protective relay is needed or not. The role of selecting protective relays to be installed at newly constructed power facilities is not included in the skill the system operation section needs to be equipped with because it should be performed by the division responsible for system planning.

The above three duties require collection of system information timely and accurately using measuring instruments, communication infrastructure and computer systems. They require familiarity with SCADA/EMS system architecture to introduce the operation technology (OT) to respond to increase of power facilities that need to be remotely supervised and controlled in the future.

Communication technology requires the skill of managing communication network, particularly to manage topology and service system that uses the network. The communication network not only allows the transmission of system information used by SCADA/EMS but be used for various services in all departments of EDM (such ERP[42] as email and e-learning and various information sharing tools etc.). Regarding that communication network is expected to be reliable, the system information linkage requires the highest quality and thus it is deemed to be the skill with which the system operation direction should be equipped representing EDM.

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[42] Enterprise Resources Planning: management system of assets (humans, goods and money) that serve as the basis of corporate management

(b) Consistency with EDM HR development program

The report on "the Feasibility Study on Vocational Training on EDM" describes its idea on HR development and lists the development programs. The report is summarized and the relationship between the skills the system operation direction should be equipped with and the development programs is provided below.

i) EDM's HR development plan

Three priority issues below are introduced as strategic education policy in the report.

- Development of leadership and management capacity
- Expansion of professionalism
- Acquisition of partial skills

ii) EDM's professional ranks

EDM employees are classified in below ranks in the career ladder and expertise skills development programs are planned to be provided according to the rank. Employees in grades 8 to 13 (highlighted in the table below) are main target of the system operation skills development as expertise skills development to develop a level of professionalism.

Table 6.3-10 Professional Ranks of EDM

Career	Example Title	Grade
Chief Executive Officer	Chairman of the Board	1
Chief-level Executive	Senior Executive Director Executive Director	2 3
Executive	Director General Director	4 5
Management	General Manager Division Manager	6 7
Professional	Lead Engineers Finance Experts Procurement Experts IT Experts, etc.	8 9 10
Technician & Analyst	Team Leader / Supervisor Technicians and similar technical grades in operation; Analysts and related grades in corporate, IT, Finance etc.	11 12 13
Associates & Support	Artisans, Clerks, Drivers	14 15 16

Source: Feasibility Study on Vocational Training in EDM (2016) – EDM 390

iii) Relationship between education curriculum EDM selects and skills to be equipped with

The relationship between the development programs offered to business units of EDM and the system operation direction[43] in the report is provided in the below table (programs with "◎" are required and those with○ are recommended as they contain relevant skills.)

System operation staff are recommended to take the programs in the table as urgent skills development.

The number of "◎" and ○ in the table indicates that there are fewer programs on computer and software technology and communication technology.

[43] It is based on the form without consideration of the syllabus of each program.

Table 6.3-11 Relationship between EDM HR Development Programs and Topics to be Learned as System Operation Staff

Business area		Program	A[1]	B[2]	Target Audience	Durartion (Weeks)	需給計画・運用	系統操作・運用	系統技術	コンピュータ・ソフトウェア技術	通信技術
Learning Needs for generation	Operation & Maintenance	Generation Maintenance Management (Thermal)	7	2	Engineers/Technicians	3					
		Generation Maintenance Management System (Hydro)	7	2	Engineers/Technicians	3					
		Generation Operation Management System (Thermal)	7	3	Engineers/Technicians	3	◎	○			
		Generation Operation Management System (Hydro)	7	3	Engineers/Technicians	1	◎	○			
		Machinery Vibration Monitoring and Analysis	6	1	Engineers/Technicians	2					
		Turbine Governor Principles	6	2	Engineers/Technicians	3			○		
		Hydraulic and Turbine Regulation	6	4	Engineers/Technicians	3					
		Thermal Power Plant Operations and Maintenance	7	3	Engineers/Technicians	4	○	○			
		Hydro Poewr Plant Operations and Maintenance	7	3	Engineers/Technicians	13	○	○			
		Center Reliability Operation	7	2	Engineers/Technicians	1				◎	○
		Shift Charge Operation	7	2	Engineers/Technicians	10					
		Switchgear Operation and Maintenance	6	3	Engineers/Technicians	3					
		Auxiliary Systems (Thermal)	7	2	Engineers/Technicians	2					
		Auxiliary Systems (Hydro)	7	2	Engineers/Technicians	2					
	Control	Instrumentation and Controls (Thermal)	7	2	Engineers	2	◎	○		○	
		Instrumentation and Controls (Hydro)	7	2	Engineers	2	◎	○		○	
		SCADA System Management	7	2	Engineers/Technicians	2	◎	◎		◎	○
		Advanced SCADA Management	7	2	Engineers/Technicians	2	◎	◎		◎	
		Schematic drawing : Analysis and representation of circuits	6	1	Engineers/Technicians	1	◎	◎	◎	◎	
		Programming, maintenance of PLCs and RTUs	6	1	Engineers/Technicians	3	◎	◎		◎	◎
Lerning Needs for Transmission	Protection & Control	Network Protection Systems subdrived into families (ABB region, SEL, Siemens, Alstom, TPU being the first 3 families of preference) to be defined in a timely manner by the beneficiaries	7	3	Engineers/Technicians	5					
		Schematic drawing : representation of circuits and norms	7	1	Engineers/Technicians	1					
		Philosophy of protection & maintenance of compensation equipment (for type of protection)	7	2	Engineers/Technicians	2		○	◎		
		Electrical Grounding of Networks (Prot / Manu)	7	1	Engineers/Technicians	2		◎			
		Auxiliary System (AC & DC)	7	3	Engineers/Technicians	1					
		Secondary Equipment Maintenance	7	5	Engineers/Technicians	1					
		Hazard Investigation and Incident Analysis (Trouble Shooting)	7	5	Engineers/Technicians	1	◎	◎		◎	◎
		Interpretation of graphs of quantities - Oscillography (OSCOP)	7	1	Engineers/Technicians	1		○	◎		
		Test Equipment (OCM, CPC100, CT Analyzaer, GPS-Line Diff.)	7	4	Engineers/Technicians	1					
	Operation of systems and operational planning	Procedures for Operartion of an Electrical System	7	3	Engineers/Technicians	1	◎	◎	◎	◎	
		Operation based on SCADA Control	7	4	Engineers/Technicians	2	◎	◎		◎	○
		Operational and Diag. of Charge	7	2	Engineers/Technicians	2					
		Incident Analysis and management of Occurences	7	3	Engineers/Technicians	1			◎	◎	◎
		Quaility of Power Supply	7	1	Engineers/Technicians	2		◎	○		
		Network Analysis, Interpretation, and Configuration	7	4	Engineers/Technicians	1			◎	○	○
	Isolation Coordination and network grounding	Coordination of isolation and grounding of the network	7	2	Engineers/Technicians	10 days	○	◎	◎		
	Compensation equipment	Compensation equipment	7	1	Engineers/Technicians	12 days		◎	◎		
Distribution	Planning & Statistics	Quality Management of materials and certification	6	3	Engineers/Technicians	5 days					
		Electrical Network Planning	7	3	Engineers/Technicians	15 days					
		Distribution Statistics	6	3	Engineers/Technicians	5 days	○	○	○	○	
		Control of energy flow and technical losses of energy	7	2	Engineers/Technicians	10 days					
		Maintenance Management	7	3	Engineers/Technicians	10 days					
		Network and customers information system (NCIS)	7	4	Engineers/Technicians	10 days					
		Training on first aid	7	1	All	5 days					
		Training on hygiene and safety at work	7	1	All	5 days					
		Administration and Finance	7	2	Engineers/Technicians	10 days					
		Executive Secretariat	6	2	Engineers/Technicians	10 days					
		Protocol & Publec Relations	6	2	Engineers/Technicians	10 days					
		Business management (Intermediate management)	7	1	Engineers/Technicians	10 days					
		Optical Informatiocs	5	3	Engineers/Technicians	10 days					
Commercial	Commercial	Technical Procedures Commercial (Readings, Inspect and Cuts and Data insertion)	7	4	All	1					
		Commercial Procedures (Service, Contracting, Billing and Collections)	7	4	All	1					
		Advanced Excel	4	3	Professionals/Technicians	2					
		Strategic Marketing and Planning	6	2	Professionals/Technicians	3					
		Negotiation and Conflict Managemnet Techniques	5	2	All	1					
		Excellence and Quality in Customer Service (face-to-face and non face-to-face service)	7	3	All	1					
		AMI/AMR Counting Technology - Automatic Meter Infrastructure	7	3	Professionals/Technicians	2				○	○
		Energy Management and business loss	7	2	Professionals/Technicians	2	○	○	○		
		Financial management	5	2	Professionals/Technicians	3					
		Technical English	5	2	All	52					
Electrical Systems Planning	Electrical Systems Planning	Arc GIS 10.0	7	2	Technicians	2					
		DP Power (Electrical Infrastructure resistration tool)	7	3	Technicians	1					
		Project Planning and Implementation	7	2	Technicians	2	○	○	○	○	
		Project Proposal Writing and Fund Rising	4	2	Technicians	2					
		PSS/E Course (Full Package)	7	3	Technicians	3		○	◎		
		Planning of Transport and Distribution Systems, including operational planning	7	3	Technicians	3		○	◎		
		Planning of Energy Generation (Coal, Gas and Diesel thermal power plants) including studies of interconnection to the national electricity network	7	3	Technicians	2	◎	○	◎		
		Planning of Energy Generation (Hydropower plants) including studies of interconnection to the national electricity network	6	3	Technicians	2	◎	○	◎		
		Technical english	7	4	Technicians	12 months					
		Introduction to DIGsilent - power factory basic v 15	6	1	Technicians	2		○	◎		
		How to write technical reports and prepare presentations	6	3	Technicians	1					
		Renewable energy planning including studies of interconnection to the national electricity network	5	1	Technicians	2	◎	○	◎		
		Environmental planning and budgeting	5	2	Technicians	1					
		Project Finance	5	1	Technicians	2					
		Substation design	5	3	Technicians	1					
		Planning and Construction of overhead lines	5	3	Technicians	1					
		Power System Engineering (Planning)	6	2	Technicians	1	○	○	◎		
		Intermediate management, leadship and good practices	5	3	Technicians	2					

Source: Produced by JICA Study Team based on Feasibility Study on Vocational Training in EDM (2016)

It is essential for EDM that does not conduct supply and demand control to provide programs on the control and it needs to be reflected comprehensively in development programs.

What skills should be acquired and what programs are needed for it are described later as they are closely associated with mid- to long-term challenges.

(2) Mid- to Long-term challenges to be solved in the same direction from short-term challenges

a. Reconfirmation of system operation businesses

As described earlier regarding current system operation and its circumstance, EDM faces serious and immediate challenges in relation to the operation. However, there are a number of such positive factors for significant development as power source and transmission network development in the future.

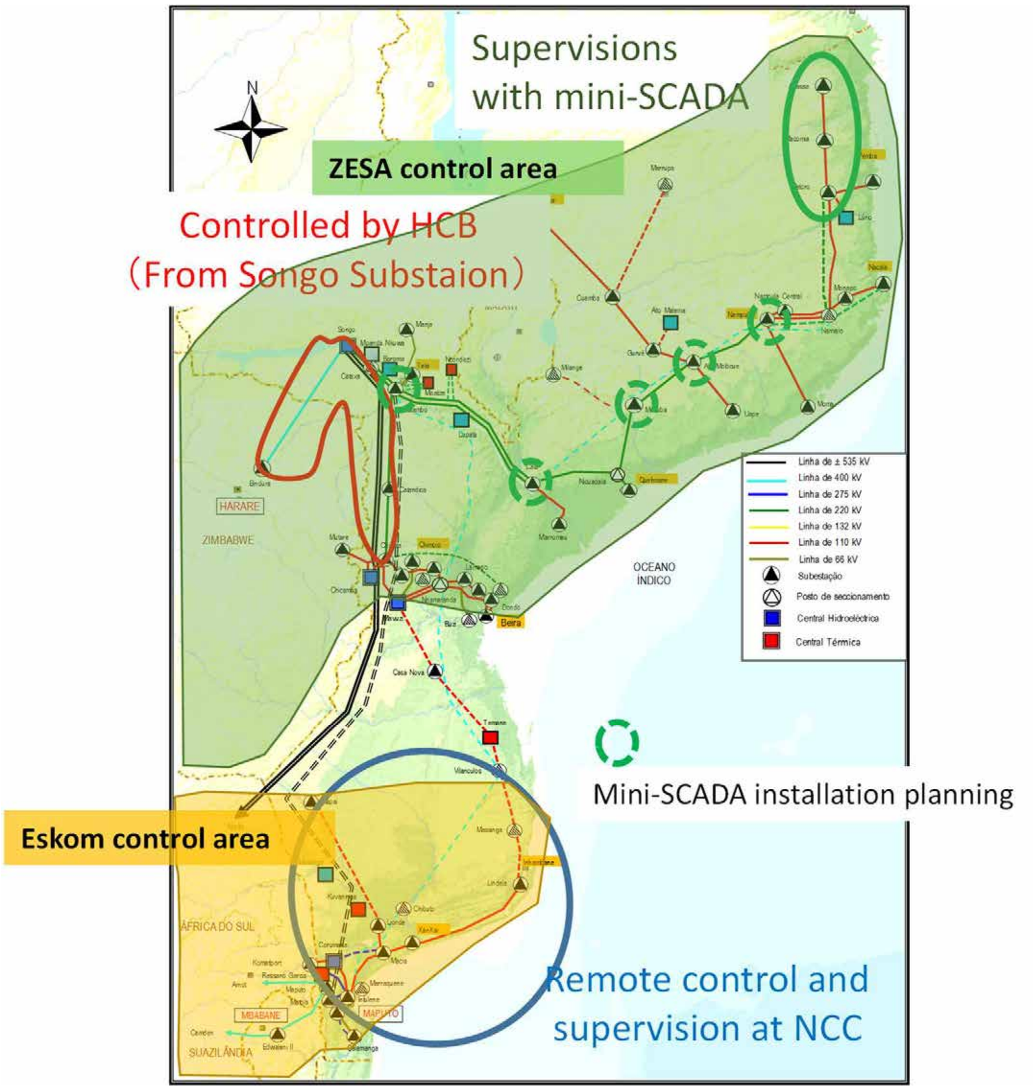
The EDF report is the original summary of ideal system operation in the future. It comprehensively introduces system operation businesses that include system operation planning and importance of operation recording and evaluation after actual operation in addition to an outline of functions SCADA/EMS is expected to have. As for the wide-area system operation, the requirements for operation are sorted out from a wide-area perspective as SAPP Operating Guideline is already available and the operation of ultra-high voltage system operation of EDM can be in accordance with the guideline.

The definition of system operation tasks EDM should aim at are described in detail so that it can examine them independently while complementing the EDF report and challenges related to realization of the businesses and positioning of the system operation businesses as EDM businesses are examined comprehensively.

b. Reconfirmation of current system operation

Mozambique covers expansive national land and its southern system around Maputo is under the centralized remote supervision and control whereas central, northcentral and northern systems are directly operated at manned substations. HCB that is an IPP wholesale electricity in Tete in the northcentral region and EDM is not involved in power generation control.

Mozambique does not control supply and demand. Central, northcentral and northern systems belong to the ZESA control area and the southern system is in Eskom control area and the supply and demand control is conducted in the respective control areas.



Source: JICA Study Team

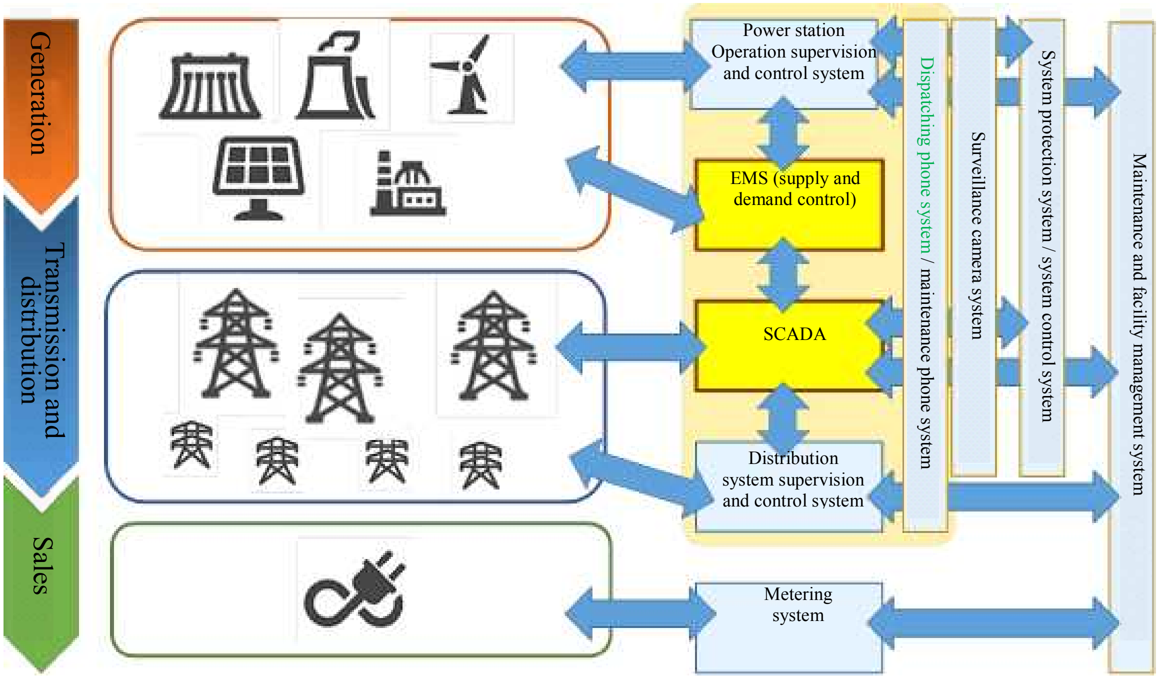
Figure 6.3-17 EDM Remote Supervision and Control / Wide-Area Control Area

c. Target setting

As it is described in the Master Plan, it is natural for Mozambique to control supply and demand as a country when the entire country is connected as a result of development of large-scale power sources and transmission network. Nationwide connection as a result of completion of STE backbone in 2024 is set to be the starting year of supply and demand control and challenges that need to be solved before it and relevant information and proposals are given herein.

d. Definition of system operation

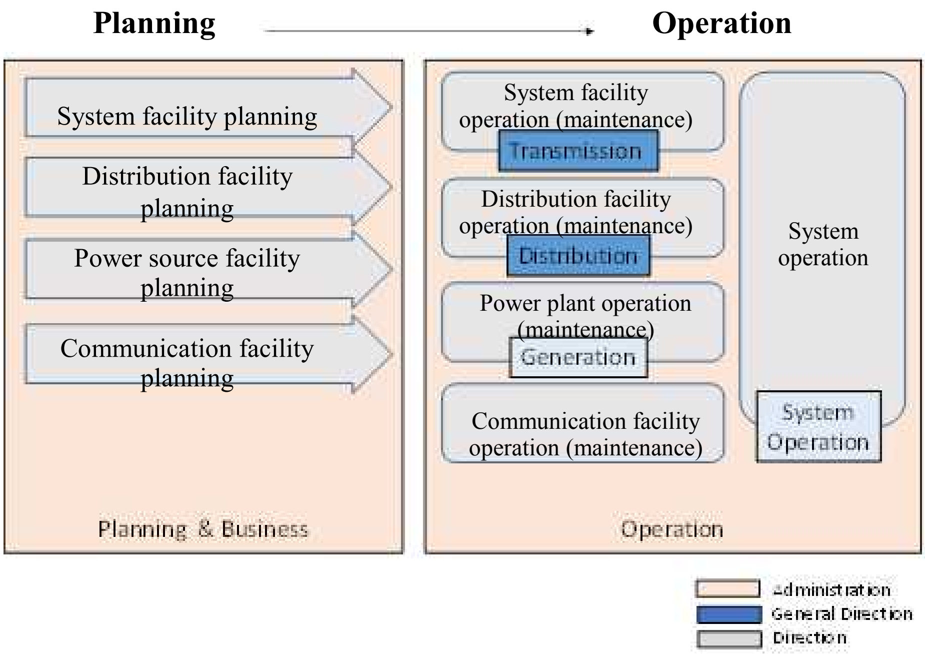
The facility boundary from the perspective of business area and system operation of typical vertically integrated power utility is provided in Figure 6.3-18. This type of utility manages the entire process from power generation, transmission and distribution to sales. The area of system operation business in the process is from control of generation in line with the demand to its delivery via transmission and distribution networks. However, EDM defines power distribution as a separate business area and thus it uses EMS that controls generation, SCADA that controls power system, dispatching phone system and maintenance phone system to contact power plants and substations as major business tools.



Source: JICA Study Team

Figure 6.3-18 Definition of Business Area

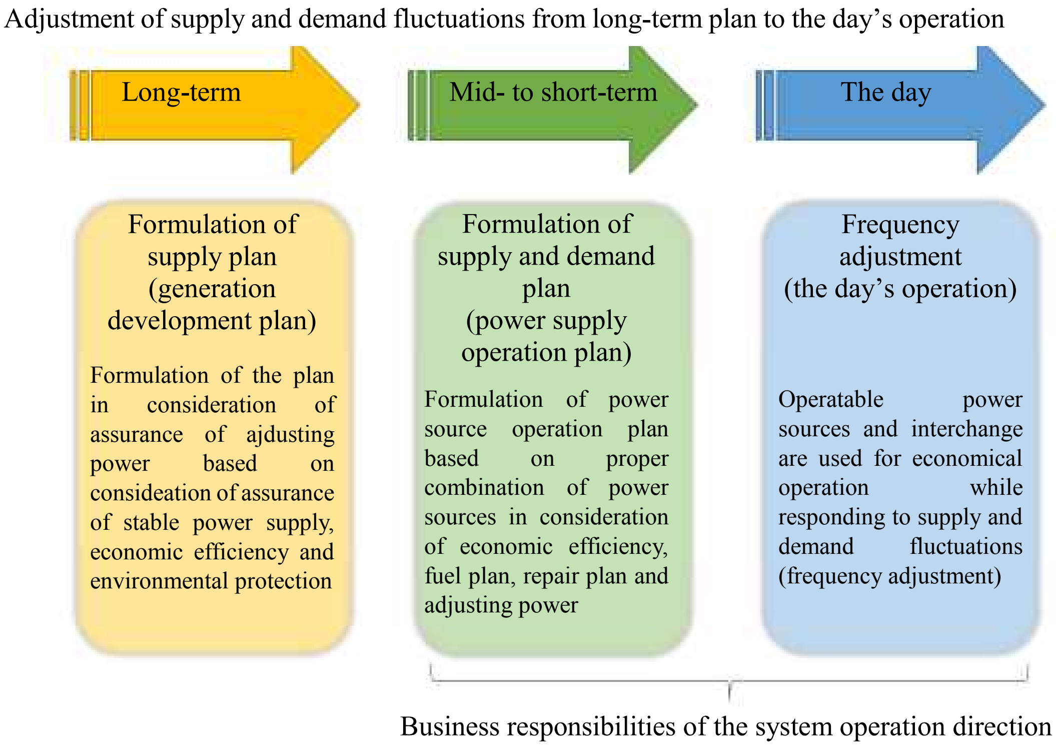
When the process from facility investment planning to construction and operation corresponds to EDM organization chart in Figure 6.3-19, it is shown in the below mapping. The business area the system operation direction is in charge of is actual system operation only there. However, the responsibility for communication facility operation is not identified.



Source: JICA Study Team

Figure 6.3-19 Business Areas in the Process from Facility Investment Planning to Operation

The business areas of the system operation direction in line with the lapse of time along with the master plan that is a long-term plan are provided in Figure 6.3-20.



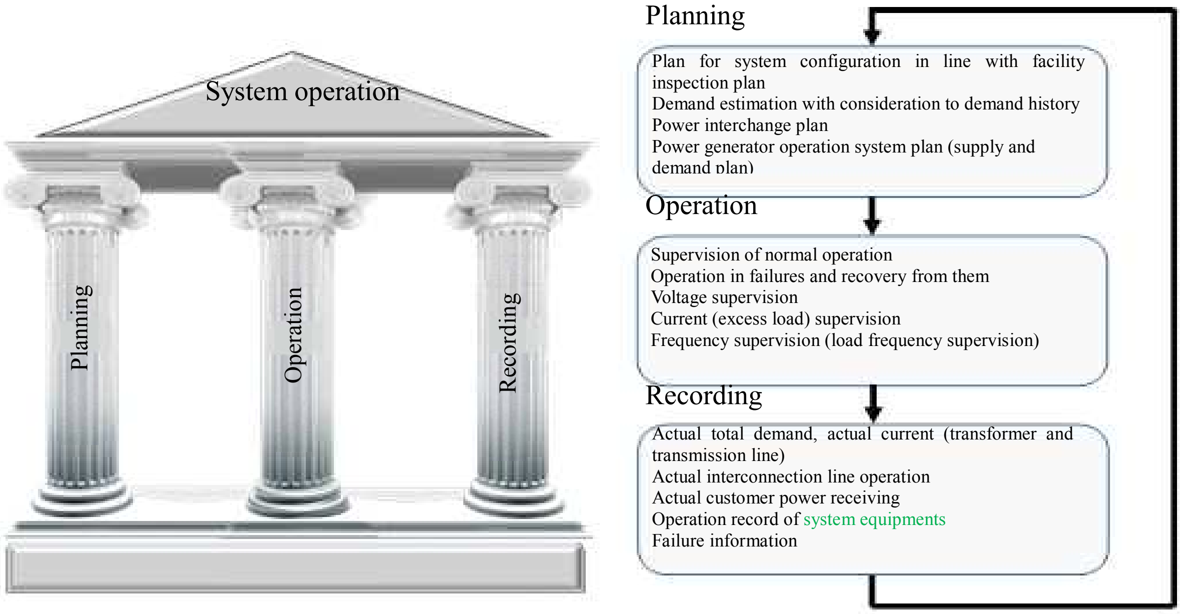
Source: JICA Study Team

Figure 6.3-20 Business Areas of System Operation in the Process from Master Planning to Operation

As the figure shows, the system operation direction is responsible for planning after the mid-term to the operation of power facility of the day and it is the duty responsibility from the perspective of facility utilization and operation. Each division in charge of maintenance performs facility maintenance.

e. Issues to be examined for better system operation (mid- to long-term challenges)

The system operation business structure consists of three basic businesses of planning to examine how to operate the system, actual operation in accordance with the plan, and recording of operation results and its evaluation to utilize it in the next plan. Operators engaged in operation are responsible for safely and correctly carrying out the business that cannot be done again.

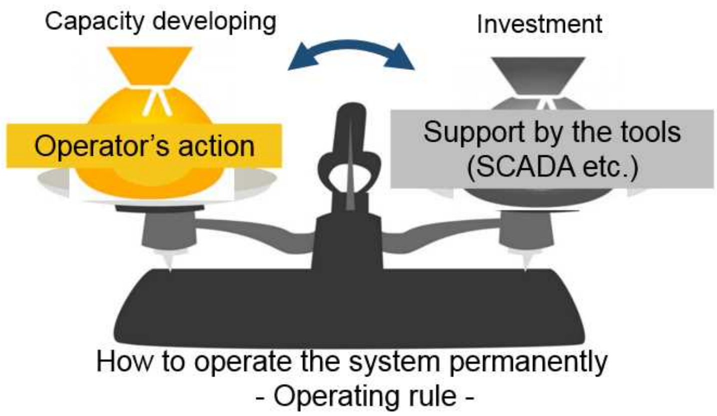


Source: JICA Study Team

Figure 6.3-21 Basic Structure of System Operation Businesses

Thus, it is important to keep a good balance between creating the environment of systems and facilities to support the operation to minimize operators' burden and development of excellent operators. The decision of the balance depends on the operating rule.

Development and securing of workers who complement and support operation business is also important.



Source: JICA Study Team

Figure 6.3-22 Balance related to Power System Operation

Against the backdrop, issues related to mid-to long-term challenges and their directions to be examined are revealed (See Table 6.3-5).

Approaches to be studied for solving the challenges are listed below.

(A) Examination of introduction of system operation facility/system facility that assist system operation
(B) Confirmation of supply and demand control process
(C) Development of SCADA/EMS based on business process of system operation direction
(D) Structure of communication network in consideration of all EDM business
(E) Desirable HR development program
(F) Data connection to SIGEM and its impacts

(A) Examination of introduction of system operation facility/power distribution facility that assist system operation

Power system operation is performed by system operators[44]. Centralized supervision and control is common for comprehensive supervision and most efficient and rational operation of the system and SCADA/EMS is needed for its realization. The two methods below are realistic solutions to reduce operators' burden while sophisticating the operation and improving its efficiency.

a. Introduction of automatic control system at power stations

b. Introduction of automatic control function using SCADA/EMS

Because the automatic control function using SCADA/EMS in b. requires entry of site information to suffice automatic control and it is also required to send out control signals to site facility promptly, sophisticated automatic control is not so feasible without a variety of technical requirements including communication infrastructure, measuring technology and remote-control technology.

Some types of automatic control system (device) at power stations with functions useful to EDM are circulated in the market and the burden of system operation imposed on operators will be reduced if it is used properly. Thus, on-site automatic control system useful to EDM is introduced below.

i) Auto reclosing system

A protective relay minimizes failed section and trips the circuit breaker next to the failed area to exclude it from operation when a failure occurred. The protective relay against a transformer and phase modifier usually detects and excludes equipment failure from operation and the failure is mostly caused by continuous (permanent) factors and it is difficult to turns on the breaker and put the equipment back into operation. In comparison, failures of transmission lines, particularly 132kV or less transmission lines of load system, are sometimes detected with causes of birds and other flying objects and thunders, and in such a case, it is highly possible to reclose the breaker that was once shut down to recover normal operation[45].

Operation at current EDM, particularly operation in cases of failure at NCC, is conducted manually by operators after confirmation of possibility of retransmission as shown in Figure 6.3-6. Failures of congested transmission lines can occur in the future as they increase in line with system expansion. Based on the assumption, if operators can focus on recovery from failures when they occur in the primary line, it may delay response to recovery from more serious failures. As an attempt to avoid it, the auto reclosing system is installed at power stations and it turns on the breaker for transmission lines under certain conditions when a failure occurred. Figure 6.3-23 provides input conditions of the auto reclosing system and example reclosing conditions. When the conditions are met and the breaker recloses within a certain period after it closed for failures[46] and blocks again, the operation is put back into the current business process, which enables significant improvement of the process of recovery from failures operators perform (See Figure 6.3-24).

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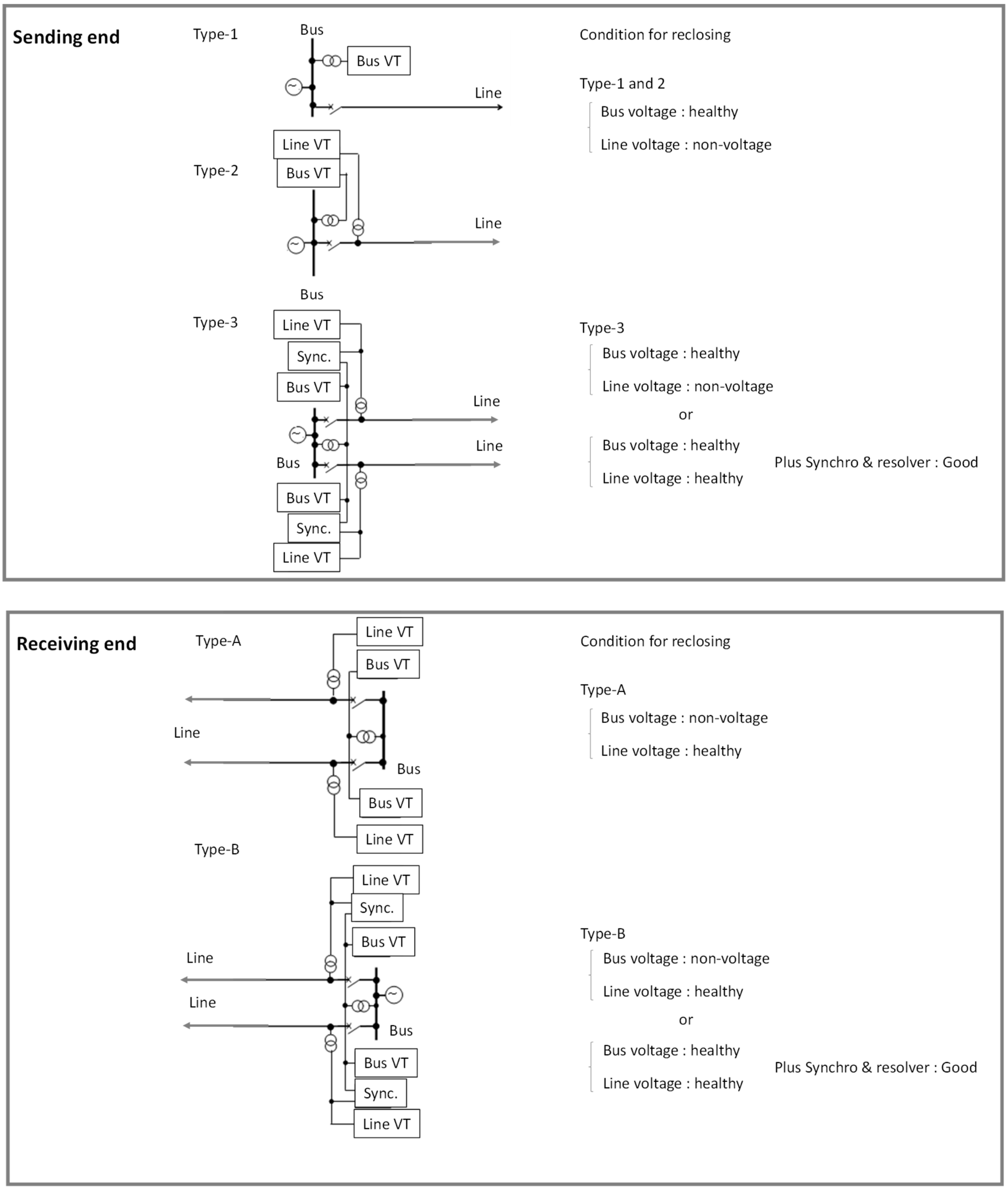
[44] System operators broadly mean workers who directly operate distribution facilities and conduct centralized supervision and control at substations.

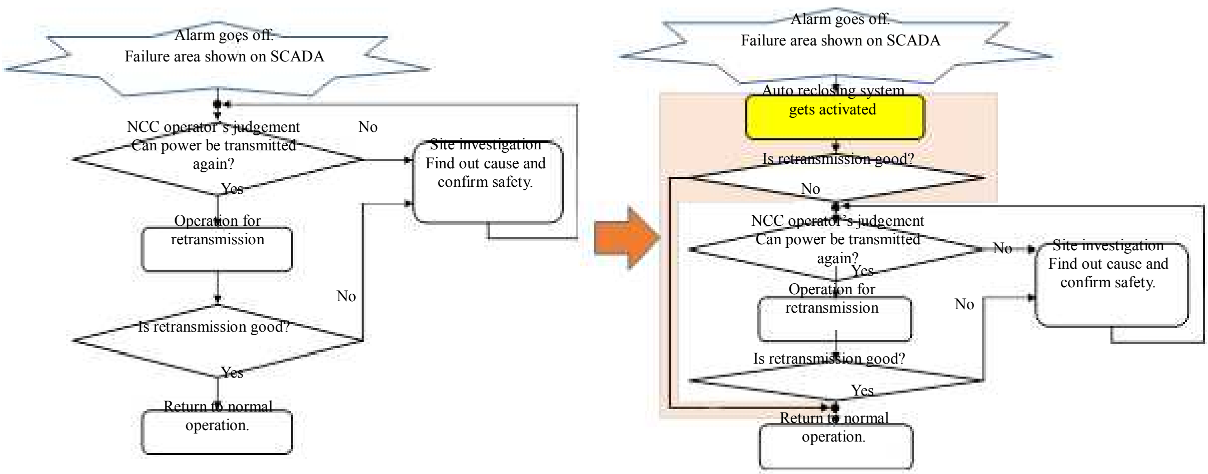
[45] According to SAPP Operating Guideline, 400kV international interconnection line and ultra-high voltage transmission lines connected to the interconnection line are provided to be equipped with a high-speed reclosing system. The system is installed to prevent system oscillation caused by failure shutdown of ultra-high voltage transmission line. The enclosure time is assumed to be 60 to 100 milliseconds from the failure shutdown.

[46] It is assumed to be around 10 seconds.



Source: JICA Study Team

Figure 6.3-23 Skelton of Auto reclosing System Functions



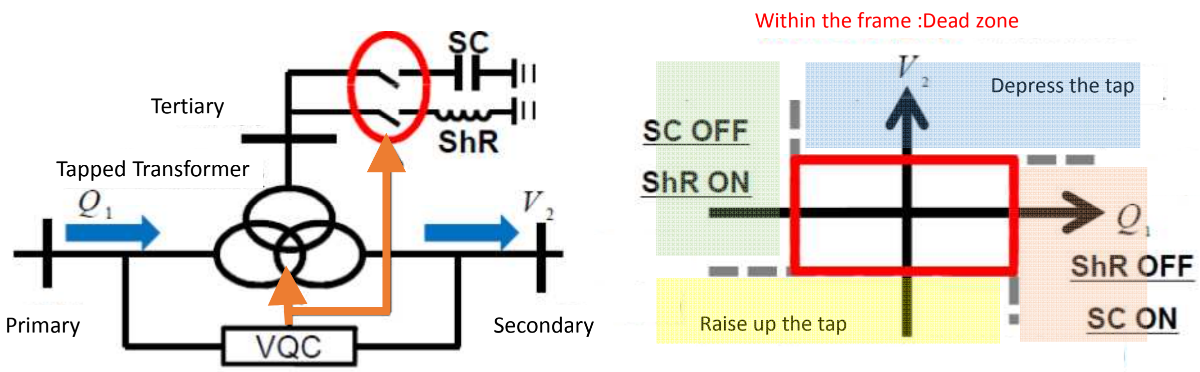
Source: JICA Study Team

Figure 6.3-24 Business Process of Recovery from Failures with Auto Reclosing System

ii) Voltage Reactive Power (Q) Control System (VQC system)

Operators manually operate phase modifiers to keep bus voltage properly at trunk substations in central, north-central and northern systems as reactive power (Q) control of long-distance transmission lines. The manual operation is performed at each trunk substation, which not only imposes a burden on operators but prevent coordinated reactive power (Q) control. VQC is on-site control device to make it efficient to conduct rational reactive power (Q) control. Basic performance image of VQC are provided in Figure 6.3-25[47].

Under the circumstances, the tap is depressed in the first quadrant (blue area in the figure) to activate it and it is raised up in the tertiary quadrant (yellow area in the figure) The capacitor is turned off or reactor is turned on in the secondary quadrant (green area in the figure) and the reactor is turned off or the capacitor is turned on in the fourth quadrant (pink area in the figure).



Source: JICA Study Team

Figure 6.3-25 Voltage and Reactive Power Control of Transformer on Secondary Side with VQC

47 It is an example of phase modifier connected to the tertiary area of the transformer. However, VQC can be managed as target of control if it is in a substation. There is also a type of control in the VOC area where multiple substations are put in a group as an extended function, which enables wide-area voltage and reactive power control.

Introduction of the system enables automated voltage reactive power control and the condition of voltage track, tap operation and phase modifier switch-on analysis can be recorded as VQC unit and power quality in the area including the substation can be checked and information on future phase modifier introduction plan can be obtained.

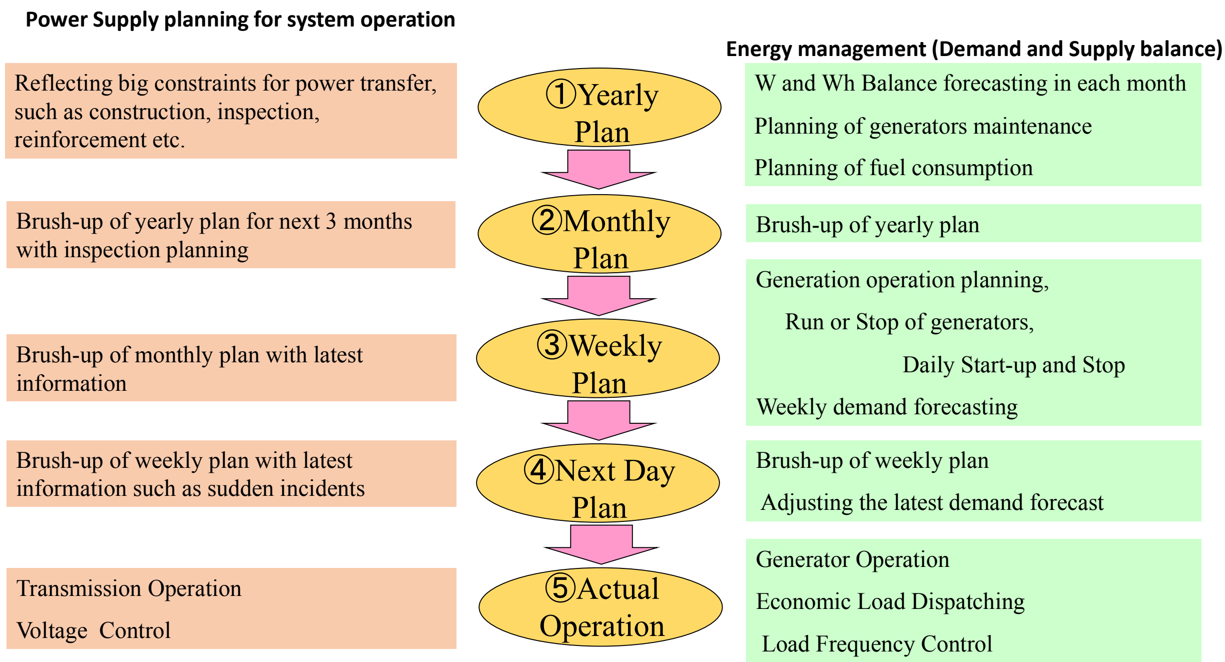
(B) Confirmation of supply and demand control process

(a) Supply & demand plan and control, study & operation of system structure

System operation businesses not realized in Mozambique are constant supervision and control of supply and demand balance and supply and demand planning of the day.

As described in the EDF Report[48], the supply and demand planning varies from yearly plan of estimating the power generation capacity (supply power) of 365 days to monthly or weekly planning with more accurate demand estimation and supply capacity calculation and final plan (plan on the previous day) for applying it to actual operation. In each stage, whether the overloading or voltage abnormalities occur or not in the power system is studied in consideration of such system conditions as suspension of transmission line work based on the balance of assumed demand and supply capacity to determine the operation system of each power generator.

The description can be illustrated in Figure 6.3-26. Although the figure has monthly and weekly plans and a plan for the following day which are more detailed planning stage than the description in the EDF Report, planning stage which EDM can carry out should be chosen.



Source: JICA Study Team

Figure 6.3-26 Overview of Supply and Demand Planning and Control and Study and Operation of System Structure

48 See Page 46/213 5.1.3 The different phases of a power system control. The report recommends planning in three stages—annual, weekly and daily.

(b) Demand estimation method in supply and demand planning

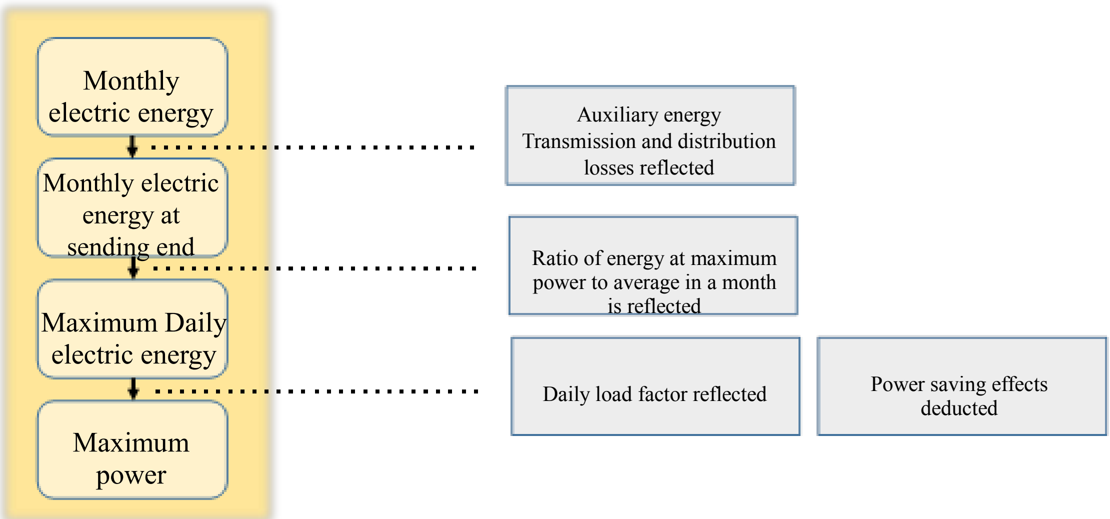
A rough demand estimation method for annual supply and demand planning shown in Figure 6.3-27 is introduced below.

Long-term power demand estimates are analyzed in the master plan (hereinafter the estimation is referred to as MP demand estimates). However, the power demand estimates as system operation business is slightly different from the estimates and it requires the perspective of daily load demand curve necessary for daily operation. In other words, it requires estimation to draw the time zone where the maximum power demand occurs and what the value is (hereinafter the demand estimation is referred to as operating demand estimates).

The operating demand estimation in annual supply and demand planning[49] is conducted by dividing the electric energy in the MP demand estimates into monthly energy and reflecting the energy at each power station and transmission and distribution loss from the value to estimate the monthly electric energy at the transmitting end. The daily electric energy rate[50] of the day when the maximum electric power occurs to the monthly energy at the transmitting end is used to estimate the daily electric energy. The daily load factor to the daily electric energy is reflected to estimate the maximum electric energy.

The demand estimates need to reflect the most recent power demand trend accurately based on the sales results and recorded daily load curve of the most recent two years. The trend also needs to incorporate evaluation of power consumer sentiment and economic activities including power saving based on the latest economic trend.

Operating demand estimates are obtained by at least calculating the daily maximum power and daily electric energy and possibly calculating the power and energy at 24 points a day.



Source: JICA Study Team

Figure 6.3-27 An Example Power Demand Estimation Method

[49] It is desired that annual supply and demand planning be performed by the middle of the previous year.
[50] Recorded actual values are used as reference.

(c) Supply capacity well balanced with estimated demand: reserve margin

A method of estimating power supply to meet the operating demand estimates described above is shown as follows;

It is a challenge directly linked to the system operation as daily supply and demand estimation in a short term (short-term supply and demand planning) and it can be classified as plans of power source construction or IPP introduction with private capital or power interchange via international interconnection lines to cope with estimated demand increase in the mid-to long term (long-term supply and demand planning). Power demand forecast and power source development plan in the master plan is regarded as one of issues to be studied in the long-term supply and demand plans[51].

Specific jobs related to supply and demand balance estimation

a) Basic

- Supply and demand balance is estimated by estimating the maximum power supply and demand balance and energy supply and demand balance.
- The maximum demand power and demand energy are indicated at the sending end.
- The monthly supply and demand balance is calculated and value at the generator end is calculated both in annual and monthly supply and demand planning.
- The maximum power supply and demand balance shows the level of balance (reserve margin) of supply and demand calculated by posting the maximum demand power and the supply capacity that can be expected stably when the maximum energy occurs and subtracting the maximum demand power from the reserve margin.
- The maximum power supply and demand balance and energy supply and demand balance are expressed with the month where maximum demand occurs (one of months from November to April in Mozambique) and reserve margin to meet the demand, respectively.
- Power procurement from other power companies (either generator or utility) is based on supply capacity calculation for the valid receiving contract. The receiving power is added and transmitting power is subtracted.
- Although there is no specific unit, it is 103kW and 106kW for power and energy, respectively, in addition to those provided, and fractions smaller than the decimal point is not given. Coefficients are in percent and fractions are shown up to one place of decimals.

b) Demand

- The estimated maximum demand power applied to the maximum power supply and demand balance is average power of up to three days from the biggest daily power of the month.
- The energy applied to the energy supply and demand balance is the total demand energy of the year in the annual balance and the total demand energy of the month for the monthly balance of the first year.

[51] The electricity master plan is described as one of supply and demand plans because it is desired that both supply and demand plans—one focuses on power development to study the development plan at the national level as South Africa and the other includes concerns over supply and demand balance and system operation (supply reliability and power quality issue) by a power company—be formulated.

c) Supply capacity

(1) Supply capacity (kW)

- ➢ General matters

- The supply capacity is expressed in hourly average power using the below formula.

  (Supply capacity) = (generation capacity of a power plant)

  －(suspended power due to planned repair, etc.)

  －(auxiliary power necessary when maximum demand power occurs)

- Monthly average is used for the suspended power due to planned repair. However, the suspended power can be decided in accordance with the situation. For example, the average of the first half or the second half of the month ca be used for the month when the monthly trend of demand and water flow is clear.

- The supply capacity of the power source is estimated in the below category.

Table 6.3-12 Power Source Category for Supply Capacity Estimation

Power Source Category	Application
Hydropower	Reservoir, regulating reservoir, natural flow
Thermal	Coal-fired, gas-fired, diesel
Renewable energy (excluding hydropower)	Solar power, solar heat, wind power, geothermal, biomass, waste
Others	Interchange, permanent backup

Source: JICA Study Team

◆ Estimation methods

a) Hydropower

The internally consumed power and suspended power due to planned repair, etc., are subtracted from the available power energy of each power plant.

The available power energy of the driest day in reference to the past flow record[52] is used to estimate the available power energy of natural-flow hydropower stations.

The available power energy of reservoir-type or regulating-reservoir-type thermal power stations[53] is calculated based on the long-term[54] inflow volume and reservoir water utilization plan.

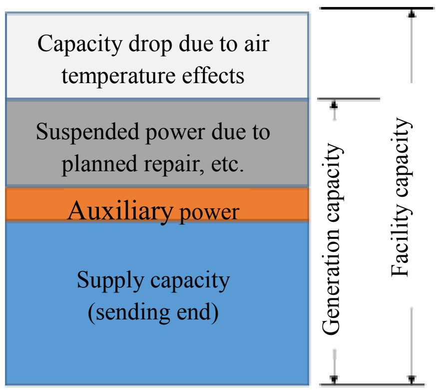
b) Thermal power

The supply capacity is estimated separately by subtracting the auxiliary power and suspended power due to planned repair, etc., from the generation energy that is obtained by subtracting capacity due to air temperature impacts from facility capacity of each power plant.

[52] Water flow record of the most recent 30 years is used in general.

[53] Available power energy of normal water level is examined in general. However, when drought continues chronically, that of the dry time can be used as that of normal water level.

[54] Inflow volume and water level at the reservoir of the latest 30 years is used in general.



Source: JICA Study Team

Figure 6.3-28 Power Generation Capacity of Thermal Power Plant

c) Renewable energy

■ Solar power

Average of the lowest five days is calculated in reference to the evaluation estimation of hydropower generation from the generation results (3 days x certain number of years) at the occurrence of the maximum three-day generation in a certain period in the past[55] and then average private consumption of the latest five years is subtracted from it.

■ Wind power

It is the same estimation method as solar power generation.

d) Interchange based on a relative contract

✓ Common issues

- When power is procured from generator of another company, the one with an existing receiving contract is calculated.
- In the case of supplying power from its own generator to another company, the one with an existing receiving contract is posted in negative figures.
- The calculation for an existing receiving contract serves as the base. However, the supply capacity after the expiration of the contract in a long-term plan is handled as below.

① It is calculated by deeming that the supply capacity under the same supply condition as that of an existing receiving contract can be secured with regard to the below.

i) The existing receiving contract is equipped with an automatic extension clause or can be deemed to have the clause.

ii) There are capital ties, etc., with the other party and it can be understood that the power can be supplied preferentially even after the termination of the contract.

② When power procurement is planned to continue under the same condition as that of a receiving contract after its expiration and it is highly probable that the receiving contract of the plan is concluded, items limited to the below can be calculated. However, the total energy of planned

[55] A period of 10 to 20 years is reasonable. However, it can be within an available period when the past power generation information for a sufficient period is unavailable.

supply capacity should be identifiable separately.

i) The existing receiving contract, etc., has preferred negotiating right.

e) SAPP market, permanent backup and receiving of off-grid surplus power

Procurement from SAPP market, permanent backup and receiving of off-grid surplus power among power receiving from and transmitting to other companies is calculated as below.

(a) Procurement from SAPP market

i) Already agreed portion under a spot contract is calculated as receiving power.

ii) Already agreed portion under a spot contract is posted in negative figures as transmitting power. Planned transmitting power including spot contracts is posted in negative figures and the total should be identifiable.

(b) Permanent backup

i) The maximum receiving power at the occurrence of maximum demand power within an existing contract period is calculated as the receiving power.

ii) The maximum transmitting power at the occurrence of maximum demand within an existing contract period as for the transmitting power and the power planned to be transmitted after its expiration are posted in negative figures. The total should be identifiable.

(c) Receiving of off-grid surplus power

i) Supply capacity with the receiving of off-grid surplus power is calculated only when its stability can be expected based on an existing receiving contract.

➢ Power of commissioning prior to operation start

The supply capacity of commissioning prior to operation start is calculated against the short-term demand plan only when stable supply can be expected in reference to the commissioning plan and past operation

(2) Supply electric energy (kWh)

◆ Estimation methods

a) Hydropower

Electric energy of overflow and auxiliary consumption is subtracted from the total available power energy in normal years of each power plant.

Accumulated average of a certain period in most recent years[56] is used as the available power energy in normal years of natural flow power plants.

The available power energy[57] of reservoir-type or regulating-reservoir-type power plants is calculated from a long-term[58] inflow volume and reservoir utilization plan.

b) Thermal power

Internally consumed power energy is subtracted from the available power energy of each power plant.

[56] Water flow record of the most recent 30 years is used in general.

[57] Available power energy of normal water level is examined in general. However, when drought continues chronically, that of the dry time can be used as that of normal water level.

[58] Inflow volume and water level at the reservoir of the latest 30 years is used in general.

c) Renewable energy

It is calculated in consideration of power receiving results for a certain period in the past[59].

d) Interchange based on a relative contract

It is calculated under the condition in d) of interchange based on a relative contract in (1) supply capacity above.

e) SAPP market, permanent backup, and receiving of off-grid surplus power

Above d): Interchanged (based on a relative contract

(a) Procurement from SAPP market

i) Already agreed portion under a spot contract is calculated for receiving power.

ii) Already agreed portion under a spot contract is posted in negative figures for transmitting power. Planned transmitting power including spot contracts is posted in negative figures and the total should be identifiable.

(b) Permanent backup

i) The receiving power within an existing contract period is calculated as the receiving power.

ii) The sending power within an existing contract period as the sending power and the power planned to be transmitted after its expiration are posted in negative figures. The total should be identifiable.

(c) Receiving of off-grid surplus power

i) Electric energy of receiving of off-grid surplus power is calculated in accordance with the real situation based on an existing receiving contract.

- Electric energy of trial operation business operation

The electric energy of commissioning prior to business operation is calculated based on the commissioning plan and past operation.

(d) Supply capacity and adjusting power

As described above, supply capacity and adjusting power are defined in relation to the power source to make the supply and demand plan obtained from the calculation of generation power and power energy relevant to the operating power demand estimates close to more realistic operation. The definition contains critical meanings in the supply and demand operation.

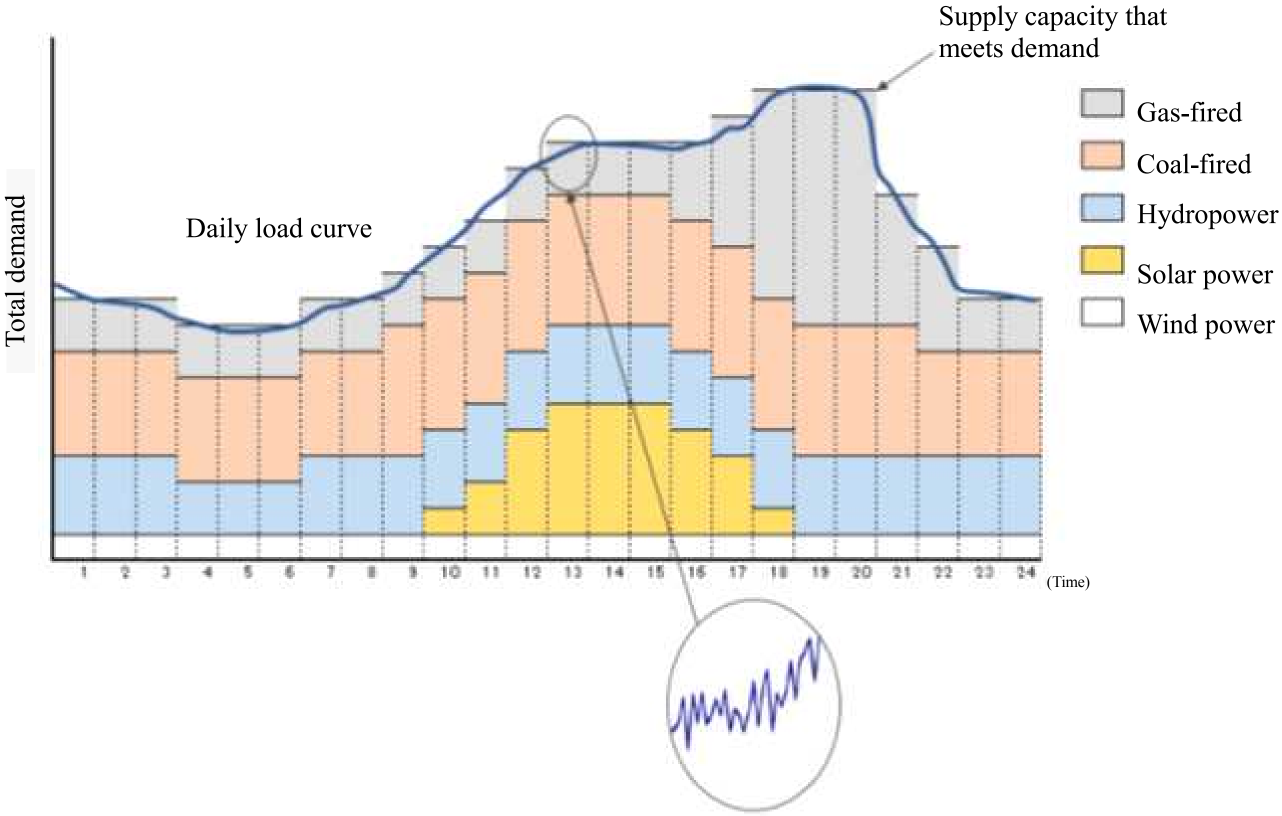
The supply capacity is the generation capacity (MW) that contributes to power supply in relevant areas in the available power generators and procurable interchange on the day. For example, it is expressed as: 300MW of thermal power generation capacity, 300MW of interchange that can be procured, and 400MW of hydropower generation capacity[60] in a day total supply capacity of 1,000MW. When the estimated peak demand of the day is 800MW, the reserve margin is 200MW.

The adjusting power refers to power source capacity that can contribute to supply and demand balance control and frequency control. As shown in Figure 6.3-29, the daily load curve fluctuates all the time. The output control to flexibly follow the fluctuations is regarded as the adjusting power. Hydropower and gas-fired thermal power

59 A period of 10 to 20 years is reasonable. However, it can be within an available period when the past power generation information for a sufficient period is unavailable.

60 It is available power capacity calculated from the water level of the reservoir herein.

generation as power sources with fast output fluctuations (Ramp) are applicable as adjusting power. Figure 6.3-29 introduces a case of estimation of solar and wind power generation as fluctuating power sources, coal-fired thermal power generation as a fixed power source, and gas-fired thermal power generation and hydropower generation as supply capacity as adjusting power. Although the composition of power sources is decided in consideration of the merit order in actual supply and demand planning[61], it may not be necessarily in accordance with the merit order as an output structure of power generators because of problems related to the system structure (excessive load of transmission line, etc.).



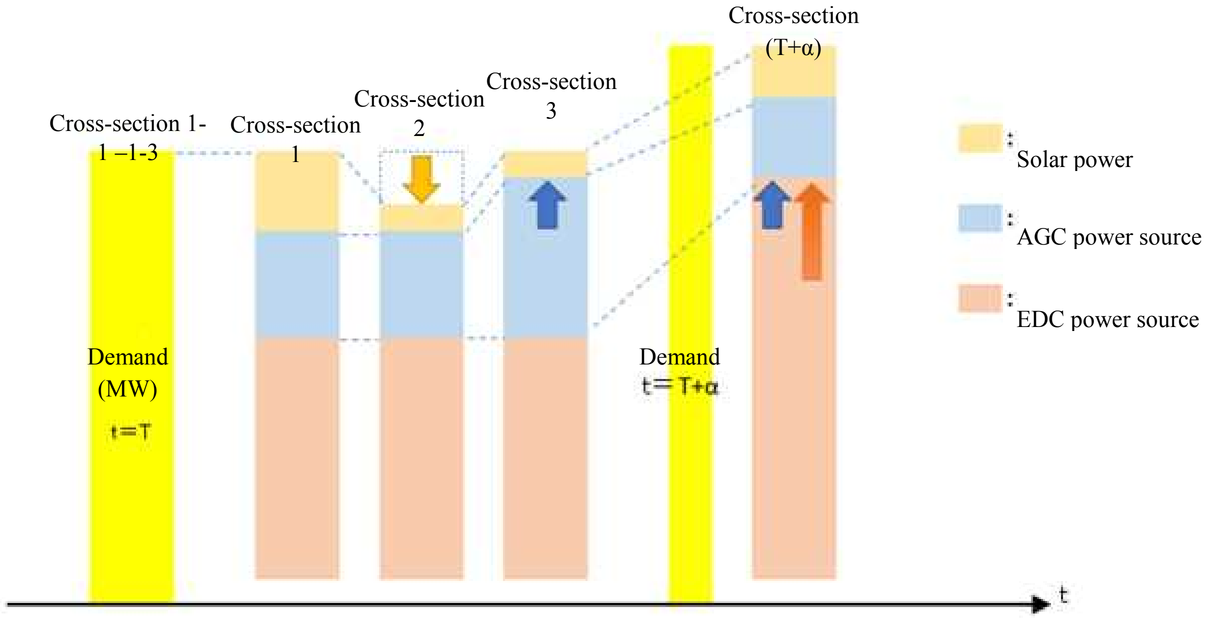
Source: JICA Study Team

Figure 6.3-29 Daily Load Demand Estimates and Supply Capacity Calculation

In addition, SAPP Operating Guideline requires designation of generators subject to automatic generation control (AGC). Generators subject to AGC are those that flexibly change the output to stabilize frequency fluctuations in load frequency control that is a mechanism of controlling supply and demand balance in the area. It is a type of adjusting power. Figure 6.3-29 shows that there are very small fluctuations when power demand in a short period is seen. The mechanism of adjusting the output to respond to the fluctuation is called governor free and the generators subject to AGC secures it.

Based on the above preposition, roles of each power source is confirmed in the case study of fluctuations of generator output to power demand shown in Figure 6.3-30.

[61] Economic output distribution of thermal and hydropower generators with different efficiency is calculated in accordance with the fluctuations of power demand as economic dispatching control (EDC) and the output is controlled.



Cross-section 1-1:	demand and generation balanced, generation shared by EDC and AGC power sources and solar power generation
Cross-section 1-2:	quick decrease of solar power generation (loss of supply and demand balance in the area) -> increase of current in international interconnection line
Cross-section 1-3:	AGC operated to bring back supply and demand balance to normal. Recovery of supply and demand balance in the area
Cross-section n:	output increase of AGC is switched to EDC output and demand increase portion secured by EDC to meet demand increase

Source: JICA Study Team

Figure 6.3-30 Fluctuations of generator output to power demand

Supply and demand are assumed to be balanced with the output of each generator as in the cross-section 1 at a certain time T. When a solar power generator that is a fluctuating power source decreases the output significantly in the next moment, the supply and demand in the supply area loses the balance and frequency falls. The current of the international interconnection tries to draw toward inside the area temporarily (Cross-section 2).

However, the generator subject to AGC that is adjusting power promptly increases output to balance supply and demand (Cross-section 3) At T+α after the lapse of a short time from T, output temporarily replaced by AGC at EDC is switched to economical generator output distribution.

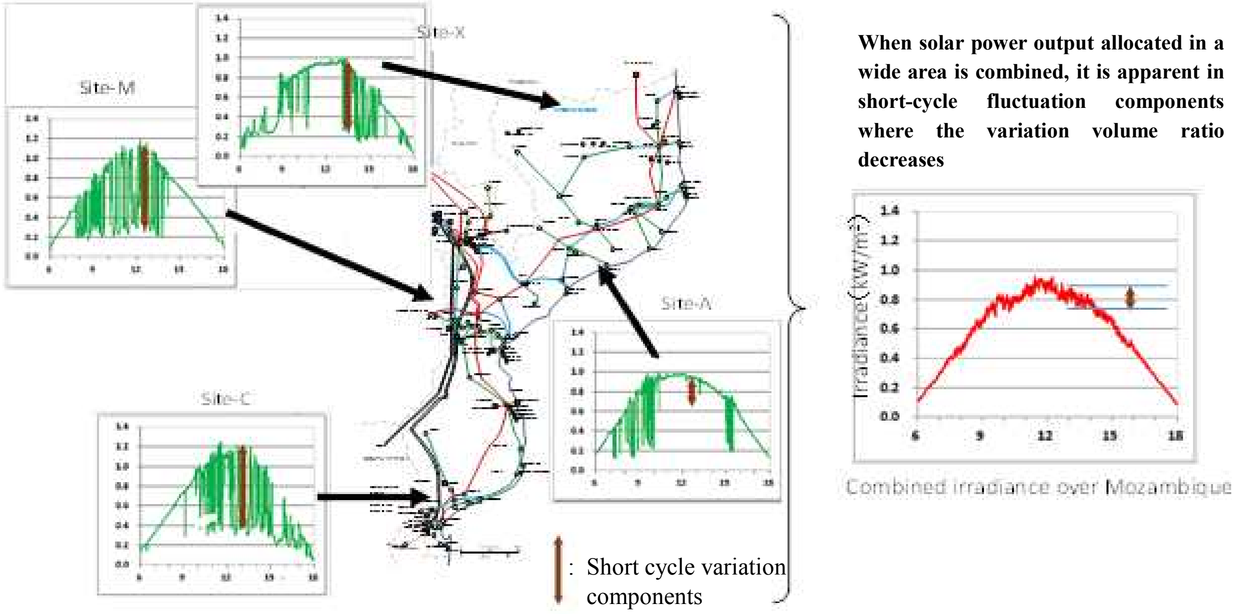
This mechanism is supply and demand operation.

(e) Study of adjusting power to cope with mass introduction of renewable energy

The supply and demand operation with solar power generation that is a fluctuating power source is introduced above. Mass introduction of such a power source makes supply and demand operation difficult and it is important to estimate the fluctuation accurately and secure sufficient adjusting power.

General information on solar power generation related to supply and demand control is decried herein. The fluctuating output of solar power generation can be explained by dividing it into short-term and long-term fluctuations. The short-term fluctuation is the output fluctuations caused by short-term fluctuations of the amount of solar radiation due to movement of thin clouds. It is the same fluctuations as those in Figure 6.3-31 and is the area that responds in governor free. However, as solar power generation spreads extensively geographically, the output fluctuations in the short period is leveled when the output by all solar power generation is superimposed[62]. Thus, the adjusting power to respond to the short-term fluctuations of solar power generation needs to be decided after examination of total solar power generation capacity and distribution of such power generation and confirmation of leveling effects.

Leveling effects of wide-area RE dispersed allocation – easing impacts of short cycle fluctuation



Source: JICA Study Team

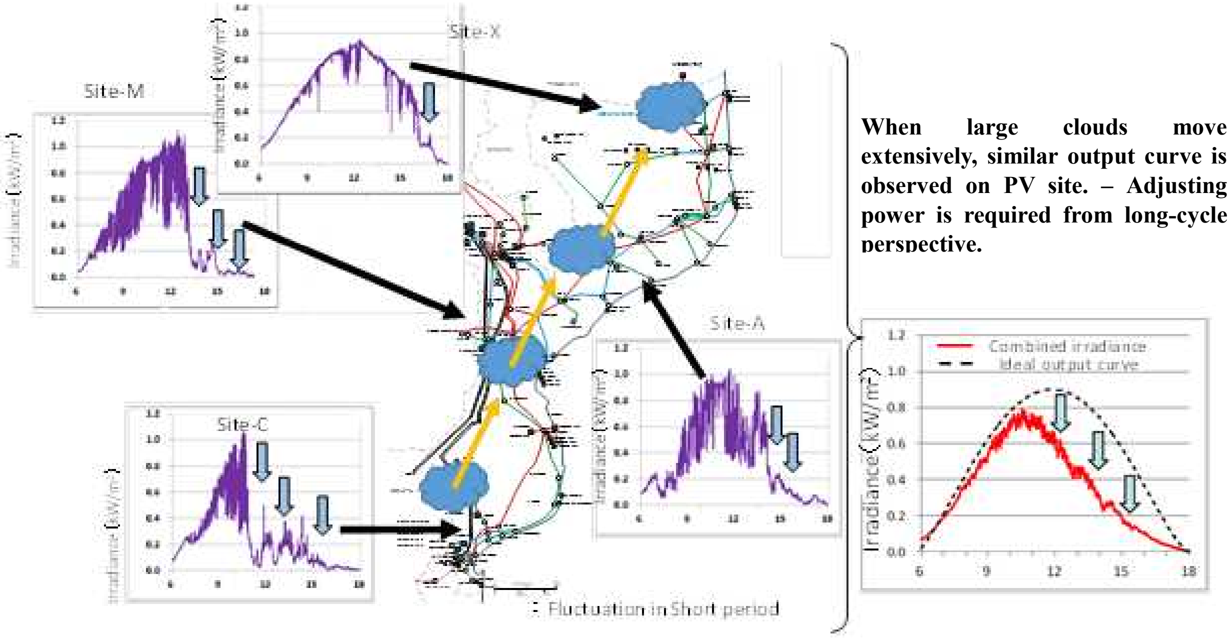
Figure 6.3-31 Response to Short-Term Fluctuations of Renewable Energy

The long-term fluctuations of solar power generation refer to the event where output fall due to blocked solar radiation by clouds occurs in turn at each solar power station and the total generation output significantly differs from ideal output curve when large-scale clouds move across Mozambique.

It is important to analyze meteorological information accurately to forecast the output of solar power generation with a certain level of accuracy in recent supply and demand operation and the result determines to what degree the adjusting power needs to be developed or procured.

62 A certain degree of leveling effects is demonstrated.

Effects of wide-area RE dispersed allocation on long-cycle fluctuation



Source: JICA Study Team

Figure 6.3-32 Response to Long-Term Fluctuations of Renewable Energy

(f) Reserve from perspective of wide area system

SAPP in which EDM participates defines the calculation method of operating reserve to be satisfied as wide-area system operation. It is not in the area of annual planning but it is an idea of reserve in the phase of actual operation.

Supply and demand planning or supply and demand operation of the day requires assurance of the reserve margin SAPP designated in addition to the above method.

[Operating reserve]

Operating reserve refers to unused supply capacity exceeding the peak demand in preparation for decline of supply capacity due to frequency fluctuation control, short-term demand forecast error and unexpected suspension of operation of power generators. The operating reserve is obtained by the additional value of spinning reserve[63] and quick reserve[64]. The operating reserve is incorporated in the supply and demand balance within 10 minutes.

The minimum necessary operating reserve (SORR) of the target system is obtained in the below formula.

$$\mathrm{SORR} = \mathrm{PORR} \times \frac{\left(\frac{2Ds}{Dt} + \frac{Us}{Ut}\right)}{3}$$

SORR = minimum necessary operating reserve in target system (MW)

PORR = necessary total operating reserve in power pool (MW)

Ds = examined annual peak demand in target system in power pool (MW)

63 Spinning reserve is surplus capacity power generator in operation. Spinning reserve shall mean the unused capacity which is synchronized to the system and is readily available to assume load without manual intervention.

64 Quick reserve shall mean the readily available from non-spinning reserve which can be started and loaded within ten (10) minutes or load that can be interrupted within ten (10) minutes.

Dt = total of Ds in target system in power pool (MW)

Us = maximum single unit capacity of power generator in target system in power pool (MW)

Ut = total of Us in target system in power pool (MW)

Table 6.3-13 shows the operating power of SAPP member countries in 2013.

Table 6.3-13 Operating Reserve in SAPP Member Countries (as of 2013)

SAPP OPERATING RESERVES FOR 2013					
Utility Name	Largest Generator [MW]	Maximum Demand [MW]	Spinning Reserve [MW] e	Quick Reserve [MW] f	Operating Reserve [MW] g = e + f
ESKOM	930	35896	518.2	518.2	1036.5
ZESA	220	2029	52.3	52.3	104.5
ZESCO	180	1611	42.2	42.2	84.5
BPC	150	578	26.9	26.9	53.8
EdM	38	629	12.1	12.1	24.1
NAMPOWER	80	611	17.6	17.6	35.3
SNEL	62	1048	19.9	19.9	39.8
LEC	24	129	4.7	4.7	9.4
SEC	10	204	3.6	3.6	7.2
TOTAL	1694	42735	698	698	1395

Source: SAPP operating guidelines Revision1.0 (2013), SAPP

(g) Concerns over power source development plan from the perspective of assurance of adjusting power

As described above, the key to supply and demand control to in what degree the adjusting power can be secured in operation. Power sources of fast output fluctuations are hydropower and gas-fired thermal power generation. Most of power source development in the master plan is led by the private sector. However, conclusion of a wholesale supply agreement as the adjusting power with a private business, or IPP, puts stress on power generators by changing the output frequently and it also results in prevention of stable wholesale power supply and leads to high wholesale supply prices.

Thus, EDM that is TSO needs to develop and possess a certain level of adjusting power and operate the system stably and development of the structure may help promote power source development by the private sector.

(C) Development of SCADA/EMS based on business process of system operation direction

(a) Definition of SCADA/EMS

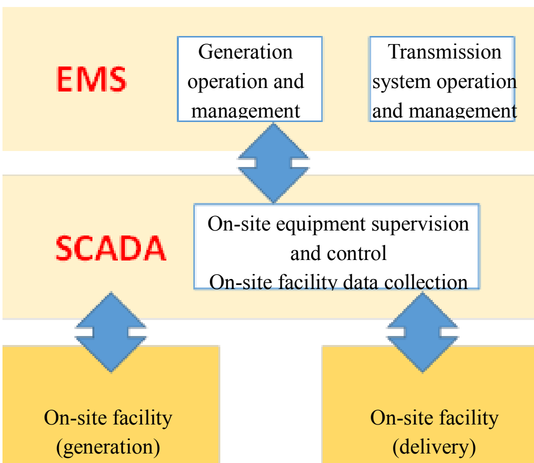
Examination of possibility of introduction of abovementioned on-site control system and details of supply and demand control business contributes to provision of the business process of the system operation direction. The most important thing in the replacement of currently working NCC and establishment of new SCADA/EMS is clarification of functions it is required to be equipped with after clarification of business relations with other divisions in EDM with the system operation direction in its center[65].

The definition of EMS and SCADA is confirmed once again.

Table 6.3-14 Definition of Computer System related to System Operation

System	Role of the System
Energy Management System (EMS)	・Supervision of power demand estimates and power generation volume and control of output to economically maintain the balance of demand (W,Wh) and output of power plants *Management of delivery facility for efficient power distribution through power system
Supervisory control and data acquisition system (SCADA)	・Supervision and control of power plants, substations, transmission lines and finding out failures ・Data collection of power facilities
Distribution supervisory control and data acquisition system (D-SCADA)	・Supervision and control of power distribution facilities ・ Data collection of power distribution facilities ・Management of tracking of recovery from failures and recovery staff

Source: JICA Study Team



Source: JICA Study Team

Figure 6.3-33 SCADA/EMS Relationship

65 Although the EDF Report lists the outlined functions SCADA/EMS are required to be equipped with, it does not reveal specific business process of how to use SCADA/EMS. Initially, EDM as a business process is expected to be reported, and effective system cannot be developed if it has no specifications of SCADA/EMS (for example, to whom it must be reported within the company).

(b) Business process analysis method

Description of business process not only enables confirmation of consistency of business but reveals the waste of business and needs for business link with other divisions. Its accumulation also leads to clarification of business rules. In other words, clarification of the process helps rational formulation of operation rules.

Business process is most effectively clarified when the business process modeling notation[66] is used.

(c) Functions backup control stations should be equipped with in EDF Report

The EDF Report contains some unclear discussions. Although regional control centers (RCC) that supervise central, northcentral and northern systems have the purpose of realizing backup of NCC that supervises the southern system and is equipped with energy management system, their function is not designed upon clarification of definition of backup. It is the discussion of whole system operation structure in RCC backup operation when NCC loses its functions and network structure to be used may change depending on the preposition of function loss of NCC.

SAPP Operating Guideline requires establishment of control centers separately from the main control center so that the system operation can be maintained continuously even when the main one loses its functions and also requires connection with control centers in the control area of its own and those in neighboring countries (regions). It also requires realization of business continuity plan (BCP) in utility business sector which much serves the public by continuity of power supply by constructing backup facilities. However, the scale of backup functions and specification of relevant infrastructure to realize them need to be decided upon examination of specific operation to which EDM is applied ad facility balance.

Specific items to be examined and part of evaluation are provided in the below table. It provides NCC risk analysis and RCC risk also needs to be analyzed similarly. Risk analysis is evaluation of where the failure occurred, whether it is fatal, and whether any alternative means is available to overcome obstacles and embodies requirements.

Currently, all EDM substations and power plants are manned and on-site facility operation can be performed to a certain degree in contingencies that include loss of functions of NCC that conducts remote supervision. Thus, risk analysis is conducted on a trial bases based on the preposition that it is sufficient enough if a structure where direct operation at power stations and supply command to on-site backup operation is realized as the last resort. Functions SCADA/EMS should be equipped with need to be carefully selected after the examination.

[66] The business process analysis method of IBM, Lean Sigma, also uses the approach.

Table 6.3-15 BCP risk Factors and Response (partial)

Event	Main Affected Place	Factor	Risk Level	Response	Matters to be Examined that Affects Response
Loss of function	NCC	Loss of power source (line)	Minor	· Power line recovery · Local B.U. operation + command station setup until recovery	Pluralization of power source supply route to NCC
		Building fire	Major	(Supply only B.U.) · Supply B.U. operation at RCC · Local B.U. operation at southern substation	—
				(All supply and control B.U.) · All-function B.U. operation at RCC	—
		Inundation	Major	(Supply only B.U.) · Supply B.U. operation at RCC · Local B.U. operation at southern substation	—
				(All supply and control B.U.) · All-function B.U. operation at RCC	—
Discontinuation of communication	NCC	Transmission route break (NCC connection)		(Supply only B.U.) · Supply B.U. operation at RCC · Local B.U. operation at southern substation	Pluralization of incoming route of communication line to NCC
				(All supply and control B.U.) · All-function B.U. operation at RCC	Pluralization of incoming route of communication line to NCC
		Transmission route break (NCC transmission route)	Minor	· Local B.U. operation at disconnected power station	Pluralization of communication network to NCC

Source: JICA Study Team

(d) Shift team formulation of National Control Center and Regional Control Center

EDM, aiming introduction of renewed National Control Centre and Regional Control Centre for robust system control platform needs to study the formation of control shift ream and its duties, as the work baseline of system operation.

- Eskom's case

  Eskom has the best-organized her National Control Centre in SAPP states, where EDM belongs to.

Source : Eskom Websie (2017)

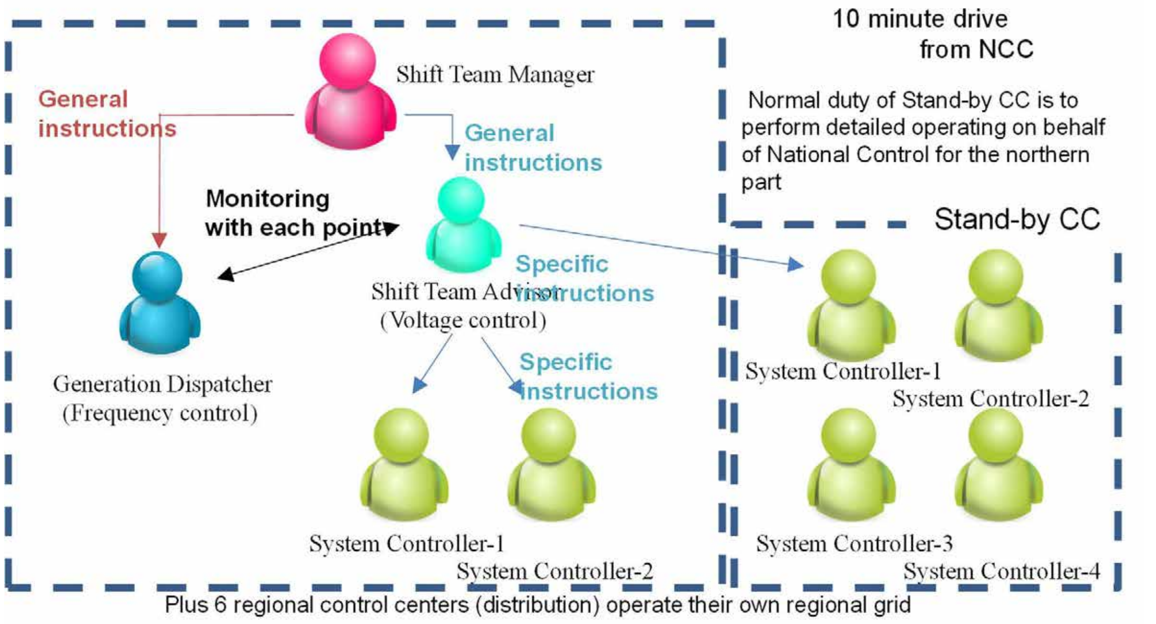
Figure 6.3-34 Eskom NCC

There are five crews[67] per one team in Eskom National Control. The shift is organized by its shift team manager. And a generation dispatcher, three system controller (one shift team advisor and two controllers) are assigned under the governance of the manager. Eskom has the stand-by control centre which locates ten-minute drive from her national control centre to be ready for the business continuity of system operation. Stand-by control centre has the compatible computer system with her national control centre and usually dives. Further, additional four crews are in stand-by control centre to operate northern system under the governance of shift team manager in NCC.

Thus, nine crews[68] in total operate not only South African grid but surrounding states, including Botswana, Namibia and southern Mozambique.

[67] Eskom has the plan to add one more crew, thus six crews in total to deal with current works.

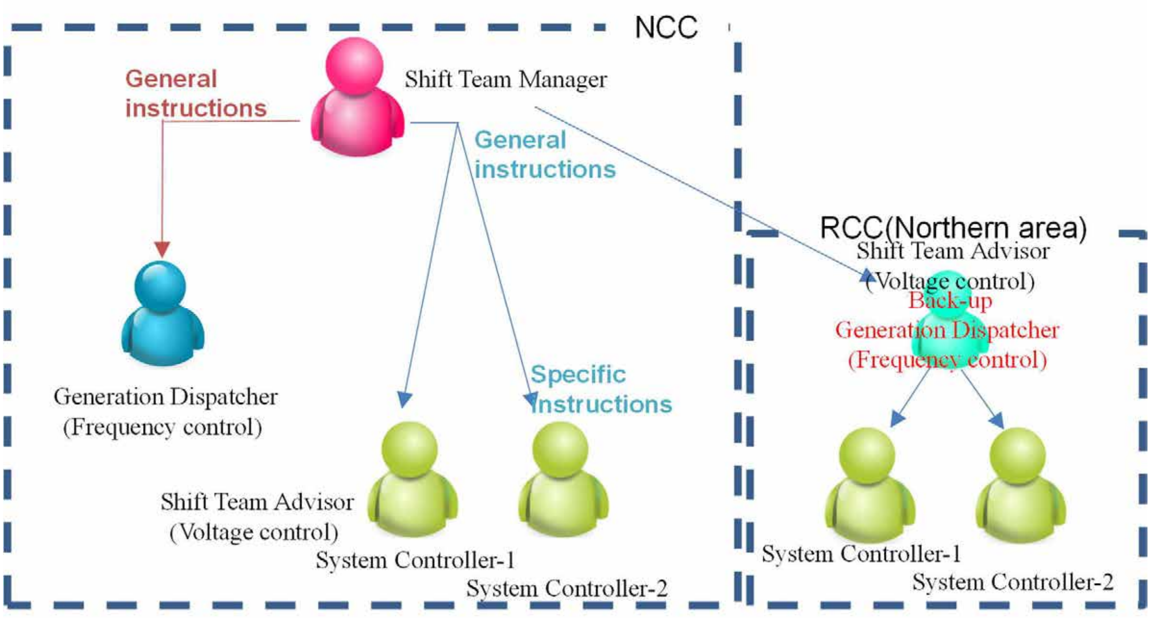
[68] Except shift team operators, supportive staff should be arranged.



Source : Study team made from interview with Eskom

Figure 6.3-35 Eskom's NCC shift team formation

Based on the aforementioned condition, EDM's shift team formation would be proposed as the following figure.



Source : JICA Study Team

Figure 6.3-36 Proposal for EDM's shift team formation

As well as Eskom's shift team formation, EDM's NCC has a shift team manager and two system controllers for managing trunk system and southern system in Mozambique. Further, one generation dispatcher under the governance of shift team manager, should be assigned to manage dispatching.

RCC has three crews in total, such as a shift team advisor and two crews as the system controller in charge of managing central system and northwards. On the point of BCP, functions of computer system (SCADA/EMS and supportive tools) in RCC and those of NCC are identical configuration[69].

EDM has the primitive condition that all substations has the site operator(s). This primitive condition is massive supportive to realize the function of BCP. In case of SCADA/EMS function loss in NCC or that in RCC, each of them can deal with supervision the system and request the instruction to control the site equipment(s) to relevant site operator(s) under the condition on which all site data such as supervisions of status of electric facilities and telemetering would be liked with NCC as well as RCC transparently.

Base on this platform, EDM should be considered following issues to create the better BCP measure.

Table 6.3-16 BCP measures for EDM's NCC / RCC

Issues	Response
Securing spare system operator at one control centre in case of function loss in the other control centre	Securing off-duty shift team(s) and capacity building to deal with system control nationwide.
Business continuity of dispatching work at RCC in case of its function loss at NCC	Appointment of dispatching work to Shift team advisor at RCC, and its capacity building

Source : JICA Study Team

EDM's NCC and RCC are planning to establish in southern area and central area respectively. In this case, it is difficult that system operators in NCC transfer to RCC so as to operate their own territory by themselves as quick as possible and vice versa.

In order to tackle this condition, system operators in each control centre should have the knowledge of the other system mutually.

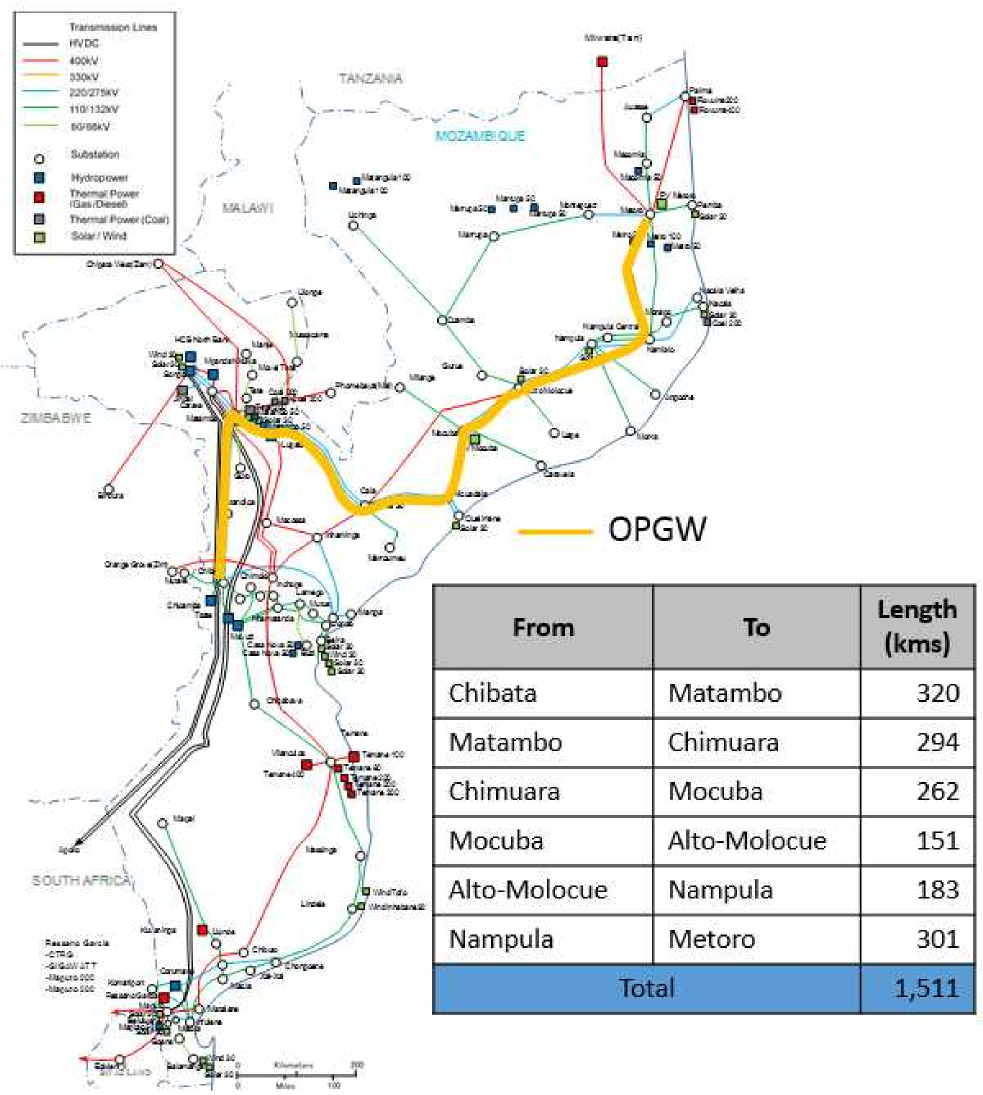
Further, dispatching work is by the dispatcher in NCC only. To prepare the function loss in NCC, person in RCC should deal with this duty in critical situation. Therefore, it is recommended that shift team advisor in RCC should have the responsible for this duty.

Based on this concept, EDM would study the comprehensive structure of system operation, including SCADA/EMS design and role and duty of system operator and support staff.

(D) Communication network construction in consideration of all EDM businesses

The EDF report proposes installation of communication network across Mozambique to link information to remote control points of RCCs while examining the establishment of central and regional control centers in line with power system expansion. It proposes the construction of such network using the optical ground wires (OPGWs) that serve as the backbone particularly in line with future power system expansion in the northern region (See Figure 6.3-37).

69 The same concept of the result of EDF report.



From	To	Length (kms)
Chibata	Matambo	320
Matambo	Chimuara	294
Chimuara	Mocuba	262
Mocuba	Alto-Molocue	151
Alto-Molocue	Nampula	183
Nampula	Metoro	301
Total		1,511

Source: Produced by Study Team based on National Control Center and Northern, Central-Northern, Central Regions Control Centers Project Feasibility Report-EDF (2013)

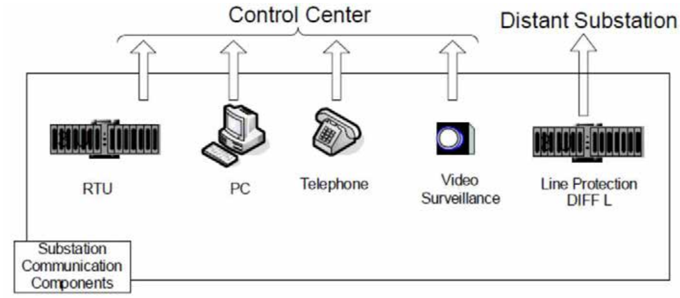
Figure 6.3-37 Communication Network Backbone Plan

The Study team also found out in the interview with EDM out that the positive introduction of OPGWs is studied to respond to future development of advanced information-oriented society and it plans to use OPGWs for existing transmission lines of 66kV or more.

However, two matters are not clarified in the report. One is that there is no comprehensive assessment of components that use the communication network and the other is that no proposal is made in relation to the concrete logical network structure with study of reliability of information transmission.

i) EDM business areas that use communication network

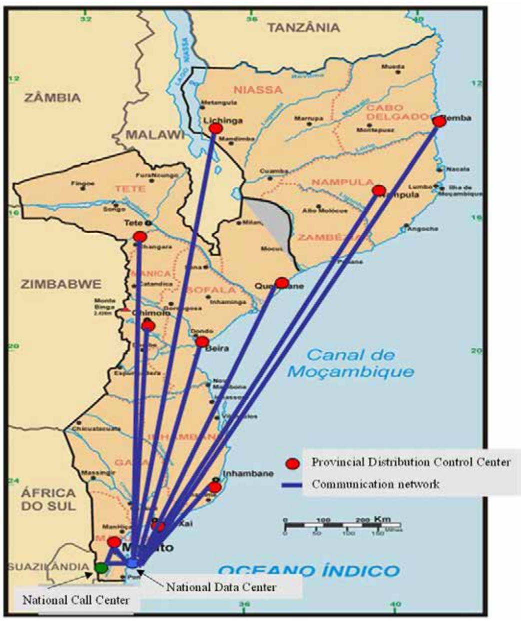
As for the first issue described above, the bandwidth of the communication network is assessed based on the volume of connected information on power stations, NCC and RCCs in the report (See Figure 6.3-38). However, the network is not constructed simply because of EDM needs for remote supervision and control but it is to be used for all of its businesses. Thus, relevant systems and components need to be studies comprehensively to decide the communication bandwidth.



Source: National Control Center and Northern, Central-Northern, Central Regions Control Centers Project Feasibility Report-EDF (2013)

Figure 6.3-38 Substation Communication Network Components

SIGEM is the system that is believed to most significantly affect bandwidth design of the network for other uses than remote supervision and control. As the SIGEM concept, distribution control centers (DCCs) is established to supervise and control the distribution system as shown in Figure 6.3-39 and connect each DCC with National Data Center[70] and call centers to find out the recovery from failures real time to improve the customer service. In addition, scalability of comprehensive control of power generation, transmission and distribution is also included. Information link on power charges collection management and customer management, which is a currently working SIGEM component, is realized partially by using general lines. When communication lines owned by the company are realized, it is desired that the information be linked using the private communication line.



Source: Procurement of the Supply, Installation & Training of an Integrated Business Management System (SIGEM) - WB (2011)

Figure 6.3-39 Connection between DCCs and National Data Center and Call Centers

70 National Data Center refers to the place where SIGEM computer system is installed.

The Study team studied the systems and components that should participate in the communication network EDM constructs in the future within the currently assumable scale. The result is shown in the below table. It covers what needs to participate in EDM's private network and alternative means are described so if any. It should be notes that the comprehensive transmission volume needs to be decided for the construction of communication network from the perspectives of the volume and frequency of communication network utilization related to other EDM businesses including SIGEM in addition to the information volume related to supervision and control for NCC and RCCs from each power station described in the EDF report.

Table 6.3-17 Systems and Components that Should Participate in EDM Communication Network

Type	Face	Use	Necessity	Notes
Communication between control centers (NCC)	NCC -- RCCs, HCB, utility of neighboring country (neighboring NCC)	Communication between control centers (ICCP)	✔✔✔	Normal-time operation
Communication between control centers (RCC)	RCC -- NCC, HCB, utility of neighboring country (neighboring NCC)	Communication between control centers (ICCP)	✔✔✔	Backup operation
Remote terminal unit (southern)	NCC -- substation	Supervision and control	✔✔✔	
Remote terminal unit (northern)	RCC -- substation	Supervision and control	✔✔✔	
Remote terminal unit (power plant)	Power plant -- NCC, RCC	Automatic feed	✔✔✔	
Surveillance camera	NCC – power station of southern system	Moving image supervision	✔	
Surveillance camera	RCC -- central, northcentral and northern electric stations	Moving image supervision	✔	
Feed phone	Electric station -- NCC, RCC	Feed command phone	✔✔	
Maintenance phone	Electric station -- NCC, RCC	Maintenance confirmation phone	✔	
Data connection	NCC -- SIGEM	Accumulation of system information	✔✔	
Data connection	RCC -- SIGEM	Accumulation of system information	✔✔	
Data connection	NIS -- SIGEM	Accumulation of site information	✔	
Data connection	ASC -- SIGEM	Customer information and charges collection	✔✔✔	Currently, ordinary communication line is used partially.
Data connection	DCC -- SIGEM	Information on distribution system	✔✔	Future
Data connection	SIGEM (connection with current ERP)	HR information, etc.	✔✔	Currently, ordinary communication line is used partially.

Note) There are more "✓" marks that indicate the necessity as the degree of necessity is higher.

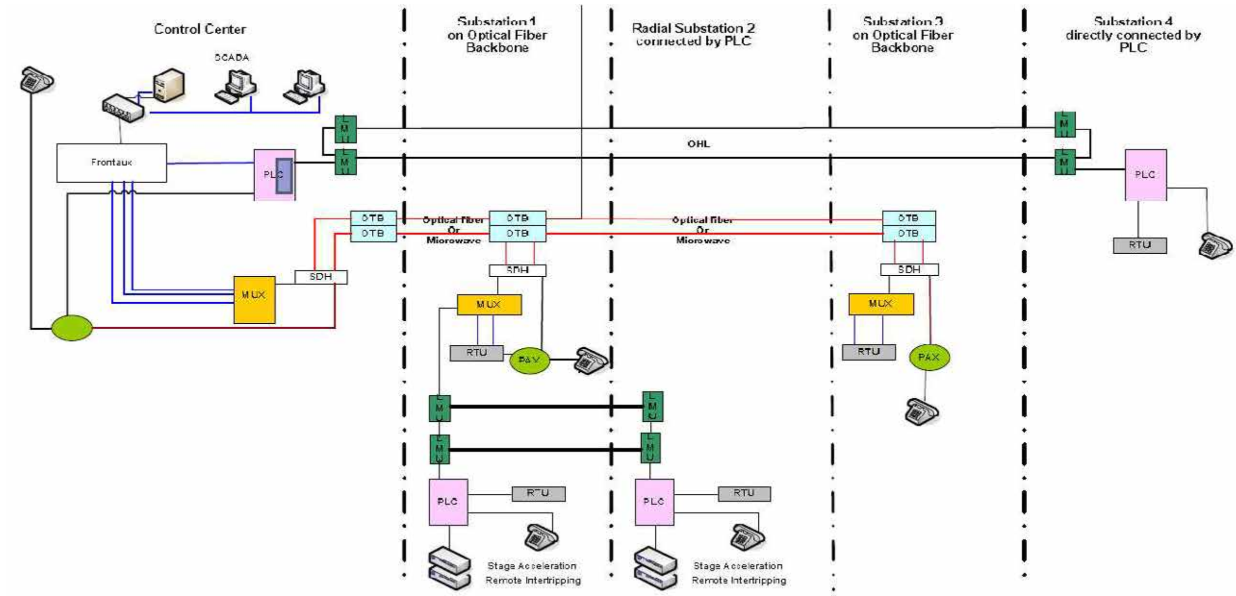
Source: JICA Study Team

ii) Targeted communication network structure

<IP network using optical communication device>

The second point described above is how reliability as communication network topology can be guaranteed when communication lines are disconnected in the communication route that connects such remote supervision and control points including NCC and RCCs with local power stations[71] as shown in the study of BCP described earlier.

Although the EDF report describes that what kinds of means of communication should be used for each component of communication network, the network topology participated in by NCC and RCCs is yet to be clarified (See Figure 6.3-40).

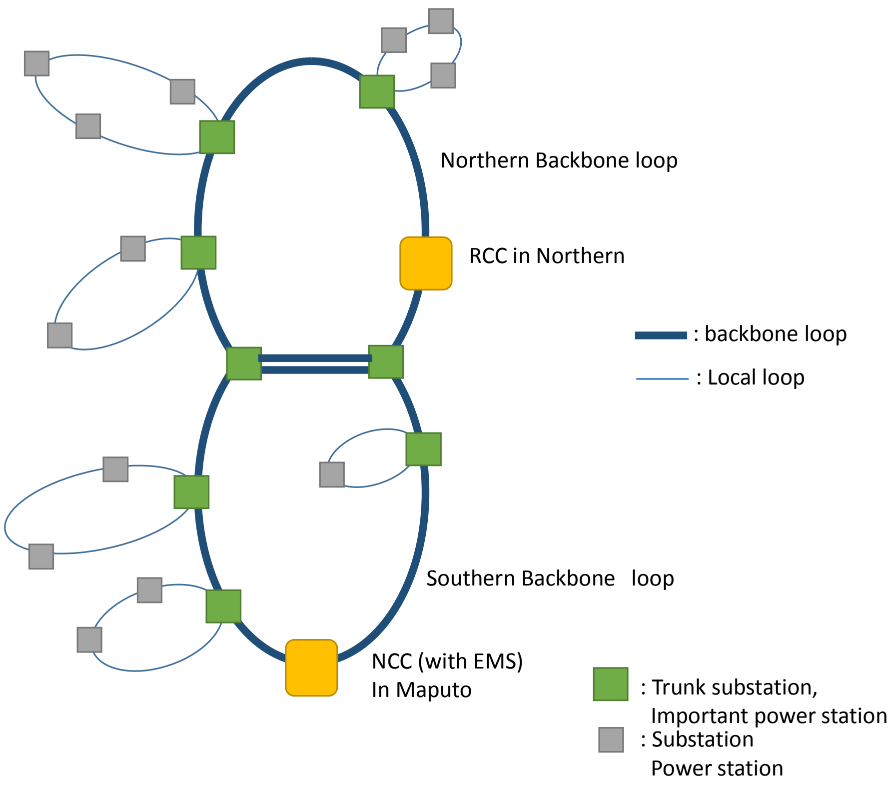


Source: National Control Center and Northern, Central-Northern, Central Regions Control Centers Project Feasibility Report-EDF (2013)

Figure 6.3-40 Design of Communication Network with NCC and RCCs by EDF

Figure 6.3-41 shows communication network topology applicable to future power facility enhancement and EDM business expansion with the network forming the backbone with OPGWs.

[71] Discontinuation of communication is an issue that should be studies also in normal reliability design not limited to BCP. It is a matter of the same level to be studies as the redundancy design of SCADA/EMS computer system described earlier.



Source: JICA Study Team

Figure 6.3-41 EDF Design of Communication Network with NCC and RCCs (final form)

The chart provides communication network topology EDM should aim at in the future. The current EDM network is an optic communication system with OPGWs in the southern region and mainly power-line carrier system with PLC in the northern region. However, construction of optical communication network with IP system is recommended in comprehensive consideration of below reasons[72] and current trend of communication technology.

- EDM has a policy of OPGW installation across Mozambique.
- It is financially efficient when compared with replacement with special-line system.
- Much IP-system optical communication applicable device has become general-purpose products and is less expensive than conventional ones.
- A large volume of information can be transmitted.
- Increase and point change of lines can be handled flexibly.

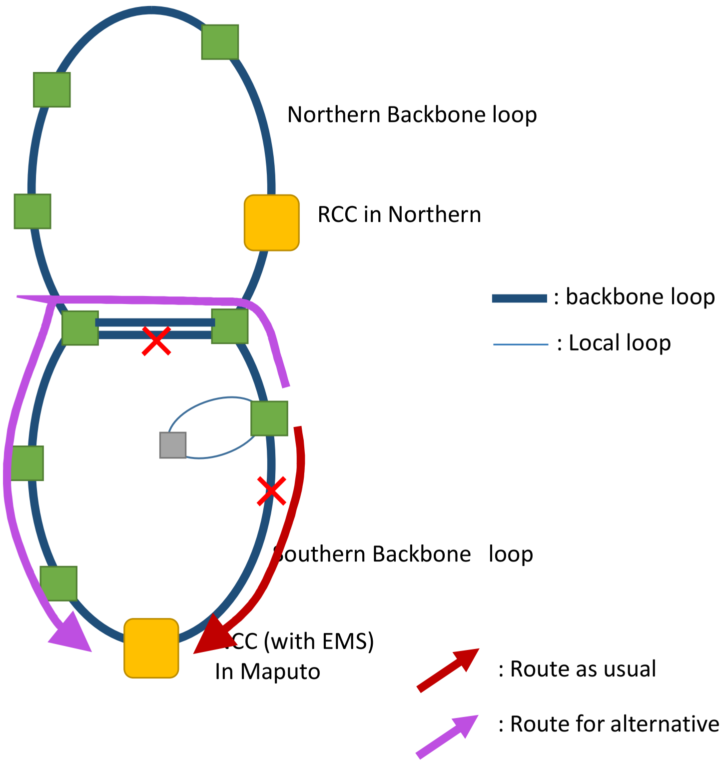
The network topology is explained below.

✓ The network in loop structure that uses OPGWs in principle. Having the loop structure, two transmission routes can be secured on a regular basis.

✓ As the information transmission coverage is relatively clearly divided--NCC and RCC supervising and controlling the southern system and central, northcentral and northern systems, respectively, the network is divided into two backbone loops—southern backbone that covers power stations of the

[72] Hybrid optical communication device is assumed to be used to construct the network. The hybrid device has a long-term operation guarantee of about 20 years and it is useful in relation to the network construction.

southern system and northern backbone loop that covers power stations of central, northcentral and northern systems. Both backbone loops are connected at the substation (relay station) in the central region. This structure enables to secure information transmission even in multiple failures of the network (See Figure 6.3-42).



Source: JICA Study Team

Figure 6.3-42 Securing of Information Transmission in Multiple Failures in Communication Network

✓ The network takes the two-layer structure of loop backbone and local loops. The network type of each loop is summarized in Table 6.3-18.

Table 6.3-18 Types of Optical Communication Network

Network Type	Use	Function	OSI Layer
Backbone loop	Used for network exchange[73] between NCC and RCCs and trunk substation and important power stations	WAN	Layer 3
Local loop	Used for network exchange between trunk substation and ordinary power stations and between ASC	WAN	Layer 3

Source: JICA Study Team

✓ The purpose is to provide simple communication infrastructure and it is not equipped with any special function (IDS, IPS, DNS, NTP, DHCP, etc.[74]).

✓ The connection between the network and participating systems and components is TCP/IP.

[73] Network exchange realized with L3 switch refers to the exchange of information between different networks using routing device that covers multiple networks.

[74] IDS (Intrusion Detection System), IPS (Intrusion Prevention System), DNS (Domain Name Server), NTP (Network Time Protocol), DHCP (Dynamic Host Configuration Protocol)

- ✓ The number of stations in one loop is up to 20 in consideration of reliability and time of accumulated transmission delay.

Routing information is designed as shown below as logical network structure in relation to the network topology.

- ✓ Open Shortest Path First (OSPF) ver.2 is used as routing information exchange protocol. This allows flexible response to topology changes and application of dynamic routing.

iii) Co-existence of PLC and IP network

The challenge related to in the promotion of the above optical communication with an IP system is the linkage with existing power stations where existing power line communication (PLC) is used. The northern system with mini-SCADA uses the PLC and the communication network specifications of mini-SCADA of trunk substations that are planned to be constructed soon from northcentral to northern systems are not clarified and use of PLC[75] is also a possibility.

Co-existence of IP optic communication and PLC needs to be examined related to the communication network of power stations where PLC lifecycle has not expired.

The co-existence structure in Figure 6.3-40 in the EDP report can be applied. Data connection with terminal power stations from NCC and RCCs can be mutually performed by converting the system to the terminal power station with PLC through the main station with IP system.

(E) Desirable HR development program

The HR development policy and specific development plan of the system operation direction was studied in consideration of the concern over current development programs revealed in the short-term challenges. A HR development management system is proposed with attention paid to the relationship with ERP under SIGEM. Details are described below.

i) Skills to be acquired

Skills the system operation direction should be equipped with need to contain the below perspective.

a. Skills necessary for system operators to perform businesses directly under laws and ordinances.
b. Skills necessary EDM to perform businesses directly due to responsibility to supply power as a utility, social responsibility and continuation of corporate continuation.
c. Skills necessary to perform businesses under EDM's internal rules

Specific skills to cope with the businesses classified below are listed in Table 6.3-19.

[75] The lifecycle of PLC component electronic device is likely to be approx. 10 years.

Table 6.3-19 Business Areas System Operation Direction should be Responsible for and Required Skills (Same as Table 6.3-9)

Business Area	Skill
Supply and demand planning and operation	Skills necessary for supply and demand operation in EDM control area and that in international interconnection
System operation	Skills necessary for feed command, operation control and power facility operation
Study of system technology	Skills necessary for system protection and analysis and power quality
Computer/software technology	Skills necessary for computer operation to operate SCADA/EMS
Communication technology	Skills necessary for communication network construction and operation

Source: JICA Study Team

ii) HR development to be offered as internal program (training by senior staff)

Although HR development programs prepared by the HR division are necessary, OJT (on-job training) is also actively provided on site and in the office[76].

Several employees in EDM rank grades 11 to 13 are trained to be key persons of education (trainers). The division manager appoints trainers from employees in grades 8 to 10 and they are responsible for training their junior employees properly in daily operation. For example, lectures[77] are provided for employees who are new to system operation to have them acquire a minimum level of knowledge on the operation and they train their junior staff.

The trainers also work to find out the level of skill acquisition of the junior employees in everyday operation, judge whether they should participate in training programs organized by the HR division periodically and make recommendations and suggestions to the division manager. The term of the trainer is limited and attention should be paid to enable employees in the division to be involved in the training for skills development equally.

It is recommended that trainers be allocated as in Table 6.3-20[78].

[76] The distribution division also plans OJT in the report of the Feasibility Study on Vocational Training in EDM.
[77] The contents of the lectures are basically selected from the lectures of HR development programs.
[78] Although trainers are allowed to have double duties in accordance with the workforce of the division, it is desired that they be allocated individually by field.

Table 6.3-20 Trainer Allocation (proposal)

Type	Main Responsibilities	Allocated Site
Trainer of supply and demand operation	・Teaching knowledge and skills related to supply and demand operation	1 trainer at NCC
Command and order trainer	・Teaching knowledge and skills related to feed command and operation control at NCC and RCCs	1 trainer each at NCC and RCC
Trainer of system skills	・Teaching knowledge and skills related to system protection and analysis and power quality	1 trainer each at NCC and RCC
Computer system trainer	・Teaching knowledge and skills related to NCC and RCCs ・Teaching measures in cases of computer system failures ・Teaching measures in cases of software failures	1 trainer each at NCC and RCC
Communication network trainer	・Teaching handling of network failures ・Teaching network design	1 trainer each at NCC and RCC

Source: JICA Study Team

iii) HE development organized by HR division (practical group training)

Needs for practical education to be provided as the system operation direction are listed in the below table. It is desired that they be handled in development programs provided by the HR division in group education programs.

Table 6.3-21 Needs for Practical Education related to System Operation Direction

Training by trainers (OJT)	・ Basic knowledge related to system operation for newly assigned employees ・ Basic use of SCADA/EMS ・ Response to failures in normal times and failure occurrences
Topics of practical education in training[79]	System operation: acquisition of basic knowledge ・ Confirmation of Grid Code ・ Confirmation of site facilities ・ Confirmation of basic functions of SCADA (recovery from single failure)
	System operation: acquisition of advanced knowledge ・ Behaviors of site distribution facilities and output to operators ・ Needs for failure report and reporting procedures ・ Reactive power (Q) control method
	Demand planning and operation: acquisition of basic knowledge ・ Definition of reserve and adjusting power ・ Power demand forecast ・ Supply capacity assessment
	Demand planning and operation: acquisition of advanced knowledge ・ Assessment of adjusting power ・ Economic operation method and assessment
	Acquisition of basic knowledge related to computer systems ・ Overview of OS ・ Learning of basic OS command (vmstat, etc.) ・ Hardware error log collection
	Acquisition of advanced knowledge related to computer systems ・ Learning of virtualization technology ・ Data design and maintenance ・ Confirmation of computer replacement procedures ・ Software management methods
	Acquisition of basic knowledge related to communication network ・ Overview of communication facilities (repeater, L2/L3 switch, firewall, etc.) ・ Acquisition of basic command to verify connectivity (ping, etc.)
	Acquisition of advanced knowledge related to communication network ・ IP address granting method ・ VPN setup method ・ Learning of command to verify connectivity (setting bandwidth restrictions, etc.) ・ Network security measures

[79] When the topics are included in existing development programs, they can be taken instead. Topics not covered in training are newly included in existing development programs or new programs are planned.

	Education for trainers ・ Mental preparation as trainers ・ Training

Source: JICA Study Team

As shown in the above, the internal development system within the system operation direction with EDM company-wide development programs are combined to enhance the education system. The below table is proposed responsibilities of HR and system operation divisions. The HR division should arrange the education system of each division including the system operation direction in EDM, identify knowledge and skills which employees should be equipped with across all divisions and plan knowledge development that also serves as communication of employees across divisions.

Table 6.3-22 Divisions in Charge of Education and Division of Responsibilities (proposal)

Division Responsible for Practical Education	Responsibilities
Human Resources & Corporative Services Administration	・ Overall management of division-specific education and education across divisions ・ Education budget management
System Operation direction	・ Planning, implementation and management of education of employees in the direction

Source: JICA Study Team

iv) Management of HR development

The system operation direction contacts the HR division to report the number and date of education of each skills area it conducted internally and manages the education results of each employee. It also manages the number and date of training trainers provided and statistically assesses and manages experiences and education of each staff[80].

v) Evaluation of HR development

The system operation direction needs to evaluate the level of learning of education provided internally and results of training provided by the HR division and reflect the results on the future education plan, etc., as needed. Specifically, it includes the progress of education and training, deepening and segmentation of contents of education.

The manager of the system operation direction finds out the development situation of his/her staff and instructs and advise them as needed[81].

Evaluation milestones that should be shared among the staff of the system operation direction as its HR development policy are proposed in Table 6.3-23. They are used not only as guidelines of individual evaluation of system operation staff but shared among them so all of them can encourage themselves to develop their skills independently and positively. The core business areas their division should perform as

[80] SIGEM possesses HR management system of EDM staff and the accumulation of the information contributes to making judgement of their career development.

[81] It can be commissioned to trainees when needed.

system operation staff are targeted to be all learned within around five years.

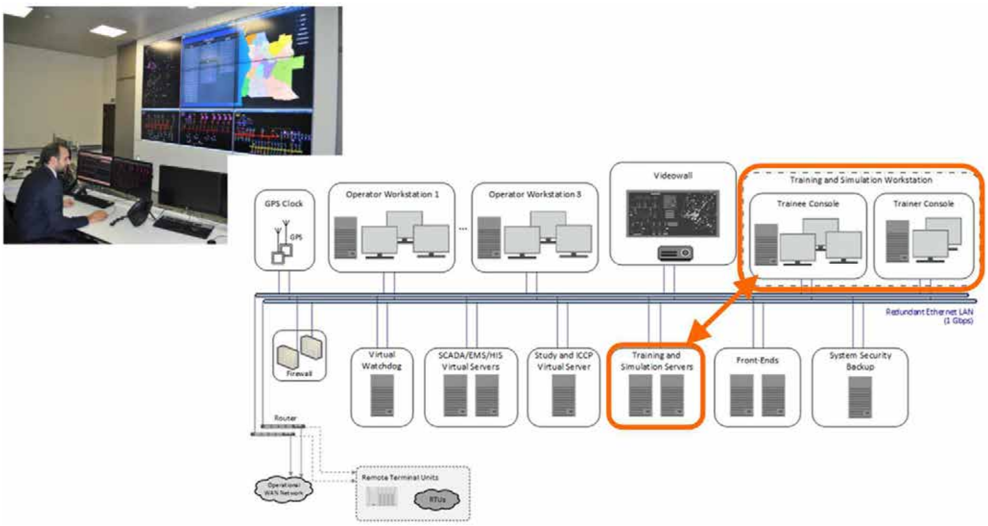
vi) HR development with simulators

The needs for SCADA/EMS for smooth system operation are described above. Although desk-top learning yields a certain level of results, exercise of recover from failures and supply and demand control using a simulator is desired to assure more efficient learning of system operation. However, the specifications simulators should have been not defined and thus detailed proposal is not made herein. The important elements which a simulator to be created should satisfy are listed below.

- It should be a simulator that focuses on exercise of recovery from failures that occur to the power system or exercise of output switching of power generators following failures (provision concerning details of system simulation)
- What should be the frequency of team training, individual training and other simulator training (provision on training scale)

As reference, components of the simulator of National Control Center established by Angora RTN is shown in Figure 6.3-43.

The simulator RTN realized is such that failure events are set and get started against past system information or system trainers freely set up so the trainees can practice recovery operation from failures. The simulation runs on the training simulation server and displays the simulated system condition on trainees' desk and promotes operation. These can be observed on trainees' desk.



Source: Prepared by JICA Study Team based on efacec materials

Figure 6.3-43 SCADA/EMS and Simulator of Angora RTN

Trainees are expected to skilled trainees and the time for simulator training and the time for trainees to create exercise events in a year need to be adjusted for efficient operation of the simulator. Staff to perform it need to be secured and developed. Participation in the training and the results of staff who have taken the simulator training also need to be included in the HR development management and evaluation described earlier.

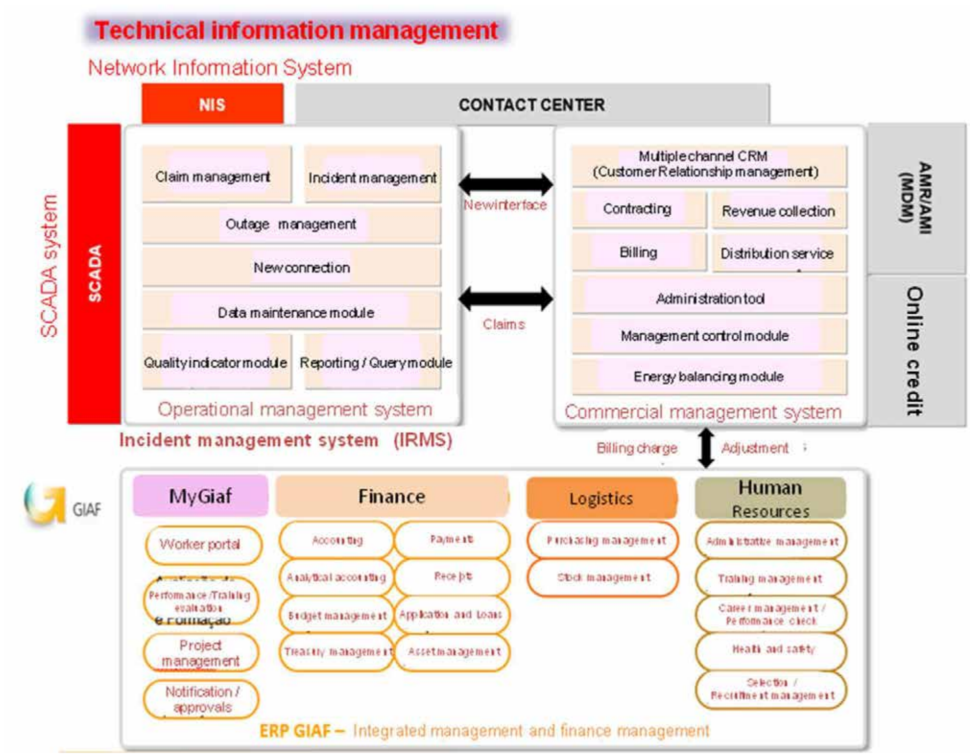
Table 6.3-23 Evaluation Milestones for Acquisition of Skills System Operation Staff should be Equipped with (proposal)

Years of Training			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10 and later
Supply and demand planning and operation	Long-term plan	Understanding of basics of demand forecast	■	■	■							
		Understanding of basics of supply capacity and adjusting power	■	■	■							
		Understanding of basics of stability		■	■							
		Capable of formulating demand plans.		■	■							
	Short-term plan	Capable of counting system facility work.			■							
		Capable of formulating monthly and weekly supply and demand plans in consideration of system facility work from a long-term plan.				■	■					
	Operation	Capable of supply and demand control based on a short-term plan.				■	■					
		Understanding of basics of stability					■	■				
		Capable of supply and demand control in consideration of stability and economic efficiency.					■	■	■	■	■	■
		Capable of educating and training transferred employees.						■	■	■	■	■
System operation	Basic knowledge	Understanding of basics of system operation based on Grid Code	■									
		Understanding of basics of system protection	■									
		Understanding of basics of power facilities (power generation, distribution and phase modification facilities)	■									
		Capable of basic operation using SCADA.	■									
		Understanding of basics of voltage operation and management		■								
		Understanding of basics of stability		■	■							
	Capacity in normal times	Capable of command operation.	■									
		Capable of operation of system protection unit and voltage.	■									
		Capable of supervision and operation of power systems.	■									
		Capable of record inspection and correction.	■									
	Capacity to respond to abnormalities	Capable of promptly finding out and reporting failures.	■									
		Capable of understanding the system in cases of failure and formulating recovery policy.		■								
		Capable of reporting failures and recovery.			■	■						
		Capable of educating and training transferred employees.						■	■	■	■	■
Computer system		Capable of basic operation of SCADA/EMS software and initial response to failures.	■	■								
		Capable of basic operation of computers and initial response to failures.	■	■	■							
		Capable of managing computer system with advanced knowledge including switching of computers and software backup.				■	■	■	■	■	■	■
		Capable of educating and training transferred employees.						■	■	■	■	■
Communication		Capable of finding out failures of communication network.	■	■								
		Capable of designing and managing communication network structure.		■	■	■	■					
		Capable of educating and training transferred employees.						■	■	■	■	■

Source: JICA Study Team

(F) Data connection to SIGEM and its impacts

Accumulation and disclosure of operation and technical information on the power system used by SCADA/EMS to SIGEM not only enables integration of information management as a power company but widens the possibility of offering information of higher-level services to customers. An example of new services and business model that use operation and technical information on power systems is introduced below.



Source: Materials EDM received (2017)

Figure 6.3-44 SIGEM's Business Management Components (same as Figure 6.3-9)

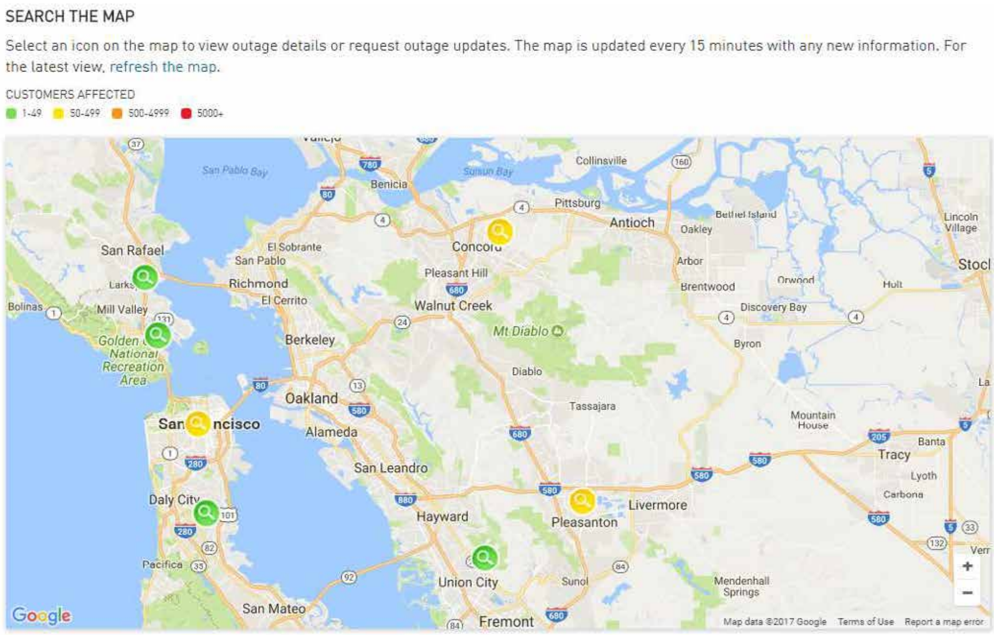
Figure 6.3-45 shows a website of US Pacific Gas & Electricity Company that discloses areas where power is lost. With a click of the eyeglass mark, the power outage situation (duration and cause of power outage) and recovery situation appear on the screen.

Real-time disclosure of information on the power system is offering of services to customers who are highly interested in power outage.

Figure 6.3-46 shows asset lifetime management[82] of US CenterPoint Energy. It is to plan facility replacement more rationally by making judgement based on various incidents and operation condition during operation.

By providing such services, the system operation changes the EDM business models, which contributes to the creation of a cycle of higher-quality system operation.

[82] SIGEM components do not include the asset management.



Source: Pacific Gas & Electricity Company website (https://www.pge.com/)

Figure 6.3-45 An Example Web Page of Areas where Power is Lost

Source: "Enabling the Intelligent Energy Future", CenterPointEnergy – SAP for Utilities, North American Conference (2014)

Figure 6.3-46 An Example of Asset Lifetime Management

(3) Proposal for well-organized system operation

Aforementioned several measures should be mobilized as soon as possible. In order to notify the plan to be integrated for the concrete system operating structure, following action plan would be materialized. This shows three kernel issues to be overcome and their deadlines. The final deadline is targeted in 2024 when STE backbone will be commissioned in. In the target year EDM should be developed with strategic planning which includes how to manage and operate the power flow on interconnectors. It is recommended that not only EDM but all related entities would be studied to make clear the relations of their positions and the role of their system operations.

Action No.1 on the table should be done by ARENE initiatively, but by all entities including EDM cooperatively. Based on the clarification, EDM would analyze internal business processes focusing on system operation business area and relations with other business area in EDM. In parallel with this, also EDM would create training curriculums to build their capacity for system operations. Further, analysis of system operation business processes would give the concept of functions to be created on SCADA/EMS and supportive tools.

Table 6.3-24 Action plan for system operation

FY / Actions		2018	2019	2020	2021	2022	2023	2024	2025
1. Establishment of internal guidelines, and formulation of formal rules									
2. Analysis of internal business process modeling in line with guidelines, creation of relevant vocational training curriculums and its mobilization	With existing curriculum Study by WB				With renewed curriculums				
3. Determination of functions on SCADA/EMS under the clarification of internal business processes and its implementation		Fit & Gap				Imprementation			

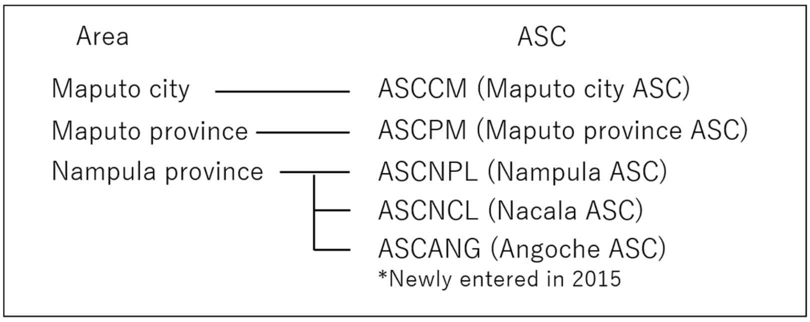
Source : JICA Study Team

Chapter 7 Distribution Development Plan

Distribution development plan will be established for Maputo city, Maputo province and Nampula province.

7.1 Distribution facilities

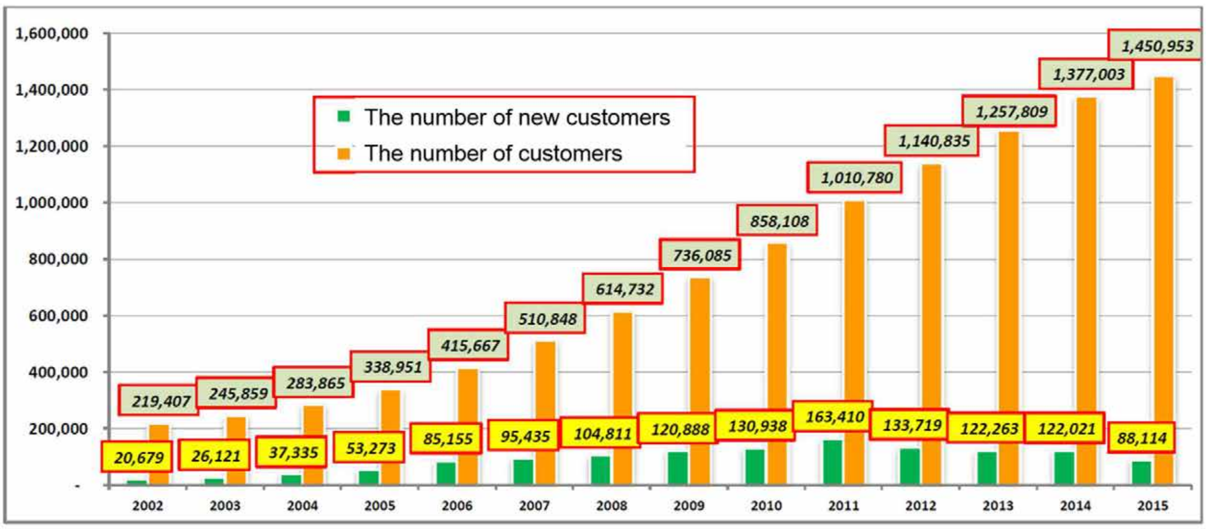
The distribution networks consist of medium voltage (MV) networks at various voltages from 6.6kV to 33kV as well as low voltage (LV) networks at 400V three-phase and 220V single-phase. Distribution facilities are managed by ASCs (*Área de Serviço ao Cliente*) individually. Figure 7.1-1 shows area covered by each ASC.



Source: JICA Study Team

Figure 7.1-1 Area covered by each ASC

Figure 7.1-2 shows the transition of the number of customers connected to the EDM grid. The number of customers has increased and reached 1,450,953 in 2015. The number of distribution facilities has increased with increasing demand.



Source: EDM Statistical Annual Report 2015

Figure 7.1-2 The transition of the number of customers to connected to the EDM grid

7.1.1 Distribution facilities in Maputo city

Table 7.1-1 shows MV and LV line lengths and the number of feeders in Maputo city. They have increased with increasing demand.

Table 7.1-1 MV and LV line lengths and the number of feeders in Maputo city ASC

Voltage		2013		2014			2015		
		Length [km]	The number of feeders	Length [km]	% from the previous year	The number of feeders	Length [km]	% from the previous year	The number of feeders
MV	33kV	373	11	384	103%	13	391	102%	14
	11kV	357	58	368	103%	58	387	105%	59
	Total	730	69	752	103%	71	778	103%	73
LV	0.4kV	1810	-	1882	104%	-	1918	102%	-

Source: JICA Study Team based on EDM information

Table 7.1-2 shows the number of installed transformers and LV line lengths per transformer. The number of installed transformers has increased with increasing demand. LV line lengths per transformer exceeds the EDM design standard of 500m. Long LV line lengths causes distribution loss increase due to increase of the resistance value of the wire. The detail of distribution loss is described in Section 7.7.

Table 7.1-2 The number of installed transformers and LV line lengths per transformer in Maputo city

Voltage	2013		2014				2015			
	Transformer [unit]	LV length per transformer [km/unit]	Transformer [unit]	% from the previous year	LV length per transformer [km/unit]	% from the previous year	Transformer [unit]	% from the previous year	LV length per transformer [km/unit]	% from the previous year
33/0.4kV	469	-	496	106%	-	-	525	106%	-	-
11/0.4kV	987	-	1031	104%	-	-	1071	104%	-	-
Total	1456	1.24	1527	105%	1.23	99%	1596	105%	1.20	98%

Source: JICA Study Team based on EDM information

Table 7.1-3 shows the number and duration of power outage that occurred in each distribution substation in Maputo city. It is changing with similar value. The value in Table 7.1-3 includes the scheduled outage for construction of distribution line, failure outage and so on. In 2015, the number of outage was 1,700, the duration of outage was 1,682 hours 20 minutes and the average recovery time per outage was 59 minutes.

Table 7.1-3 The number and duration of power outage that occurred in distribution network in Maputo city

Distribution Substation	The number of outage [times]			The duration of outage [hours:minutes]			The duration per outage [hours:minutes]		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
SE1	42	15	45	54:59	11:31	22:36	1:18	0:46	0:30
SE2	98	81	132	54:20	43:34	259:40	0:33	0:32	1:58
SE3	84	58	127	107:17	28:42	136:56	1:16	0:29	1:04
SE4	56	67	57	127:43	41:00	60:03	2:16	0:36	1:03
SE5	7	45	75	8:20	25:09	58:09	1:11	0:33	0:46
SE6	235	137	302	208:25	174:44	251:07	0:53	1:16	0:49
SE7	88	25	89	74:02	22:49	61:54	0:50	0:54	0:41
SE8	29	48	107	106:16	94:43	108:31	3:39	1:58	1:00
SE9	240	166	293	356:41	174:50	293:18	1:29	1:03	1:00
SE10	-	28	215	-	34:18	160:26	-	1:13	0:44
SE Marracuene	127	37	223	51:59	11:41	226:46	0:24	0:18	1:01
SE CTM (ASCCM side)	81	35	35	96:23	42:54	42:54	1:11	1:13	1:13
Whole ASCCM	1087	742	1700	1246:25	705:55	1682:20	1:08	0:57	0:59

Source: JICA Study Team based on EDM information

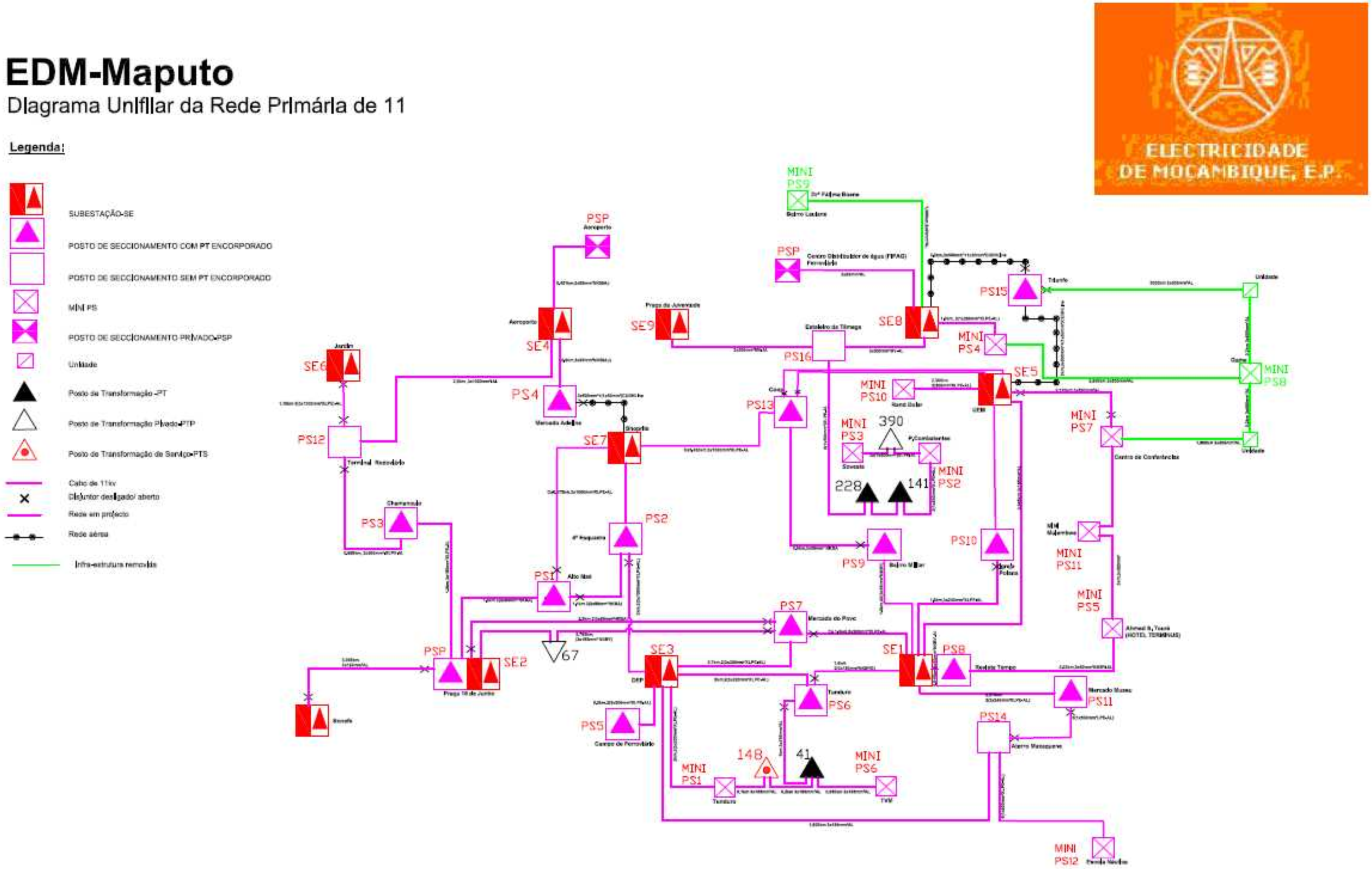
Table 7.1-4 shows the number and duration of power outage due to failure. In 2015, the number of outage was 414, the duration of outage was 414 hours and the average recovery time per outage was 1 hour.

Table 7.1-4 The number and duration of power outage due to failure that occurred in distribution network in Maputo city

Voltage	The number of outage [times]			The duration of outage [hours : minutes]			The duration per outage [hours : minutes]		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
33kV	-	133	133	-	184:27	133:00	-	1:23	1:00
11kV	-	281	281	-	186:39	281:00	-	0:39	1:00
Whole ASCCM	527	414	414	484:30	371:06	414:00	0:55	0:53	1:00

Source: JICA Study Team based on EDM information

Figure 7.1-3 shows the configuration of 11kV distribution network in Maputo city. SE and PS represent distribution substation and switching station (Figure 7.1-4, Figure 7.1-5), respectively. 11kV distribution network has open loop system and load can be switched between substations by operating at PS. There is distribution operation center (Figure 7.1-6) in SE2. Switches of distribution substation in Maputo city, Maputo province, Gaza province and Inhambane province can be operated remotely. As of October 2017, PS1 and PS10 can be operated remotely and other PSs are operated at distribution substation. Some of the PSs deteriorate and replacement of them will be planned.



Source: : EDM

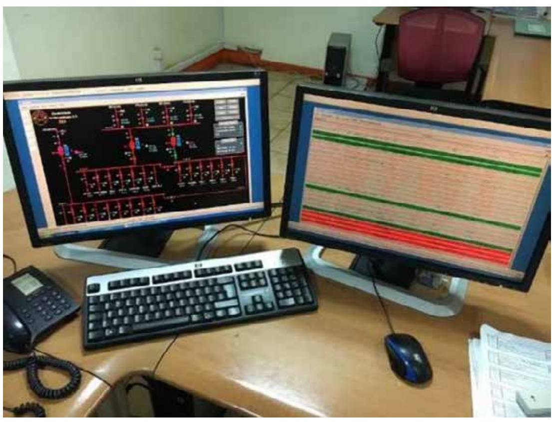
Figure 7.1-3 Configuration of 11kV distribution network in Maputo city

Source: JICA Study Team

Figure 7.1-4　Switching station in Maputo city

Source: JICA Study Team

Figure 7.1-5　Inside of PS (Left: Remote operation type, Right: Manual operation type)



Source: JICA Study Team

Figure 7.1-6　Distribution operation center (Left: Inside, Right: Operation terminal)

Table 7.1-5 shows operation ratio of transformer in each substation in Maputo city. Operation ratio of some transformers exceeds 100% in 2015, and EDM managed to be less than 100% by switching load between distribution substations in 2016. However, it is expected that it will be difficult to operate load switching between distribution substation and inspect substation periodically with stoppage of transformers. Therefore, new additional 40 MVA will be installed under Urgent Project supported by WB. In section 7.2, distribution substation development plan to meet N-1 criterion will be investigated.

Table 7.1-5 Operation ratio of transformer in each substation in Maputo city

ASCCM - PONTAS NAS SUBESTAÇÕES						
Nº	Subestação	Transformador	Potência Instalada [MW]	Ponta Máx (MW)	Índice de Carga 2015 (%)	Índice de Carga 2014 (%)
1	SE1	TR3 - 1x30 MVA - 66/11 kV	24,00	31,08	130%	108%
2	SE2	TR2 - 1x30 MVA - 66/11 kV	24,00	32,00	133%	108%
3	SE3	TR2 - 1x30 MVA - 66/11 kV	24,00	25,85	108%	96%
		TR3 - 1x30 MVA - 66/11 kV	24,00	28,29	110%	100%
4	SE4	TR1 - 1x30 MVA - 66/11 kV	24,00	21,29	89%	71%
5	Se5	TR1 - 1x20 MVA - 66/11 kV	16,00	23,29	146%	108%
		TR2 - 1x20 - 66/11 kV	16,00	21,49	134%	125%
6	SE6	BAR 1 - 1x10 MVA - 66/11 kV	32,00	39,93	125%	86%
		BAR 2 - 1x30 MVA - 66/33 kV				
7	SE7	TR1 - 1x30 MVA - 66/11 kV	24,00	34,25	143%	107%
8	SE8	TR1 - 1x30 MVA - 66/11 kV	24,00	31,16	130%	93%
9	SE9	TR1 - 1x30 MVA - 66/11 kV	24,00	20,58	86%	65%
		TR2 - 1x30 MVA - 66/33 kV	24,00	27,30	114%	120%
10	SE10	TR1 - 1x40 MVA - 66/33 kV	32,00	24,51	77%	98%
		TR2 - 1x10 MVA - 33/11 kV	8,00			
11	SE Marracuene	Tr1 - 1x20 MVA - 66/33 kV	16,00	19,76	124%	97%

Source: EDM Performance of Distribution Network Report 2015

7.1.2 Distribution facilities in Maputo province

Table 7.1-6 shows MV and LV line lengths and the number of feeders in Maputo province. They have increased with increasing demand.

Table 7.1-6 MV and LV line lengths and the number of feeders in Maputo province

Voltage		2013		2014			2015		
		Length [km]	The number of feeders	Length [km]	Percent from the previous year	The number of feeders	Length [km]	Percent from the previous year	The number of feeders
MV	33kV	1268	34	1353	107%	33	1383	102%	33
	22kV	8	1	8	100%	1	8	100%	1
	19.1kV	87	0	87	100%	1	87	100%	1
	11kV	98	11	101	103%	11	101	100%	11
	Total	1461	46	1549	106%	46	1579	102%	46
LV	0.4kV	5160	-	5289	103%	-	5329	101%	-

Source: JICA Study Team based on EDM information

Table 7.1-7 shows the number of installed transformers and LV line lengths per transformer in Maputo province. The number of installed transformers has increased with increasing demand. LV line lengths per transformer exceeds the EDM design standard of 500m. Long LV line lengths causes distribution loss increase due to increase of the resistance value of the wire. The detail of distribution loss is described in Section 7.7.

Table 7.1-7 The number of installed transformers and LV line lengths per transformer in Maputo province

Voltage	2013		2014				2015			
	Transformer [unit]	LV length per transformer [km/unit]	Transformer [unit]	% from the previous year	LV length per transformer [km/unit]	% from the previous year	Transformer [unit]	% from the previous year	LV length per transformer [km/unit]	% from the previous year
33/0.4kV	1371	-	1528	111%	-	-	1669	109%	-	-
22/0.4kV	16	-	16	100%	-	-	16	100%	-	-
19.1/0.4kV	23	-	23	100%	-	-	23	100%	-	-
11/0.4kV	118	-	131	111%	-	-	131	100%	-	-
Total	1528	3.38	1698	111%	3.11	92%	1839	108%	2.90	93%

Source: JICA Study Team based on EDM information

Table 7.1-8 shows the number and duration of power outage that occurred in each distribution substation in Maputo city. The value in Table 7.1-8 includes scheduled outage for construction of distribution line, failure outage and so on. In 2015, the number of outage was 1,857, the duration of outage was 1,154 hours 37 minutes and the average recovery time per outage was 37 minutes.

Table 7.1-8 The number and duration of power outage that occurred in distribution network in Maputo province

Distribution Substation	The number of outage [times]			The duration of outage [hours:minutes]			The duration per outage [hours:minutes]		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
SE Matola Gare	169	177	246	79:31	163:24	168:43	0:28	0:55	0:41
SE Matola Rio	105	79	130	84:19	44:26	61:45	0:48	0:33	0:28
SE Salamanga	95	100	132	52:02	92:43	182:41	0:32	0:55	1:23
SE CTM (ASCPM side)	197	160	207	141:34	95:47	112:34	0:43	0:35	0:32
SE Machava	246	297	440	175:16	23:03	229:21	0:42	0:04	0:31
SE Boane	414	314	586	172:15	214:42	281:00	0:24	0:41	0:28
SE Manhica	172	74	92	111:17	65:59	80:11	0:38	0:53	0:52
SE Beluluane	1	17	6	0:57	27:17	16:36	0:57	1:36	2:46
Whole ASCPM	1427	1291	1857	896:05	801:59	1154:37	0:37	0:37	0:37

Source: JICA Study Team based on EDM information

Table 7.1-9 shows the number and duration of power outage due to failure in Maputo province. In 2015, the number of outage was 655, the duration of outage was 570 hours 1 minute and the average recovery time per outage was 52 minutes. Distribution area in Maputo province is wide and distribution substations are separated from each other, therefore it is difficult to configure loop system. Then, it is difficult to supply electricity from another energized distribution line and the power outage time sometimes become longer.

Table 7.1-9 The number and duration of power outage due to failure that occurred in distribution network in Maputo province

Voltage	The number of outage [times]			The duration of outage [hours : minutes]			The duration per outage [hours : minutes]		
	2013	2014	2015	2013	2014	2015	2013	2014	2015
33kV	-	646	646	-	556:25	556:25	-	0:51	0:51
22kV	-	0	0	-	0:00	0:00	-	0:00	0:00
19.1kV	-	0	0	-	0:00	0:00	-	0:00	0:00
11kV	-	9	9	-	13:36	13:36	-	1:30	1:30
Whole ASCPM	1246	655	655	746:35	570:01	570:01	0:35	0:52	0:52

Source: JICA Study Team based on EDM information

Table 7.1-10 shows operation ratio of transformer in each substation in Maputo province. Operation ratio of some transformers exceeds 100% in 2015. Therefore, it is expected that it will be difficult to operate load switching between distribution substation and inspect substation periodically with stoppage of transformers. In section 7.2, distribution substation development plan to meet N-1 criterion will be investigated.

Table 7.1-10 Operation ratio of transformer in each substation in Maputo province

ASCPM - PONTAS NAS SUBESTAÇÕES						
Nº	Subestação	Transformador	Potência Instalada [MW]	Ponta Máx (MW)	Índice de Carga 2015 (%)	Índice de Carga 2014 (%)
1	MACHAVA	TR1 - 1x30 MVA - 66/33 kV	24,00	27,16	113%	96%
		TR2 - 1x30 MVA - 66/33 kV	24,00	29,69	124%	
2	SALAMANGA	TR1 - 1x10 MVA - 66/33 kV	8,00	9,71	121%	58%
		TR2 - 1x10 MVA - 66/33 kV	8,00	9,70	121%	58%
3	BOANE	TR1 - 1x30 MVA - 66/33 kV	24,00	22,10	92%	88%
4	MATOLA RIO	TR1 - 1x30 MVA - 66/33 kV	24,00	24,74	103%	77%
5	CTM	TR1 - 2x30 MVA - 66/33 kV	48,00	29,93	62%	59%
6	BELULUANE	TR1 - 1x20 MVA - 66/11 kV	16,00	2,00	13%	25%
7	MATOLA GARE	TR1 - 1x30 MVA - 66/33 kV	24,00	26,17	109%	107%
		TR2 - 1x10 MVA - 66/33 kV	8,00	7,19	90%	
8	MANHICA	TR1 - 1x30 MVA - 66/33 kV	24,00	10,56	44%	27%
9	INFULENE MOVEL	TR1 - 1x10 MVA - 66/33 kV	8,00	10,07	126%	111%
10	KONGOLOTE MOVEL	TR1 - 1x10 MVA - 66/33 kV	8,00	3,90	49%	86%
11	EL7-KONGOLOTE	TR1 - 1x10 MVA - 66/33 kV	8,00	10,06	126%	
12	CORRUMANA	Tr1 - 1x10 MVA - 110/33 kV	8,00	0,90	11%	8%

Source: EDM Performance of Distribution Network Report 2015

7.1.3 Distribution facilities in Nampula province

There are Nampula ASC, Nacala ASC and Angoche ASC in Nampula province, since distribution area is wide. Angoche ASC were newly entered in 2015.

Table 7.1-11 shows MV and LV line lengths and the number of feeders in Nampula province. They have increased with increasing demand. 22kV and 6.6kV line length in Nampula ASC is zero, since the management of distribution line was transferred to Angoche ASC.

Table 7.1-11 MV and LV line lengths and the number of feeders in Nampula province

Voltage	ASC		2013		2014			2015		
			Length [km]	The number of feeders	Length [km]	Percent from the previous year	The number of feeders	Length [km]	Percent from the previous year	The number of feeders
MV	ASCNPL	33kV	894	7	903	101%	5	922	102%	5
		22kV	123	2	123	100%	2	0	0%	0
		11kV	129	8	130	101%	10	123	95%	10
		6.6kV	25	3	25	100%	3	0	0%	0
		Total	1171	20	1181	101%	20	1045	88%	15
	ASCNCL	33kV	659	9	662	100%	7	670	101%	5
		11kV	56	11	57	102%	10	58	102%	10
		Total	715	20	719	101%	17	728	101%	15
	ASCANG	33kV	-	-	-	-	-	369	-	1
		22kV	-	-	-	-	-	123	-	2
		6.6kV	-	-	-	-	-	25	-	2
		Total	-	-	-	-	-	517	-	5
	Nampula province	33kV	1553	16	1565	101%	12	1961	125%	11
		22kV	123	2	123	100%	2	123	100%	2
		11kV	129	19	187	145%	20	181	97%	20
		6.6kV	25	3	25	100%	3	25	100%	2
		Total	1830	40	1900	104%	37	2290	121%	35
LV	ASCNPL	0.4kV	960	-	2057	214%	-	2098	102%	-
	ASCNCL	0.4kV	460	-	1151	250%	-	1159	101%	-
	ASCANG	0.4kV	-	-	-	-	-	144	-	-
	Nampula province	Total	1420	-	3208	226%	-	3401	106%	-

Source: JICA Study Team based on EDM information

Table 7.1-12 shows the number of installed transformers and LV line lengths per transformer in Nampula province. The number of installed transformers has increased with increasing demand. LV line lengths per transformer exceeds EDM design standard of 500m. Long LV line lengths causes distribution loss increase due to increase of the resistance value of the wire. The detail of distribution loss is described in Section 7.7.

Table 7.1-12 The number of installed transformers and LV line lengths per transformer in Nampula province

ASC	Voltage	2013		2014				2015			
		Transformer [unit]	LV length per transformer [km/unit]	Transformer [unit]	% from the previous year	LV length per transformer [km/unit]	% from the previous year	Transformer [unit]	% from the previous year	LV length per transformer [km/unit]	% from the previous year
ASCNPL	33/0.4kV	159	-	181	114%	-	-	232	128%	-	-
	22/0.4kV	15	-	14	93%	-	-	0	0%	-	-
	11/0.4kV	184	-	187	102%	-	-	219	117%	-	-
	6.6/0.4kV	23	-	14	61%	-	-	0	0%	-	-
	Total	381	2.52	396	104%	5.19	206%	451	114%	4.65	90%
ASCNCL	33/0.4kV	261	-	289	111%	-	-	314	109%	-	-
	11/0.4kV	53	-	64	121%	-	-	68	106%	-	-
	Total	314	1.46	353	112%	3.26	223%	382	108%	3.03	93%
ASCANG	33/0.4kV	-	-	-	-	-	-	46	-	-	-
	22/0.4kV	-	-	-	-	-	-	17	-	-	-
	6.6/0.4kV	-	-	-	-	-	-	7	-	-	-
	Total	-	-	-	-	-	-	70	-	2.06	-
Nampula Province	33/0.4kV	420	-	470	112%	-	-	592	126%	-	-
	22/0.4kV	15	-	14	93%	-	-	17	121%	-	-
	11/0.4kV	237	-	251	106%	-	-	287	114%	-	-
	6.6/0.4kV	23	-	14	61%	-	-	7	50%	-	-
	Total	695	2.04	749	108%	4.28	210%	903	121%	3.77	88%

Source: JICA Study Team based on EDM information

Table 7.1-13 shows the number and duration of power outage that occurred in each distribution substation in Nampula province. The value in Table 7.1-13 includes the value of scheduled outage for construction of distribution line, failure outage and so on. In 2015, the number of outage was 543, the duration of outage was 685 hours 43 minutes and the average recovery time per outage was 1 hour 15 minutes.

Table 7.1-13 The number and duration of power outage that occurred in distribution network in Nampula province

ASC	Distribution Substation	The number of outage [times]			The duration of outage [hours:minutes]			The duration per outage [hours:minutes]		
		2013	2014	2015	2013	2014	2015	2013	2014	2015
ASCNPL	SE Nampula	1031	1266	432	1462:18	941:48	457:03	1:25	0:44	1:03
	SE Moma	-	-	-	-	-	-	-	-	-
	SE Angoche (ASCNPL side)	-	-	-	-	-	-	-	-	-
	Whole ASCNPL	1031	1266	432	1462:18	941:48	457:03	1:25	0:44	1:03
ASCNCL	SE Nacala	634	1071	-	637:12	433:51	-	1:00	0:24	-
	SE Angoche (ASCNCL side)	-	-	-	-	-	-	-	-	-
	SE Monapo	345	490	-	210:55	285:58	-	0:36	0:35	-
	Whole ASCNCL	979	1561	-	848:07	719:49	-	0:51	0:27	-
ASCANG		-	-	111	-	-	228:40	-	-	2:03
Whole Nampula province		2010	2827	543	2310:25	1661:37	685:43	1:08	0:35	1:15

Source: JICA Study Team based on EDM information

Table 7.1-14 shows the number and duration of power outage due to failure in Nampula province. In 2015, the number of outage was 1,996, the duration of outage was 1242 hours 55 minute and the average recovery time per outage was 37 minutes. Distribution area in Nampula province is wide and distribution substations are separated from each other, therefore it is difficult to configure loop system. Then, it is difficult to supply electricity from another energized distribution line and the power outage time sometimes become longer.

Table 7.1-15 and Table 7.1-16 show operation ratio of transformer in each substation in ASCNPL and ASCNCL respectively. Operation ratio of some transformers exceeds 100% in 2015. Therefore, it is expected that it will be difficult to operate load switching between distribution substation and inspect substation periodically with stoppage of transformers. In section 7.2, distribution substation development plan to meet N-1 criterion will be investigated.

Table 7.1-14 The number and duration of power outage due to failure that occurred Nampula province

ASC	Voltage	The number of outage [times]			The duration of outage [hours : minutes]			The duration per outage [hours : minutes]		
		2013	2014	2015	2013	2014	2015	2013	2014	2015
ASCNPL	33kV	-	299	299	-	334:55	334:55	-	1:07	1:07
	22kV	-	55	0	-	68:30	0:00	-	1:14	0:00
	11kV	-	449	449	-	315:25	315:25	-	0:42	0:42
	6.6kV	-	0	0	-	0:00	0:00	-	0:00	0:00
	Whole ASCNPL	512	803	748	1155:19	718:50	650:20	2:15	0:53	0:52
ASCNCL	33kV	-	1121	1121	-	343:26	343:26	-	0:18	0:18
	11kV	-	28	28	-	38:55	38:55	-	1:23	1:23
	Whole ASCNCL	525	1149	1149	430:26	382:21	382:21	0:49	0:19	0:19
ASCANG	33kV	-	-	-	-	-	-	-	-	-
	22kV	-	-	-	-	-	-	-	-	-
	6.6kV	-	-	-	-	-	-	-	-	-
	Whole ASCANG	-	-	99	-	-	210:14	-	-	2:07
Whole Nampula province		1037	1952	1996	1585:45	1101:11	1242:55	1:31	0:33	0:37

Source: JICA Study Team based on EDM information

Table 7.1-15 Operation ratio of transformer in each substation in ASCNPL

ASCNPL - PONTAS NAS SUBESTAÇÕES					
Nº	Subestação	Transformador	Potência Instalada [MW]	Índice de Carga 2015 (%)	Índice de Carga 2014 (%)
1	NAMPULA	TR2 1x35 MVA 110/33 kV	28	102%	112%
2	NAMPULA MOVEL 1	TR 10 MVA 110/33 kV	8	130%	125%
3	NAMPULA MOVEL 2	TR 10 MVA 110/33 kV	8	130%	125%

Source: EDM Performance of Distribution Network Report 2015

Table 7.1-16 Operation ratio of transformer in each substation in ASCNCL

ASCNCL - PONTAS NAS SUBESTAÇÕES					
Nº	Subestação	Transformador	Potência Instalada [MW]	Índice de Carga 2015 (%)	Índice de Carga 2014 (%)
1	NACALA	TR1 - 1x35 MVA - 110/33 kV	28	81%	91%
		TR2 - 1x35 MVA - 110/33 kV	28	94%	78%
2	MONAPO	TR2 - 1x10 MVA - 110/33 kV	8	34%	
		TR - 1x16 MVA - 110/33 kV	12,8	75%	78%

Source: EDM Performance of Distribution Network Report 2015

7.2 Distribution substation development plan based on demand forecast

It is expected that it will be difficult to operate load switching between distribution substation and inspect substation periodically with stoppage of transformers. Distribution substation development plan should be established to evaluate future supply plan and its reliability. JICA study team propose methodology of distribution substation development plan so that EDM can establish the plan and invite investment from donors in the future.

Conditions for investigation of distribution substation development plan are as follows;

・PSSE load data is used as demand of each substation in 2017.
・At least 2 transformer can be installed to each distribution substation.
・All distribution substations are designed to meet N-1 criterion by 2022.
・Shortage of transmission capacity with installation of additional transformer and construction of distribution substation, is not considered due to this investigation based on transmission development plan.
・Construction cost of distribution substation is accumulated to transmission development plan.

7.2.1 Distribution substation development plan in Maputo city

Table 7.2-1 shows the demand forecast of each distribution substation in Maputo city. Black circle mark represents that the demand exceeds the transformer capacity.

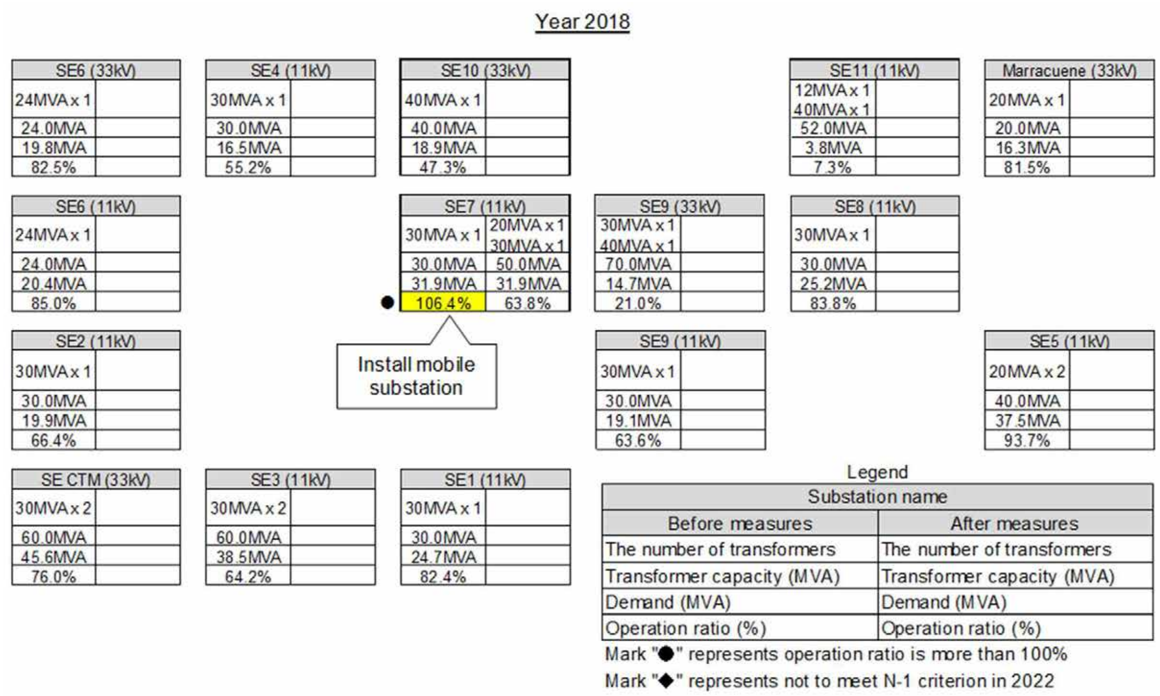
Table 7.2-1 Demand forecast of each distribution substation in Maputo city

[MVA]

Distribution Substation	Substation Capacity	Year				
		2018	2019	2020	2021	2022
SE1	30MVA x 1	24.7	26.8	30.0	●32.6	●35.2
SE2	30MVA x 1	19.9	21.6	24.2	26.2	28.3
SE3	30MVA x 2	38.5	41.8	46.7	50.7	54.8
SE4	30MVA x 1	16.5	17.9	20.1	21.8	23.5
SE5	20MVA x 2	37.5	●40.6	●45.4	●49.3	●53.2
SE6	24MVA x 1 (33kV)	19.8	21.5	24.0	●26.0	●28.1
	24MVA x 1 (11kV)	20.4	22.1	●24.7	●26.8	●29.0
SE7	30MVA x 1	●31.9	●34.6	●38.6	●42.0	●45.4
SE8	30MVA x 1	25.2	27.3	●30.5	●33.1	●35.8
SE9	30MVA x 1 (33kV)	14.7	15.9	17.8	19.3	20.9
	30MVA x 1 (11kV)	19.1	20.7	23.1	25.1	27.1
SE10 Zimpeto	40MVA x 1	18.9	20.5	22.9	24.9	26.9
SE11	12MVA x 1 40MVA x 1	3.8	4.2	4.7	5.0	5.5
SE CTM	30MVA x 2	45.6	49.5	55.3	60.0	●64.9
SE Marracuene	20MVA x 1	16.3	●21.8	●23.2	●25.6	●28.0

Source: JICA Study Team

Figure 7.2-1 shows demand of each distribution substation in Maputo city in 2018. Installation of mobile substation for SE 7 will be investigated due to excess of transformer capacity.



Source: JICA Study Team

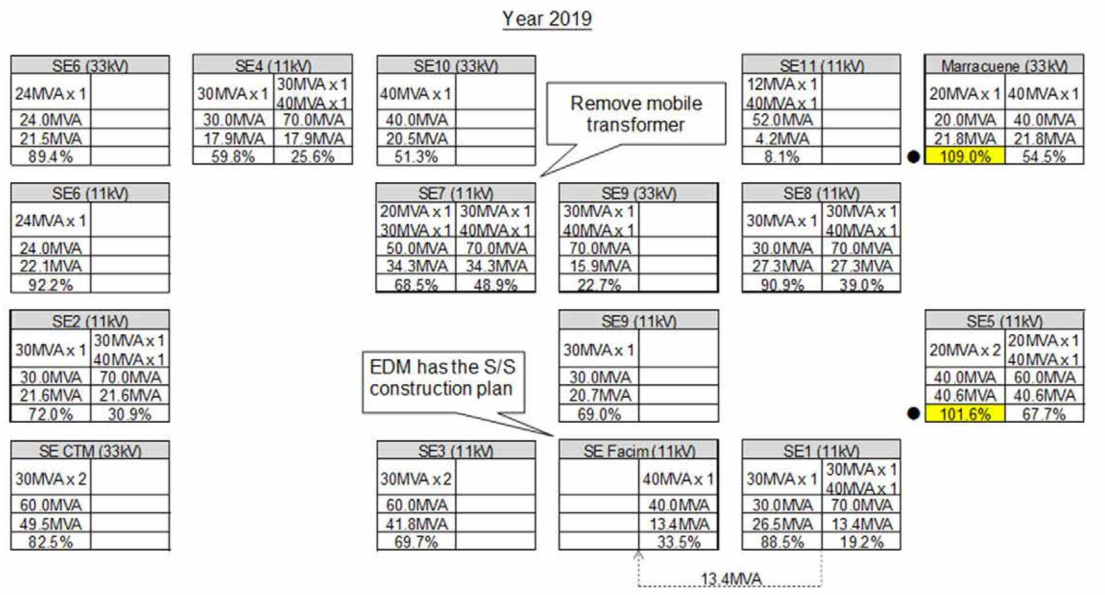
Figure 7.2-1 Demand of each distribution substation in Maputo city in 2018

Figure 7.2-2 shows the demand of each distribution substation in Maputo city in 2018. Following measures are necessary.

・Construction of SE Facim (WB Mid-term project).

・Installation of 40 MVA transformer to SE 1, SE 2, SE 4, SE 5, SE 7 and SE 8 (WB Emergency project)

・Installation of 40MVA transformer to SE Marracuene



Source: JICA Study Team

Figure 7.2-2 Demand of each distribution substation in Maputo city in 2019

Figure 7.2-3 shows the demand of each distribution substation in Maputo city in 2020. New additional transformer should be installed to SE 6 (11kV).

Year 2020

	SE6 (33kV)	24MVA x 1	24.0MVA	24.0MVA	100.0%
	SE4 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	20.1MVA	28.7%
	SE10 (33kV)	40MVA x 1	40.0MVA	22.9MVA	57.3%
	SE11 (11kV)	12MVA x 1 40MVA x 1	52.0MVA	4.7MVA	9.0%
	Marracuene (33kV)	40MVA x 1	40.0MVA	23.2MVA	58.0%
●	SE6 (11kV)	24MVA x 1	24.0MVA	24.7MVA	103.0%
	SE6 (11kV)	24MVA x 1 40MVA x 1	64.0MVA	24.7MVA	38.6%
	SE7 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	38.7MVA	55.3%
	SE9 (33kV)	30MVA x 1 40MVA x 1	70.0MVA	17.8MVA	25.4%
	SE8 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	30.5MVA	43.6%
	SE2 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	24.2MVA	34.5%
	SE9 (11kV)	30MVA x 1	30.0MVA	23.1MVA	77.1%
	SE5 (11kV)	20MVA x 1 40MVA x 1	60.0MVA	45.4MVA	75.7%
	SE CTM (33kV)	30MVA x 2	60.0MVA	55.3MVA	92.2%
	SE3 (11kV)	30MVA x 2	60.0MVA	46.7MVA	77.9%
	SE Facim (11kV)	40MVA x 1	40.0MVA	15.0MVA	37.5%
	SE1 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	15.0MVA	21.4%

Source: JICA Study Team

Figure 7.2-3 Demand of each distribution substation in Maputo city in 2020

Figure 7.2-4 shows the demand of each distribution substation in Maputo city in 2021. New additional transformer should be installed to SE 6 (33kV).

Year 2021

●	SE6 (33kV)	24MVA x 1	24.0MVA	26.0MVA	108.4%
	SE6 (33kV)	24MVA x 1 40MVA x 1	64.0MVA	26.0MVA	40.7%
	SE4 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	21.8MVA	31.1%
	SE10 (33kV)	40MVA x 1	40.0MVA	24.9MVA	62.3%
	SE11 (11kV)	12MVA x 1 40MVA x 1	52.0MVA	5.0MVA	9.6%
	Marracuene (33kV)	40MVA x 1	40.0MVA	25.6MVA	64.0%
	SE6 (11kV)	24MVA x 1 40MVA x 1	64.0MVA	26.8MVA	41.9%
	SE7 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	42.0MVA	59.9%
	SE9 (33kV)	30MVA x 1 40MVA x 1	70.0MVA	19.3MVA	27.6%
	SE8 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	33.1MVA	47.3%
	SE2 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	26.2MVA	37.4%
	SE9 (11kV)	30MVA x 1	30.0MVA	25.1MVA	83.6%
	SE5 (11kV)	20MVA x 1 40MVA x 1	60.0MVA	49.3MVA	82.1%
	SE CTM (33kV)	30MVA x 2	60.0MVA	60.0MVA	100.0%
	SE3 (11kV)	30MVA x 2	60.0MVA	50.7MVA	84.5%
	SE Facim (11kV)	40MVA x 1	40.0MVA	16.3MVA	40.6%
	SE1 (11kV)	30MVA x 1 40MVA x 1	70.0MVA	16.3MVA	23.2%

Source: JICA Study Team

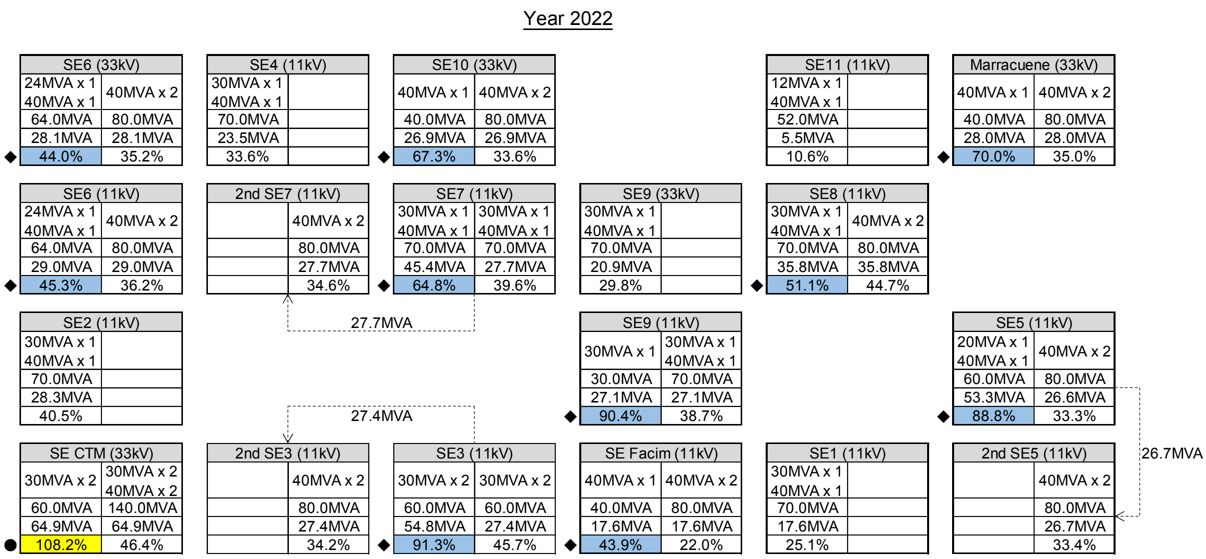
Figure 7.2-4 Demand of each distribution substation in Maputo city in 2021

Figure 7.2-5 shows the demand of each distribution substation in Maputo city in 2022. Black square mark represents not to meet N-1 criterion in 2022. Following measures are necessary.

・Installation of new additional 40 MVA transformer to SE 5, SE 6 (both 11kV and 33kV), SE 8, SE 9 (11kV), SE 10, SE CTM, SE Facim and SE Marracuene

・Construction of 2nd SE 3, 2nd SE 5 and 2nd SE 7

・Load switching from SE 3 to 2nd SE 3 and from SE 5 to 2nd SE 5



Source: JICA Study Team

Figure 7.2-5 Demand of each distribution substation in Maputo city in 2022

Table 7.2-2 shows the measures for distribution substation in Maputo city from 2018 to 2022.

Table 7.2-2 Measures for distribution substation in Maputo city from 2018 to 2022

Area	Year	New distribution substation	Additional transformer (including replacement)	Mobile substation	
				Installation	Removal
Maputo city	2018			SE7	
	2019	SE Facim	SE1, SE2, SE4 SE5, SE7, SE8, SE Marracuene		SE7
	2020		SE6 (11kV)		
	2021		SE6 (33kV)		
	2022	2nd SE3, 2nd SE5 2nd SE7	SE5, SE6 (11kV, 33kV), SE8, SE9 (11kV) SE CTM, SE Facim, SE Marracuene		

Source: JICA Study Team

7.2.2 Distribution substation development plan in Maputo province

Table 7.2-3 shows the demand forecast of each distribution substation in Maputo province. Black circle mark represents that the demand exceeds the transformer capacity.

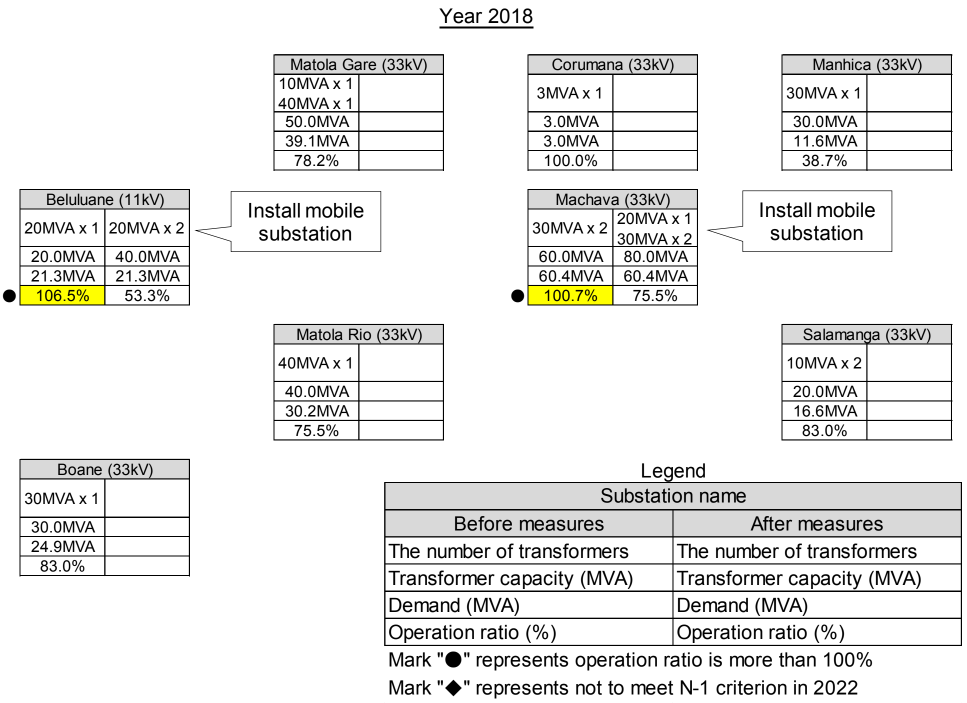
Table 7.2-3 Demand forecast of each distribution substation in Maputo province

[MVA]

Distribution Substation	Substation Capacity	Year 2018	2019	2020	2021	2022
SE Beluluane	20MVA x 1	●21.3	●28.4	●30.2	●33.3	●36.4
SE Boane	30MVA x 1	24.9	●33.2	●35.3	●38.9	●42.6
SE Machava	30MVA x 2	●60.4	●80.5	●85.7	●94.4	●103.2
SE Manhica	30MVA x 1	11.6	15.5	16.5	18.1	19.8
SE Matola Gare	10MVA x 1 40MVA x 1	39.1	●52.1	●55.5	●61.2	●67.0
SE Matola Rio	40MVA x 1	30.2	●40.4	●43.0	●47.2	●51.8
SE Salamanga	10MVA x 2	16.6	●22.0	●23.4	●25.8	●28.4
SE Corumana	3MVA x 1	3.0	●4.1	●4.3	●4.8	●5.2

Source: JICA Study Team

Figure 7.2-6 shows the demand of each distribution substation in Maputo province in 2018. Mobile substation should be installed to SE Beluluane and SE Machava.



Source: JICA Study Team

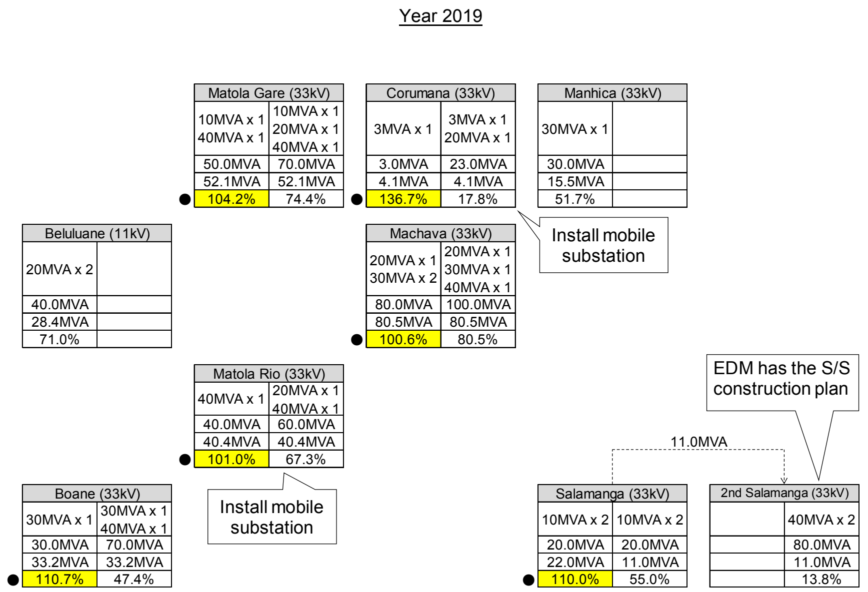
Figure 7.2-6 Demand of each distribution substation in Maputo province in 2018

Figure 7.2-7 shows the demand of each distribution substation in Maputo province in 2019. Following measures are necessary.

・Construction of SE 2nd Salamanga (WB Mid-term project).

・Installation of mobile substation to SE Corumana, SE Matola Gare and SE Matola Rio

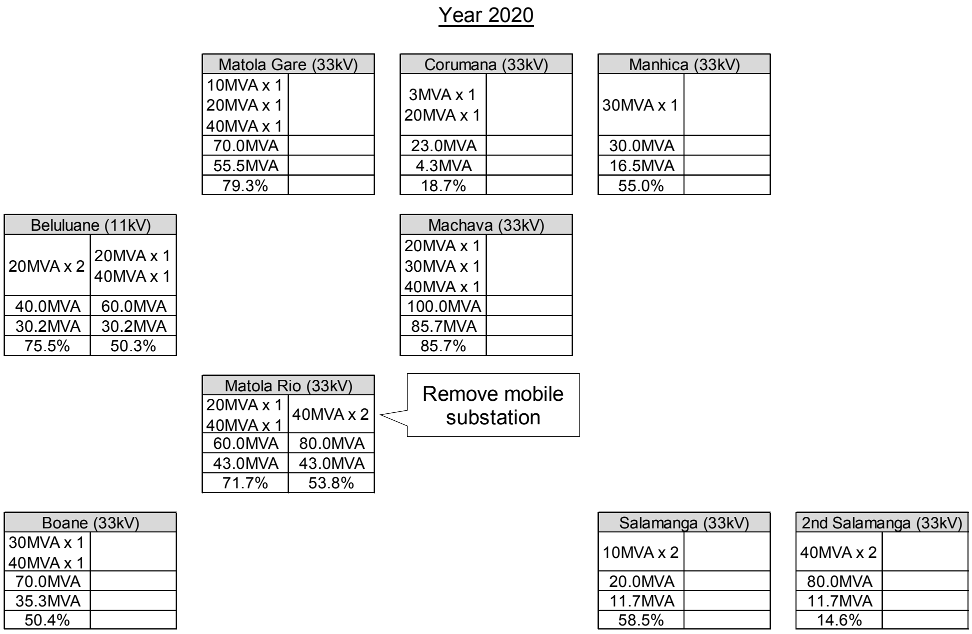
・Installation of new additional 40 MVA transformer to SE Boane and SE Machava



Source: JICA Study Team

Figure 7.2-7　Demand of each distribution substation in Maputo province in 2019

Figure 7.2-8 shows the demand of each distribution substation in Maputo province in 2020. New additional 40 MVA transformer should be installed to SE Beluluane and SE Matola Rio.



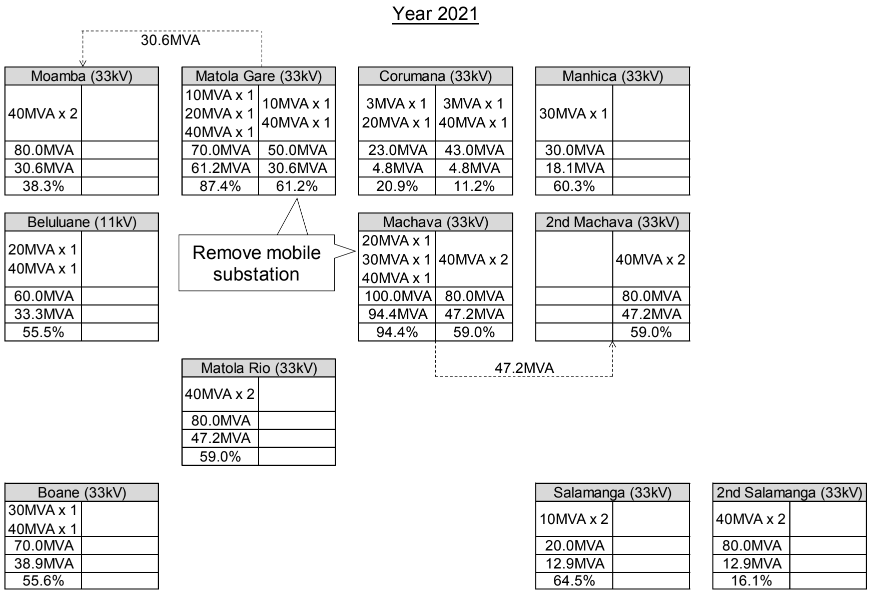
Source: JICA Study Team

Figure 7.2-8　Demand of each distribution substation in Maputo province in 2020

Figure 7.2-9 shows the demand of each distribution substation in Maputo province in 2021. Following measures are necessary.

・Construction of SE Moamba (WB Mid-term project) and SE 2nd Machava

・Installation of transformer to SE Corumana



Source: JICA Study Team

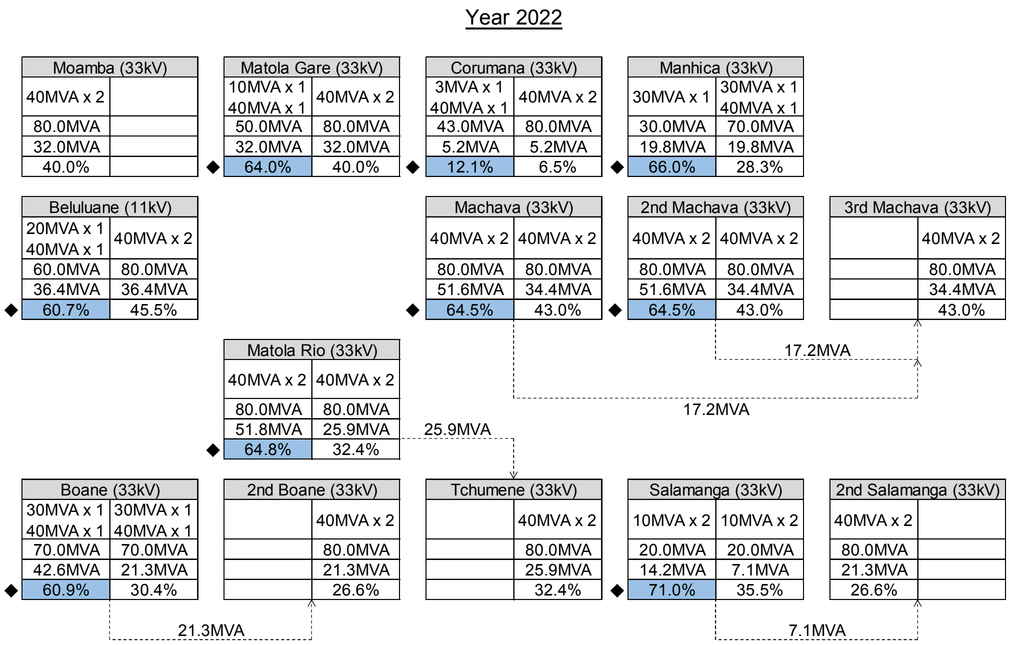
Figure 7.2-9 Demand of each distribution substation in Maputo province in 2021

Figure 7.2-10 shows demand of each distribution substation in Maputo province in 2022. Black square mark represents not to meet N-1 criterion in 2022. Following measures are necessary.

・Installation of new additional 40 MVA transformer to SE Moamba, SE Matola Gare, SE Manhica, SE Beluluane, SE Matola Rio, SE Tchumene and SE Salamanga.

・Construction of SE 2nd Boane, SE Tchumene (WB Mid-term project), SE 3rd Machava

・Load switching from SE Salamanga to SE 2nd Salamanga



Source: JICA Study Team

Figure 7.2-10 Demand of each distribution substation in Maputo province in 2022

Table 7.2-4 shows the measures for distribution substation in Maputo city from 2018 to 2022.

Table 7.2-4 Measures for distribution substation in Maputo province from 2018 to 2022

Area	Year	New distribution substation	Additional transformer (including replacement)	Mobile substation	
				Installation	Removal
Maputo province	2018			SE Beluluane SE Machava	
	2019	2nd SE Salamanga	SE Machava SE Boane	SE Corumana SE Matola Gare SE Matola Rio	
	2020		SE Beluluane SE Matola Rio		SE Beluluane SE Matola Rio
	2021	SE Moamba 2nd SE Machava	SE Corumana		SE Corumana SE Matola Gare SE Machava
	2022	2nd SE Boane 3rd SE Machava SE Tchumene	SE Corumana, SE Manhica, SE Beluluane SE Matola Gare, SE Matola Rio		

Source: JICA Study Team

7.2.3 Distribution substation development plan in Nampula province

Table 7.2-5 shows the demand forecast of each distribution substation in Nampula province. Black circle mark represents that the demand exceeds the transformer capacity.

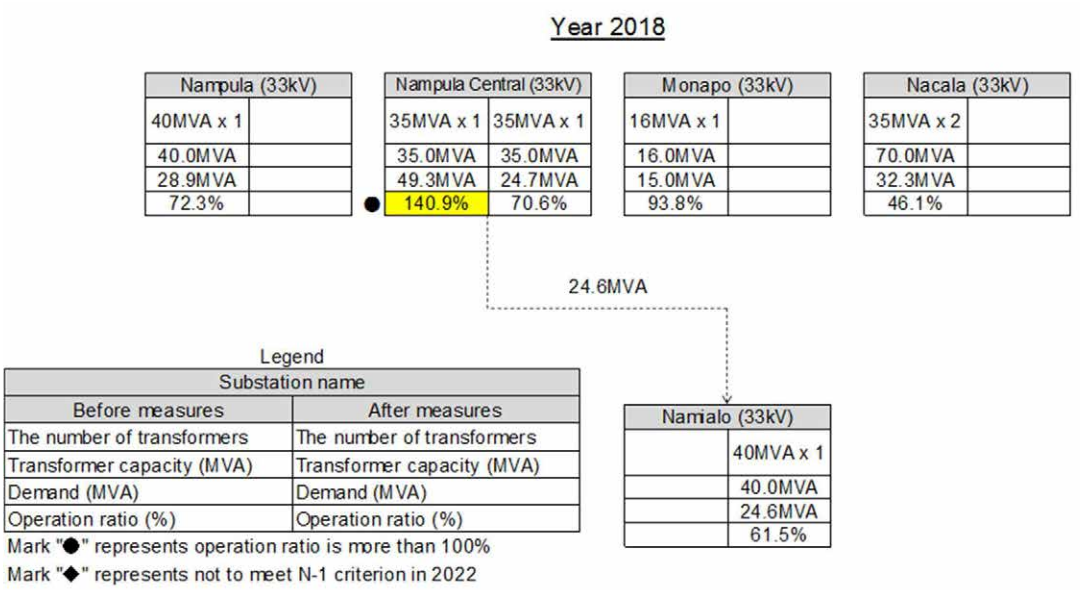
Table 7.2-5 Demand forecast of each distribution substation in Nampula province

[MVA]

Distribution Substation	Substation Capacity	Year				
		2018	2019	2020	2021	2022
Nampula	40MVA x 1	28.9	31.1	33.2	36.8	●40.6
Nampula Central	35MVA x 1	●49.3	●53.0	●56.6	●62.8	●69.0
Monapo	16MVA x 1	15.0	●16.2	●17.2	●19.1	●21.1
Nacala	35MVA x 2	32.3	34.8	37.0	41.2	43.2

Source: JICA Study Team

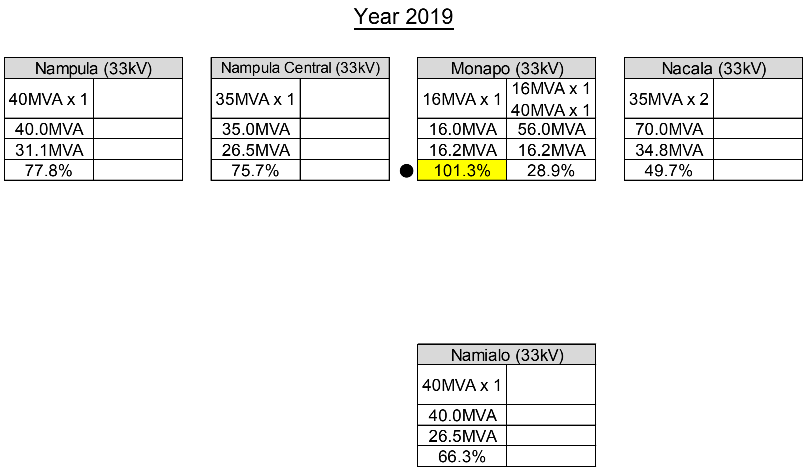
Figure 7.2-11 shows the demand of each distribution substation in Nampula province in 2018. SE Namialo is constructed under JICA project.



Source: JICA Study Team

Figure 7.2-11 Demand of each distribution substation in Nampula province in 2018

Figure 7.2-12 shows the demand of each distribution substation in Nampula province in 2019. 40 MVA transformer should be installed to SE Monapo.



Source: JICA Study Team

Figure 7.2-12 Demand of each distribution substation in Nampula province in 2019

Figure 7.2-13 shows the demand of each distribution substation in Nampula province in 2020. Measures are not needed.

Year 2020

Nampula (33kV)	
40MVA x 1	
40.0MVA	
33.2MVA	
83.0%	

Nampula Central (33kV)	
35MVA x 1	
35.0MVA	
28.3MVA	
80.9%	

Monapo (33kV)	
16MVA x 1 40MVA x 1	
56.0MVA	
17.2MVA	
30.7%	

Nacala (33kV)	
35MVA x 2	
70.0MVA	
37.0MVA	
52.9%	

Namialo (33kV)	
40MVA x 1	
40.0MVA	
28.3MVA	
70.8%	

Source: JICA Study Team

Figure 7.2-13　Demand of each distribution substation in Nampula province in 2020

Figure 7.2-14 shows demand of each distribution substation in Nampula province in 2021. Measures are not needed.

Year 2021

Nampula (33kV)	
40MVA x 1	
40.0MVA	
36.8MVA	
92.0%	

Nampula Central (33kV)	
35MVA x 1	
35.0MVA	
31.4MVA	
89.7%	

Monapo (33kV)	
16MVA x 1 40MVA x 1	
56.0MVA	
19.1MVA	
34.1%	

Nacala (33kV)	
35MVA x 2	
70.0MVA	
41.2MVA	
58.9%	

Namialo (33kV)	
40MVA x 1	
40.0MVA	
31.4MVA	
78.5%	

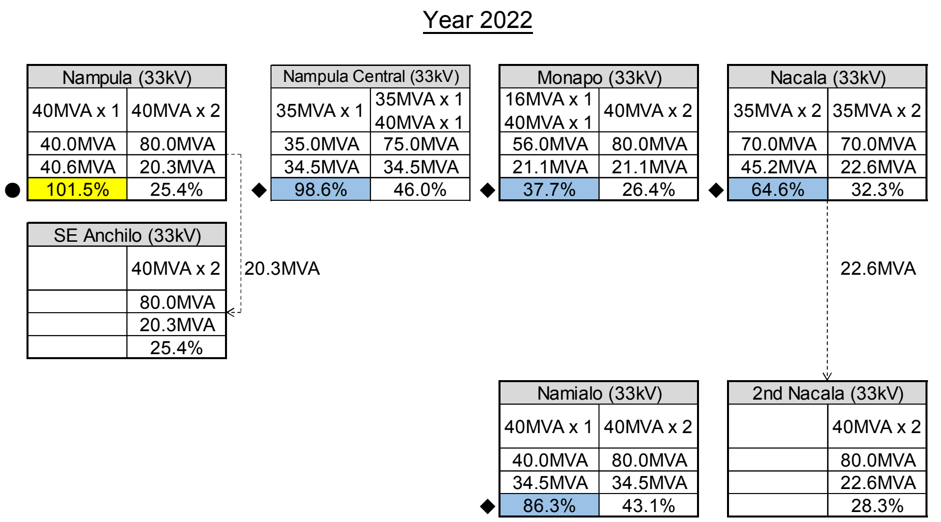
Source: JICA Study Team

Figure 7.2-14　Demand of each distribution substation in Nampula province in 2021

Figure 7.2-15 shows demand of each distribution substation in Maputo province in 2022. Black square mark represents not to meet N-1 criterion in 2022. Following measures are necessary.

・Installation of new additional 40 MVA transformer to SE Nampula, SE Nampula Central, SE Monapo, SE Namialo and Nacala Vale

・Construction of SE 2nd Nampula



Source: JICA Study Team

Figure 7.2-15 Demand of each distribution substation in Nampula province in 2022

Table 7.2-6 shows the measures for distribution substation in Nampula province from 2018 to 2022.

Table 7.2-6 Measures for distribution substation in Nampula province from 2018 to 2022

Area	Year	New distribution substation	Additional transformer (including replacement)	Mobile substation	
				Installation	Removal
Nampula province	2018	SE Namialo			
	2019		SE Monapo		
	2020				
	2021				
	2022	SE Anchilo 2nd SE Nacala	SE Nampula, SE Nampula Central SE Namialo, SE Nacala, SE Monapo		

Source: JICA Study Team

7.2.4 Proposal for review of distribution substation development plan

Peak demand in distribution network is recorded in summer (January or February). It is possible to formulate a more effective distribution development plan by comparing the demand forecast with the actual demand and reviewing the distribution substation development plan in March every year. Additionally, it is possible to formulate a more effective distribution development plan by investigating switchover load between substations based on reviewed distribution substation development plan. To investigate switchover load between substations, detailed investigation based on site survey is required for poles, overhead lines and underground cables.

7.3 Utilization methodology of mobile substation

Utilization methodology of mobile substation is as follows;

・Bypass power supply when inspection and replacement of transformer in distribution substation.

・Bypass power supply to recover outage due to failure of transformer.

Since SE 7 demand exceeds transformer capacity in 2018 as shown in Figure 7.2-1, mobile substation should be installed to SE 7. Arrangement plan of mobile substation should be established in line with future demand of distribution substation.

When failure of transformer occurred, mobile substation has to be installed immediately to distribution substation and needs to supply electricity. JICA Study Team proposes the following utilization methodology of mobile substation to recover failure promptly.

1: Utilization for education and training when mobile substation is not operated.

2: Grasp mobile substation installation time for all substations in advance.

Generally, mobile substation does not accumulate operation data necessary for power system operation such as transformer operation ratio, date of peak demand occurrence and relay condition. Therefore, mobile substation should be operated carefully.

7.4 Construction cost of distribution facilities

The construction cost of distribution facilities consists of the costs by EDM construction and contractor construction. When construction scale is large and it is difficult to construct by EDM itself, EDM contracts with overseas contractors as well as domestic contractors and outsources distribution line construction.

7.4.1 EDM construction cost

There are transformers for overhead line (Figure 7.4-1) and underground line (Figure 7.4-2). Transformers for underground line are mainly found in Maputo city.

Source: JICA Study Team

Figure 7.4-1 Transformer for overhead line (100kVA)

Source: JICA Study Team

Figure 7.4-2 Transformer for underground line (315kVA)

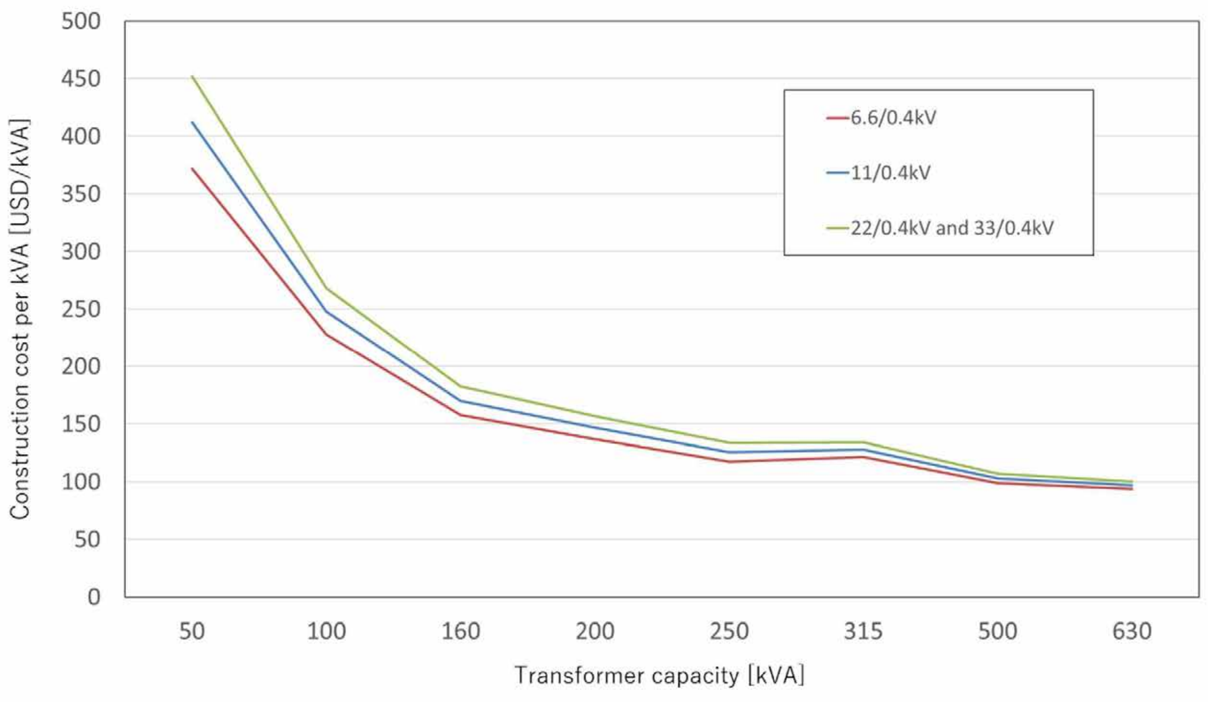
Table 7.4-1 shows the construction cost of transformer for overhead line. As the transformer capacity and primary side voltage increase, the construction cost increases.

Table 7.4-1 EDM construction cost of transformer for overhead line

Capacity [kVA]	Transformation ratio	Construction cost [USD]	Construction cost per kVA [USD/kVA]
50	6.6/0.4kV	18,600	372
	11/0.4kV	20,600	412
	22/0.4kV	22,600	452
	33/0.4kV	22,600	452
100	6.6/0.4kV	22,800	228
	11/0.4kV	24,800	248
	22/0.4kV	26,800	268
	33/0.4kV	26,800	268
160	6.6/0.4kV	25,200	157.5
	11/0.4kV	27,200	170
	22/0.4kV	29,200	182.5
	33/0.4kV	29,200	182.5
200	6.6/0.4kV	27,400	137
	11/0.4kV	29,400	147
	22/0.4kV	31,400	157
	33/0.4kV	31,400	157
250	6.6/0.4kV	29,400	117.6
	11/0.4kV	31,400	125.6
	22/0.4kV	33,400	133.6
	33/0.4kV	33,400	133.6
315	6.6/0.4kV	38,200	121.3
	11/0.4kV	40,200	127.6
	22/0.4kV	42,200	134.0
	33/0.4kV	42,200	134.0
500	6.6/0.4kV	49,400	98.8
	11/0.4kV	51,400	102.8
	22/0.4kV	53,400	106.8
	33/0.4kV	53,400	106.8
630	6.6/0.4kV	59,200	94.0
	11/0.4kV	61,200	97.1
	22/0.4kV	63,200	100.3
	33/0.4kV	63,200	100.3

Source: JICA Study Team based on EDM information

Figure 7.4-3 shows the construction cost of transformer for overhead line per capacity. As the transformer capacity increases, the construction cost per capacity decreases. In other words, the construction cost can be reduced by installing a transformer to meet demand.



Source: JICA Study Team based on EDM information

Figure 7.4-3 EDM construction cost of transformer for overhead line per capacity

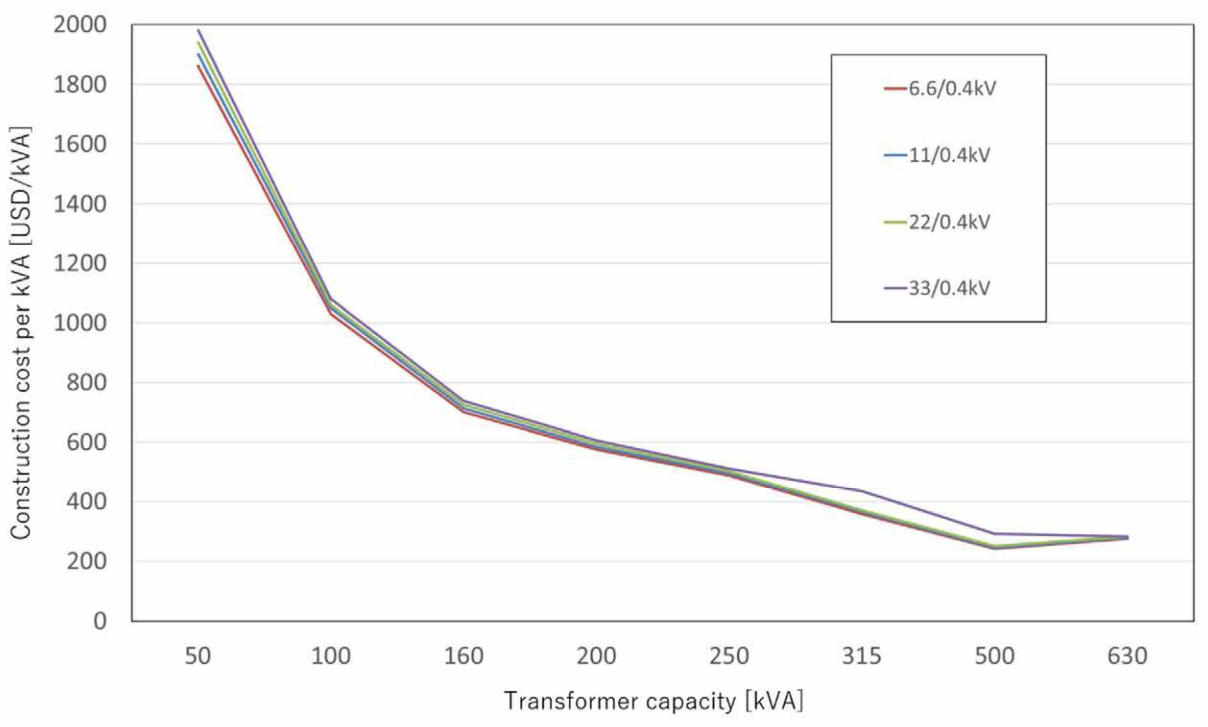
Table 7.4-2 shows the construction cost of transformer for underground line. As the transformer capacity and primary side voltage increase, the construction cost increases.

Table 7.4-2 EDM construction cost of transformer for underground line

Capacity [kVA]	Transformation ratio	Construction cost [USD]	Construction cost per kVA [USD/kVA]
50	6.6/0.4kV	93,000	1860
	11/0.4kV	95,000	1900
	22/0.4kV	97,000	1940
	33/0.4kV	99,000	1980
100	6.6/0.4kV	103,000	1030
	11/0.4kV	105,000	1050
	22/0.4kV	106,000	1060
	33/0.4kV	108,000	1080
160	6.6/0.4kV	112,200	701.3
	11/0.4kV	114,200	713.8
	22/0.4kV	116,200	726.3
	33/0.4kV	118,200	738.8
200	6.6/0.4kV	115,200	576
	11/0.4kV	117,000	585
	22/0.4kV	119,200	596
	33/0.4kV	121,200	606
250	6.6/0.4kV	121,800	487.2
	11/0.4kV	123,800	495.2
	22/0.4kV	125,800	503.2
	33/0.4kV	127,800	511.2
315	6.6/0.4kV	112,800	358.1
	11/0.4kV	114,800	364.4
	22/0.4kV	116,800	370.8
	33/0.4kV	136,800	434.3
500	6.6/0.4kV	120,800	241.6
	11/0.4kV	122,800	245.6
	22/0.4kV	124,800	249.6
	33/0.4kV	145,500	291
630	6.6/0.4kV	173,800	275.9
	11/0.4kV	175,800	279.0
	22/0.4kV	177,800	282.2
	33/0.4kV	177,800	282.2

Source: JICA Study Team based on EDM information

Figure 7.4-4 shows the construction cost of transformer for overhead line per capacity. As the transformer capacity increases, the construction cost per capacity decreases. In other words, the construction cost can be reduced by installing a transformer to meet demand.



Source: JICA Study Team based on EDM information

Figure 7.4-4　EDM construction cost of transformer for underground line per capacity

Table 7.4-3 shows the construction cost of MV line per kilometer. The construction cost includes material cost, transportation cost and labor cost.

Table 7.4-3　EDM construction cost of MV line per kilometer

Designation	Unit	Unit cost [USD]			Qty	Total Cost [USD]
		Material	Transportation	Installation		
Wooden pole (12.25m)	pole	164.3	29.4	77.5	13	3,525
AAAC 150mm²	m	1.9	0.1	0.8	3,000	8,450
Accessories (insulator, screw etc.)						6,016
TOTAL						**17,991**

Source: JICA Study Team based on EDM information

Table 7.4-4 shows the construction cost of LV line per kilometer. The construction cost includes material cost, transportation cost and labor cost.

Table 7.4-4 EDM construction cost of LV line per kilometer

Designation	Unit	Unit cost [USD]			Qty	Total Cost [USD]
		Material	Transportation	Installation		
Wooden pole (9m)	pole	85.1	22.0	42.9	25	3,751
ABC cable 4x95+70mm^2	m	4.3	0.1	1.8	1,000	6,233
Accessories (connector, screw etc.)						4,951
TOTAL						**14,936**

Source: JICA Study Team based on EDM information

Table 7.4-5 shows the construction cost for single-phase contract households and three-phase contract households respectively. The construction cost includes labor cost and accessories cost such as meter board and screw besides a service wire and a meter.

Table 7.4-5 EDM construction cost for single-phase contract households

Designation	Qty	Unit Price [USD]	Total Price [USD]
ABC cable 2x10 mm^2	40	0.8	32
Meter	1	77.7	77.7
Accessories (meter board, screw etc.)			11.4
Labor cost			14.3
Subtotal			135.3
Tax			23.0
Total			158.3

Source: JICA Study Team based on EDM information

Table 7.4-6 shows the construction cost for single-phase contract households and for three-phase contract households respectively. The construction cost includes labor cost and accessories cost such as meter board and screw besides a service wire and a meter.

Table 7.4-6 EDM construction cost for three-phase contract households

Designation	Qty	Unit Price [USD]	Total Price [USD]
ABC cable 4x16 mm^2	40	2.3	92.0
Meter	1	126.5	126.5
Accessories (meter board, screw etc.)			15.5
Labor cost			19.8
Subtotal			253.7
Tax			43.1
Total			296.9

Source: JICA Study Team based on EDM information

7.4.2 Contractor construction cost

When construction scale is large and it is difficult to construct by EDM itself, EDM contracts with overseas contractors as well as domestic contractors and outsources distribution line construction. This construction cost is reviewed every year and it is applied for one year after the decision, even if the exchange rate changes within contract year.

7.5 Connection fee which is borne by customers for new connection

The customers have to pay the connection fee to EDM for new connection as shown in Table 7.5-1. The connection fee depends on contract. The new customers bear about 30% of the EDM connection cost. There are customers who cannot pay connection fee and they give up to access to electricity[83]. The connection fee represents a significant burden for customers. Therefore, electrification will be accelerated by setting connection fee appropriate for customer's economic conditions[84].

Table 7.5-1 Connection fee which is borne by customers for new connection

Contract type	Price [USD]	Price [MZN]
Connection fee for single-phase installation	55	3,501
Connection fee for three-phase installation	126	7,980

Source: EDM

7.6 Distribution investment plan

There are two types of budget for distribution line construction. One is the budget for construction by EDM while the other is the budget for construction by donor support.

7.6.1 The budget of distribution line construction which is supported by donors

EDM needs to pursue steady implementation of expansion and rehabilitation of distribution line to improve electrification ratio and electricity supply reliability. It is important to continuously implement the projects which are not being implemented, considering the deterioration of the distribution facilities. Therefore, distribution investment plan which adds donor support project to the previous Master Plan[85] should be established. Distribution development plan is established for Maputo city, Maputo province and Nampula province, however, all distribution projects are prioritized from the viewpoint of financial aspects.

Conditions for investigation of distribution investment plan are as follows;

・Each distribution project is categorized into "electrification", "reinforcement" and "rehabilitation" for prioritization of them.

・Current project cost is obtained by multiplying the cost of the previous Master Plan by the escalation

83 Interview for Nampula ASC
84 Development of NESP to Accelerate Universal Access to Energy in Mozambique by 2030, World Bank
85 Master Plan Update Report 2012-2027, Norconsult

rate, 2.5% per year.

・The escalation rate is not used for on-going project.

・If project start year of electrification, reinforcement and rehabilitation project overlap in the same year, overlapped all projects are implemented.

・If start year of several electrification projects overlap in the same year, high priority is given to project with low electrification cost per customer.

・If start year of several reinforcement projects overlap in the same year, high priority is given to project with a large number of electrified customer.

・If start year of several rehabilitation projects overlap in the same year, high priority is given to project with a large number of electrified customer.

・Project start year is adjusted so that investment cost of each year from 2018 to 2024 flats as possible.

Table 7.6-1 shows distribution investment plan from 2018 to 2024. Black circle mark represents the projects in Maputo city, Maputo province and Nampula province. The budget is 1,234 million USD in whole EDM, 327 million USD in Maputo city, 288 million USD in Maputo province and 71 million USD in Nampula province.

Table 7.6-1 Distribution investment plan from 2018 to 2024

	Project No	Financier	Project Name	Province	Start year	End year	Category	Total Budget [MUSD]	New Customers	Cost per Customer [USD]	2018	2019	2020	2021	2022	2023	2024
			Northern Area ASC														
	Urgent ID2	AfDB	New SE Anchilo construction		2016	2018	Reinforcement	9.19	-	-	9.19						
	Urgent ID11	AfDB	Rehabilitation of the Network in Nampula		2016	2018	Rehabilitation	5.00	-	-	5.00						
	Emergency	WB	Rehabilitation of distribution network in Nacala		2017	2019	Rehabilitation	8.54	4,670	1,829	4.27	4.27					
	0-1a-N		Network Rehabilitation, Reinforcement and Expansion in Pemba City	Cabo delgado			Electrification	11.99	4,040	2,969	6.00	5.99					
	0-1b-N		Network Rehabilitation, Reinforcement and Expansion in ASC Pemba	Cabo delgado			Electrification	17.79	4,600	3,866		8.89	8.90				
	0-2-N		Network Rehabilitation, Reinforcement and Expansion in ASC Lichinga	Niassa			Electrification	19.12	4,050	4,720		9.56	9.56				
●	0-4-N		Network Rehabilitation, Reinforcement and Expansion in ASC Nampula	Nampula			Electrification	5.66	1,080	5,238		2.83	2.83				
●	1-69-N		Rehabilitation and Expansion of the Distribution Network of Nampula	Nampula			Electrification	42.43	16,000	2,652			14.15	14.14	14.14		
	1-66-N		Rehabilitation and Strengthening of the Distribution Network in Pemba	Cabo delgado			Rehabilitation	10.11	2,150	4,705				5.06	5.05		
	2-68-N		Rehabilitation of Distribution Network in Lichinga	Niassa			Rehabilitation	20.37	15,100	1,349				10.19	10.18		
	2-70-N		Close to border Areas Electrification of the North Region	Niassa			Electrification	3.82	671	5,699				1.91	1.91		
●	2-71-N		Supply to Agriculture Development in Northern region	Nampula, Cabo delgado, Niassa			Electrification	22.88	3,591	6,371						11.44	11.44
	3-64-N		Rehabilitation, Strengthening and Expansion of Distribution Network in	Niassa			Electrification	12.42	3,045	4,080						6.21	6.21
							Northern area total	189.31	58,997		24.46	31.54	35.44	31.30	31.28	17.65	17.65
			Central Area ASC														
	Urgent 10	AfDB	Replacement of overloaded 11kV cable of SE Nova		2016	2018	Reinforcement	11.70	-	-	11.70						
	0-3a-CN		Network Rehabilitation, Reinforcement and Expansion in Tete City	Tete			Electrification	5.51	2,152	2,561	5.51						
	0-3b-CN		ASC Tete – Moatize Network Rehabilitation, Reinforcement and Expansion	Tete			Electrification	5.32	1,329	4,000	5.32						
	0-2-CN		Network Rehabilitation, Reinforcement and Expansion in ASC Quelimane	Zambezia			Electrification	15.66	4,085	3,833	7.83	7.83					
	0-1-CN		Network Rehabilitation, Reinforcement and Expansion in ASC Mocuba	Zambezia			Electrification	35.62	5,500	6,476		17.81	17.81				
	1-70-CN		Close to border Electrification of Milange	Zambezia			Electrification	15.08	5,100	2,957			7.54	7.54			
	1-45-CN		ASC Tete - Strengthening of Tete distribution capacity - Phase 2	Tete			Reinforcement	27.63	2,870	9,627				13.82	13.81		
	2-48-CN		Quelimane Network Rehabilitation	Zambezia			Rehabilitation	15.62	1,000	15,625				7.81	7.81		
	2-50-CN		Supply to Agriculture Development in Central region	Zambezia, Tete, Manica, Sofala			Electrification	88.76	8,410	10,554					29.59	29.59	29.58
							Central norhern area total	220.90	30,446		30.36	25.64	25.35	29.17	51.21	29.59	29.58
	STIP 8	Danida/kfW/EIB	Rehabilitation and Reinforcement of the Network of Munhava in Beira city		2016	2018	Reinforcement	2.10	333	6,300	2.10						
		Elsewed Electric	Rehabilitation and Reinforcement of the network of Chimoio and Messica		2016	2018	Reinforcement	7.34	-	-	7.34						
	0-1-C		ASC Chimoio Network Rehabilitation, Reinforcement and Expansion	Manica			Electrification	32.58	8,826	3,692	16.29	16.29					
	0-2-C		ASC Beira Network Rehabilitation, Reinforcement and Expansion	Sofala			Electrification	21.27	1,400	15,193		10.64	10.63				
	1-41-C		Rehabilitation and Extension of Distribution Networks in the Beira Corridor	Manica, Sofala			Electrification	17.31	3,715	4,660			8.66	8.65			
	1-82-C		Rural Electrification of Sofala North Administrative Posts	Sofala			Electrification	23.56	1,675	14,063			11.78	11.78			
	2-70-C		Close to border Areas Electrification of the Central Region	Tete, Manica, Zambezia			Electrification	15.60	3,440	4,535					7.80	7.80	
	2-50b-C		Supply to Agriculture Development around Vanduzi in Central Region	Manica			Electrification	6.34	880	7,200							6.34
							Central area total	126.10	20,270		25.73	26.93	31.06	20.43	7.80	7.80	6.34
			Southern Area ASC														
	Urgent ID8	AfDB	Rehabilitation, reinforcement and expansion of Matola city network		2016	2018	Reinforcement	6.70	1,039	6,452	6.70						
●	0-4-S		Network Rehabilitation, Reinforcement and Expansion ASC Maputo Province	Maputo			Electrification	53.97	24,500	2,203	17.99	17.99	17.99				
	0-1-S		Network Rehabilitation, Reinforcement and Expansion ASC Inhambane	Inhambane			Electrification	48.16	11,900	4,047	16.06	16.05	16.05				
	0-2-S		Network Rehabilitation, Reinforcement and Expansion ASC Xai-Xai	Gaza			Electrification	13.46	2,200	6,120	6.73	6.73					
	0-3-S		Network Rehabilitation, Reinforcement and Expansion ASC Chokwe	Gaza			Electrification	14.44	1,600	9,023		7.22	7.22				
●	1-13-S		Strengthening Primary and Secondary Network in Matola	Maputo			Reinforcement	16.52	-	-			8.26	8.26			
●	1-13b-S		Rehabilitation and Construction of new Switching Stations (PS) in Maputo pro	Maputo			Rehabilitation	8.15	-	-			4.08	4.07			
●	1-26-S		Supply to Agriculture Development in Southern region	Maputo, Inhambane, Gaza			Electrification	58.72	9,200	6,383			19.58	19.57	19.57		
●	2-25-S		Electrification of the Southern Region close to border areas	Maputo			Electrification	7.85	*500*	15,704				3.93	3.92		
●	3-90-S		Urban and Rural Electrification in Maputo Province	Maputo			Electrification	81.22	*62,000*	1,310					27.08	27.07	27.07
●	3-143-S		Rehabilitation and Expansion of Matola Distribution Network	Maputo			Electrification	26.90	*12,940*	2,079					13.45	13.45	
●	3-86-S		Reinforcement of Matola Network	Maputo			Electrification	34.95	*9,667*	3,615						17.48	17.47
							Southern area total	371.05	135,545		47.48	47.99	73.18	35.83	64.02	58.00	44.54
			Maputo City ASC														
●	Emergency ID3	STEEL/ERI	Rehabilitation and reinforcement of the Maputo city network		2016	2018	Reinforcement	7.39	-	-	7.39						
●	Urgent ID9	AfDB	Rehabilitation of Maputo city network		2016	2018	Rehabilitation	7.00	350	20,000	7.00						
●	1-1-MC		ASC Maputo City – Reinforcement of Maputo – Phase II	Maputo city			Reinforcement	99.41	-	-	49.71	49.70					
●	1-158-MC		KaTembe Development Project in Maputo City Phase I	Maputo city			Electrification	22.94	3,500	6,555		11.47	11.47				
●	2-16-MC		Rehabilitation and Strengthening of the Distribution Network of Maputo City	Maputo city			Electrification	56.57	20,000	2,828			28.29	28.28			
●	2-159-MC		KaTembe Development Project in Maputo City Phase II	Maputo city			Electrification	23.78	22,000	1,081				11.89	11.89		
●	3-127-MC		Reinforcement and Extension of Maputo Netgrid Phase I	Maputo city			Reinforcement	17.11	3,070	5,573				8.56	8.55		
●	3-131-MC		Reinforcement and Extension of Maputo Netgrid Phase II	Maputo city			Reinforcement	21.79	7,270	2,997						10.90	10.89
●	3-145-MC		Rehabilitation and Reinforcement of Maputo city MV and LV Network	Maputo city			Rehabilitation	36.09	18,000	2,005						18.05	18.04
●	3-144-MC		Network Rehabilitation, Expansion Reinforcement and Service Connections i	Maputo city			Electrification	34.96	16,971	2,060							34.96
							Maputo city total	327.04	91,161		64.1	61.2	39.8	48.7	20.4	28.9	63.9
							Total - Distribution Projects	1234.40	336,419		192.13	193.27	204.79	165.46	174.75	141.99	162.00

Source: JICA Study Team based on existing Master Plan

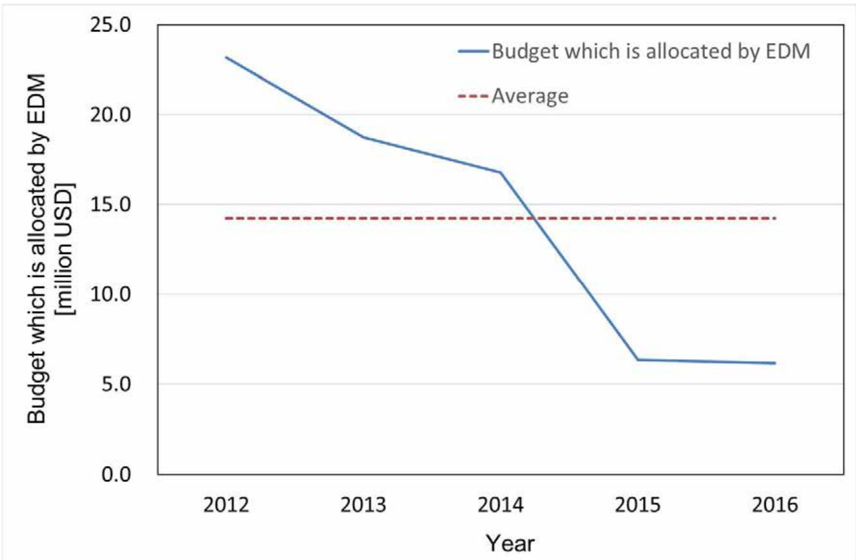
7.6.2 The budget of distribution line construction by EDM

According to EDM budget document, PAO (*Plano de Actividades e Orçamento*) and exchange rate used for financial analysis (Table 7.6-2), dollar-based EDM budget is shown in Figure 7.6-1. It is decreasing year by year from 2012, and the budget in 2016 is 27% of the budget in 2012 in USD-base.

Table 7.6-2 Exchange rate from 2012 to 2016 [MZN/USD]

Year	2012	2013	2014	2015	2016
Exchange rate [MZN/USD]	29.0	29.0	33.0	38.7	63.1

Source: EDM



Source: JICA Study Team

Figure 7.6-1 Budget of distribution line construction by EDM (USD-base)

7.6.3 Distribution budget from 2018 to 2042

Since distribution facilities to be rehabilitated will increase with acceleration of electrification to achieve universal access, EDM needs to secure a budget to expand and rehabilitate distribution facilities. Therefore, it is assumed that EDM budget should be increased to average (14.2 million USD). According to EDM budget document, PAO 2016, 49.5% of distribution budget was used as rehabilitation budget. Therefore, it is assumed that rehabilitation budget is 7 million USD per year. Electrification budget is estimated in section 8.5.

Table 7.6-3 shows the distribution budget until 2042. Total amount of distribution budget is 6,587 million USD (263 million USD per year).

Table 7.6-3 Distribution budget from 2018 to 2042

[million USD]

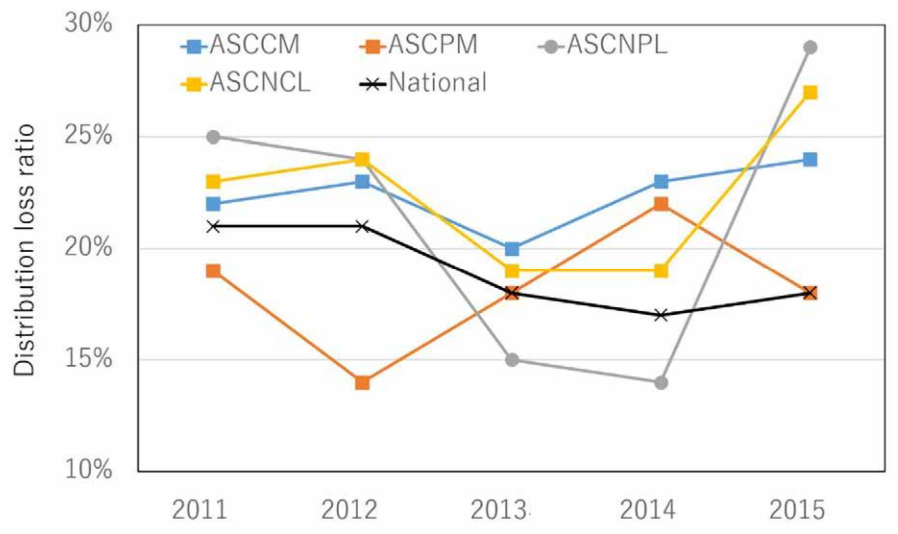
		Distribution budget	
		Total	per year
Rehabilitation budget	Budget from EDM	176	7
	Budget from donors	1,461	58
Electrification budget		4,950	198
Total		6,587	263

Source: JICA Study Team

7.7 Distribution loss

Figure 7.7-1 shows the distribution loss ratio in each ASC and country. EDM target of transmission and distribution loss is approximately 10% in 2024. However, distribution loss still be high and it should be reduced. Distribution loss reduction will have the same effect as increasing supply capability through construction of new power stations. In other words, distribution loss reduction projects will reduce construction cost and operation cost (including fuel cost) of power stations.

High distribution losses can be attributed to technical loss caused by long length distribution lines and the inadequate connection of LV distribution lines, and non-technical loss, such as electricity theft and inaccurate metering[86]. Electricity theft is caused by illegal connection to LV bare wires or by tampering with meters.



Source: JICA Study Team

Figure 7.7-1 Distribution loss ratio in each ASC and country

[86] It is difficult to acquire measured value in which technical loss and non-technical loss are separated. The approximate value of technical loss can be calculated by using the value of wire resistance and current, but the data necessary for the calculation are so insufficient that the values of technical loss and non-technical loss cannot be separated at present.

7.7.1 Technical loss

Figure 7.7-2 shows non-standard connection of distribution line in some areas. Customer are receiving electricity by themselves using wood and wire instead of electricity pole and conductor. Since resistivity of wire (galvanized iron wire) is higher than that of copper wire, it causes technical loss increase. Additionally, since bare wire is used instead of insulated wire, customer can easily connect to the wire. Therefore, technical loss will increase due to inadequate connection of LV distribution lines and non-technical loss will increase due to electricity theft. Moreover, since it is a dangerous facility from the viewpoint of public security, EDM promotes to eliminate non-standard connection.

Figure 7.7-3 shows customer-to-customer connection in densely populated area, which causes technical loss increase. Generally, customers are connected from the nearest LV line. If there is no LV line nearby, higher priority is given to customer-to-customer connection to supply electricity rapidly and inexpensively. EDM has the following issues for customer-to-customer connection.

・If power outage occurs in a house somewhere, other houses will also suffer power outage.

・It is difficult to identify the cause of failure, and it takes much time to recover from the power outage.

・Since there is no space in densely populated area, wooden or concrete poles cannot be carried and constructed.

Installation of "panzer mast[87]" is one of solution. Instructions and directions for use of panzer mast are as follows;

・Since panzer mast is easier to rust than concrete pole, thorough periodic inspection is required.

・If guy wire is installed to a pole that high tensile force is applied such as pole at the end of distribution line, guy wire should be installed to such poles.

Source: JICA Study Team

Figure 7.7-2 Non-standard connection of distribution line

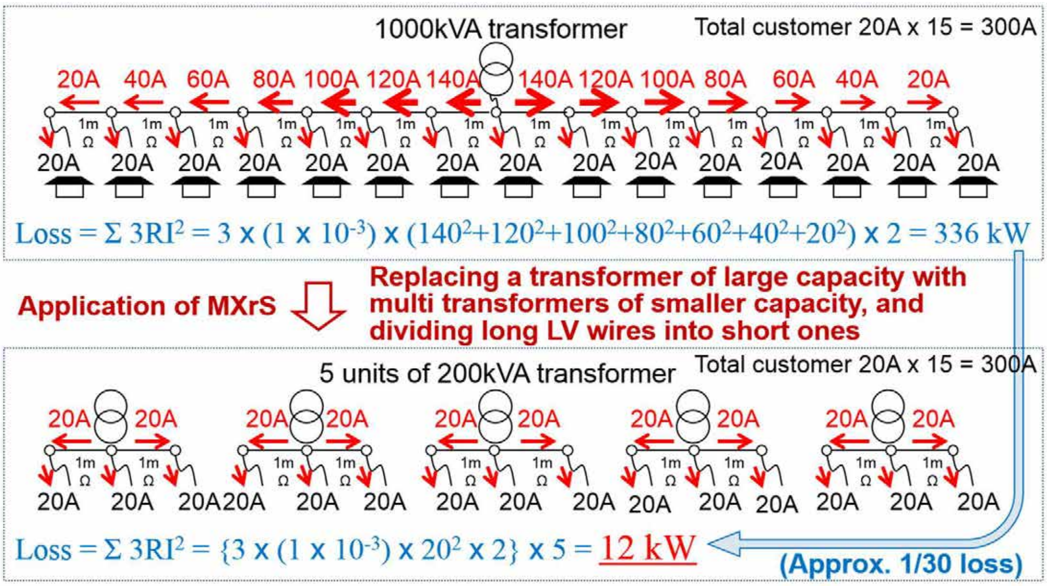
[87] Panzer mast is a steel plate assembly pole, which is assembled by joining tubular component parts into one pole. Each component part is about 2m, which can be assembled into electric poles of various lengths for many purpose.
Panzer mast is very easy to assemble and construct because special tools and skills are not needed.

Source: JICA Study Team

Figure 7.7-3 Customer to customer connection

7.7.2 Distribution loss reduction by introducing multi transformer system

According to the EDM distribution network design manual, LV line should be installed to be less than 500m. Actually, LV line lengths exceeds 500m as described in section 7.1. It is expected that technical loss is large due to long length LV line and it should be reduced. Therefore, the introduction of multi transformer system (Figure 7.7-4) is proposed. Distribution loss can be reduced drastically by introducing multi transformer system.



Source: JICA Study Team

Figure 7.7-4 Multi transformer system

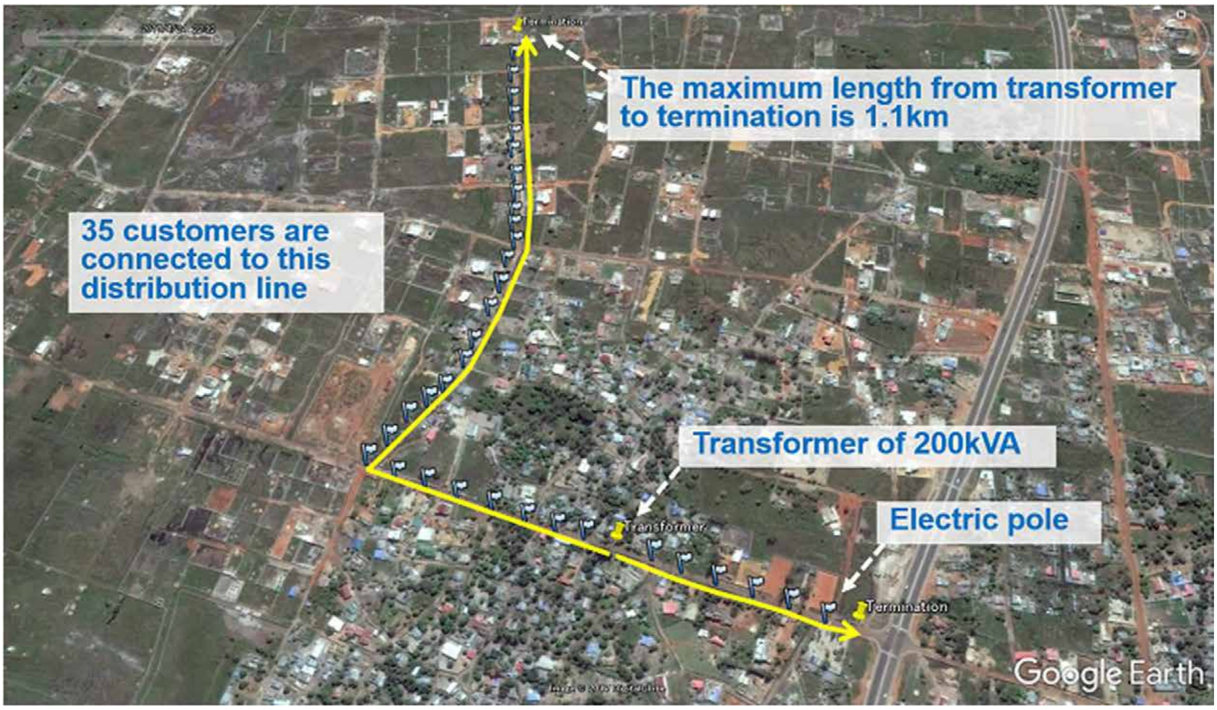
Figure 7.7-5 shows existing distribution line in Maputo province. The maximum LV line length from transformer to the end of LV line is 1.1km. Figure 7.7-6 shows LV line introduced multi transformer system. New additional transformer is installed at the center of load.

Table 7.7-1 shows distribution loss and loss reduction ratio before and after the introduction of multi transformer system. It shows that distribution loss can be reduced drastically by introducing multi transformer system. MV line extension and additional transformer installation are required, the initial investment cost should be evaluated.

Table 7.7-1 Distribution loss and loss reduction ratio before and after the introduction of multi transformer system

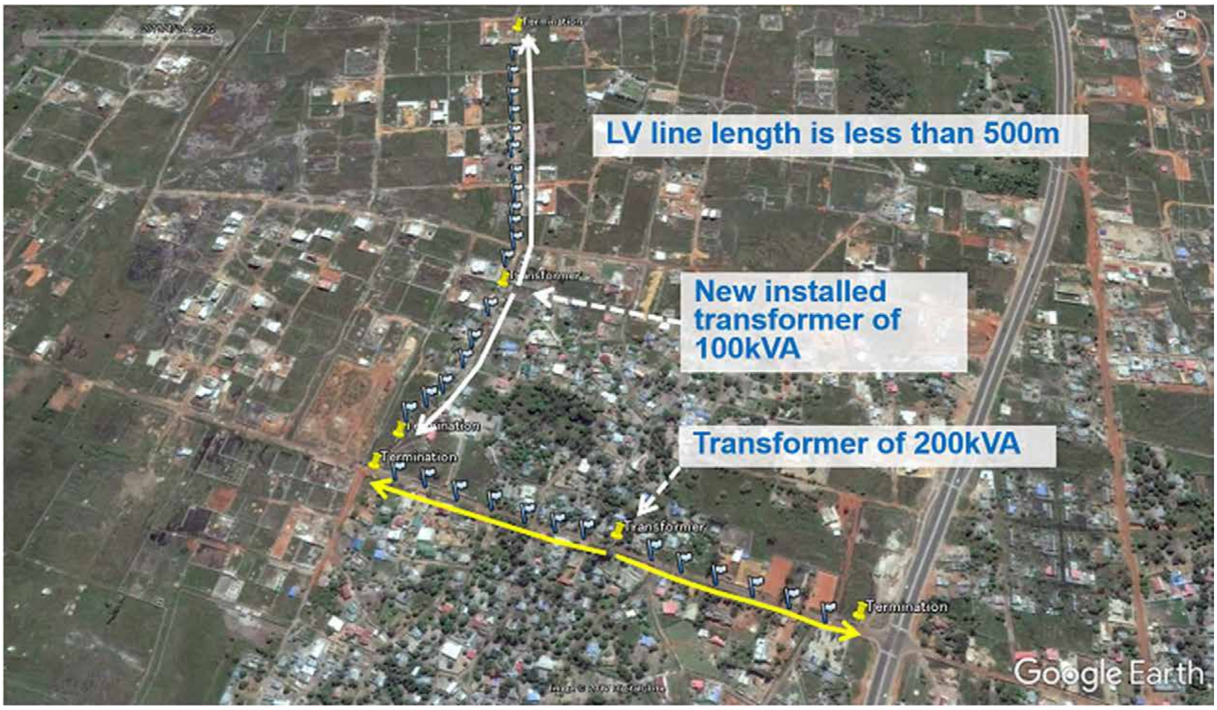
Current distribution lines	After the introduction of multi transformer system	Loss reduction ratio
746.6W	112.3W	85%

Source: JICA Study Team



Source: JICA Study Team

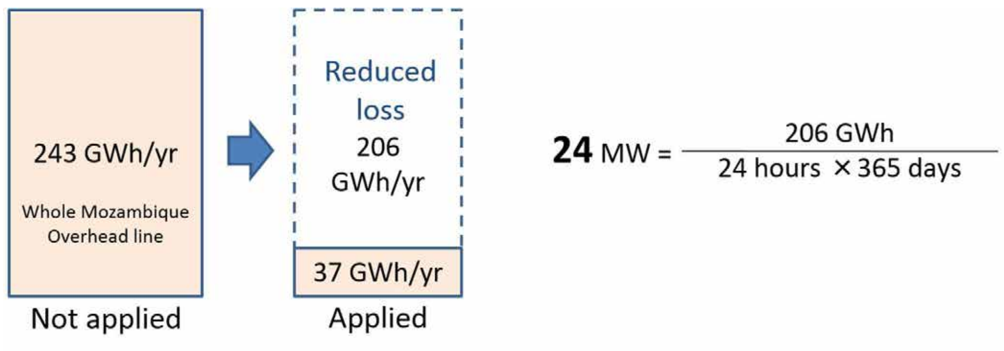
Figure 7.7-5 Existing distribution line in Maputo province



Source: JICA Study Team

Figure 7.7-6 LV line introduced multi transformer system

Figure 7.7-7 shows the amount of distribution loss reduction based on Table 7.7-1, if multi transformer system is installed to overhead line in whole Mozambique. It is expected that the distribution loss will be reduced by 206GWh per year. The reduced loss of 206 GWh/year is worth of the power of a 24MW power plant.



Source: JICA Study Team

Figure 7.7-7 The amount of distribution loss reduction before and after the introduction of multi transformer system to overhead line in whole Mozambique.[88]

The effect of loss reduction improved by multi transformer system would be equivalent to the power of a 24 MW power plant, which would cost about 461 MIL USD for 25 years as shown in Table 7.7-2. Meanwhile, the project cost for introduction of multi transformer system is 317 million USD. Multi transformer system

88 Demand after 10 years is two times as much as the one in 2017 Based on demand forecast in this study.

can reduce construction cost and operation cost (including fuel cost) of power stations.

Table 7.7-2 Total cost of 24MW power plant for 25 years[89]

[million USD]

Initial cost for CCGT plant	41
Fuel cost and O&M cost for 25 years	420
Total	461

Source: JICA Study Team

7.7.3 Non-technical loss

EDM selects meter to be installed in the house so that electricity tariff can be reliably collected. EDM has post-paid meter (Figure 7.7-8), pre-paid meter (Figure 7.7-9) and split meter (Figure 7.7-10). In the past, post-paid meters were installed, but it may have contributed to non-technical losses due to electricity theft and inaccurate meter readings. At present, pre-paid meters are mainly installed, and the replacement of post-paid meters by pre-paid meters is being conducted in the country (Figure 7.7-11 ~ Figure 7.7-15).

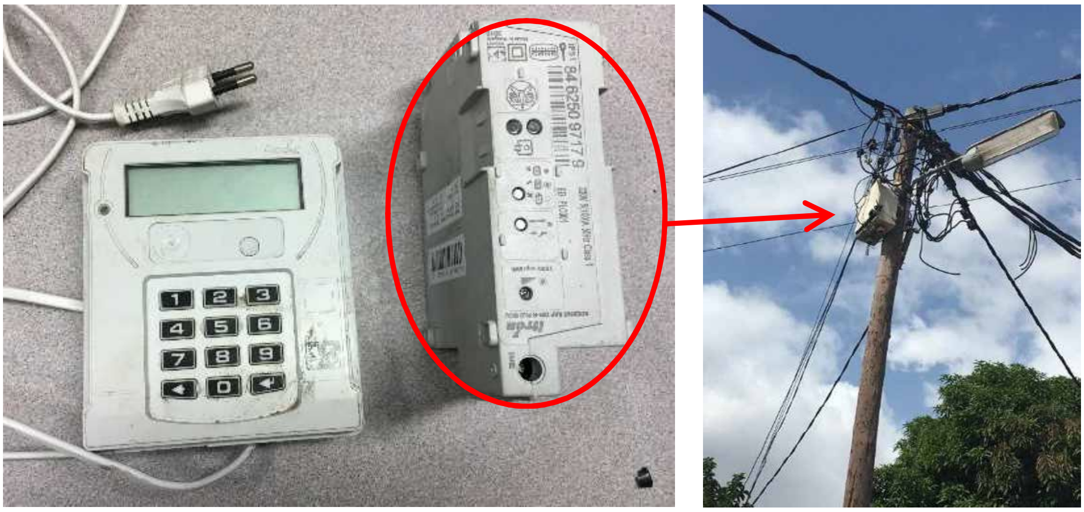
Source: JICA Study Team

Figure 7.7-8 Post-paid meter

[89] Assumptions: Power generation system is CCGT. Its construction cost is 1,700 USD/kW. Fuel cost is 3.7 cents/kWh. Fix value is 8.7 million USD/year and variable value is 2.4 USD/MWh as operation and maintenance cost.

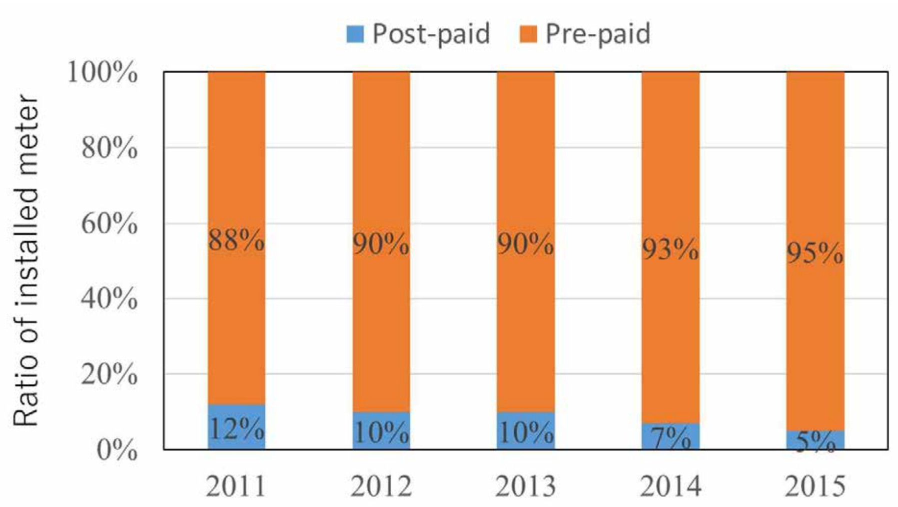
Source: JICA Study Team

Figure 7.7-9 Pre-paid meter



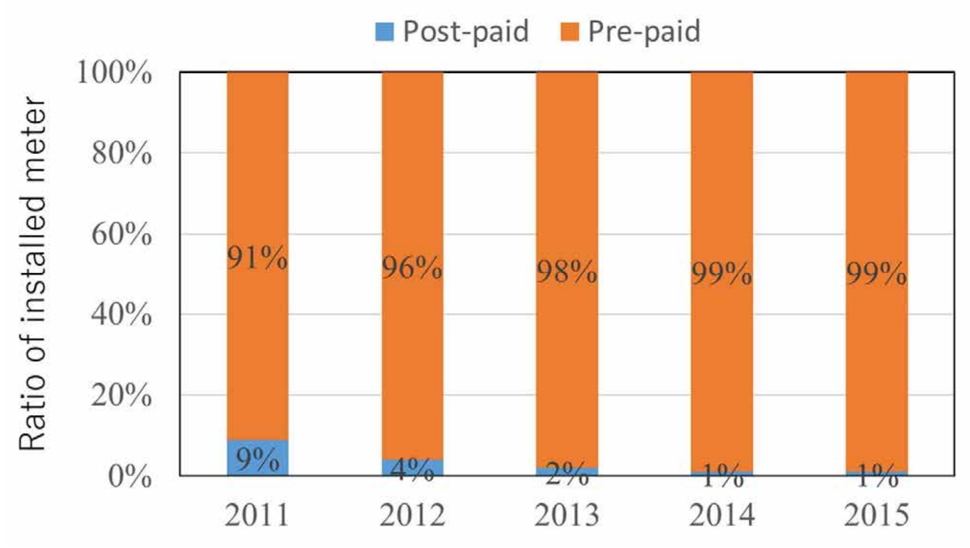
Source: JICA Study Team

Figure 7.7-10 Split meter



Source: JICA Study Team based on EDM information

Figure 7.7-11 Ratio of installed post-paid meter and pre-paid meter in Maputo city

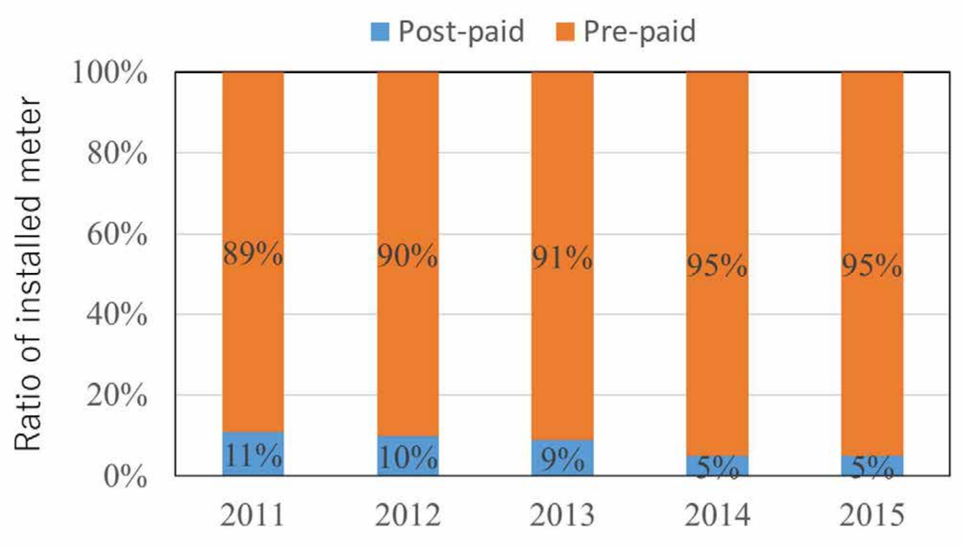


Source: JICA Study Team based on EDM information

Figure 7.7-12 Ratio of installed post-paid meter and pre-paid meter in Maputo province

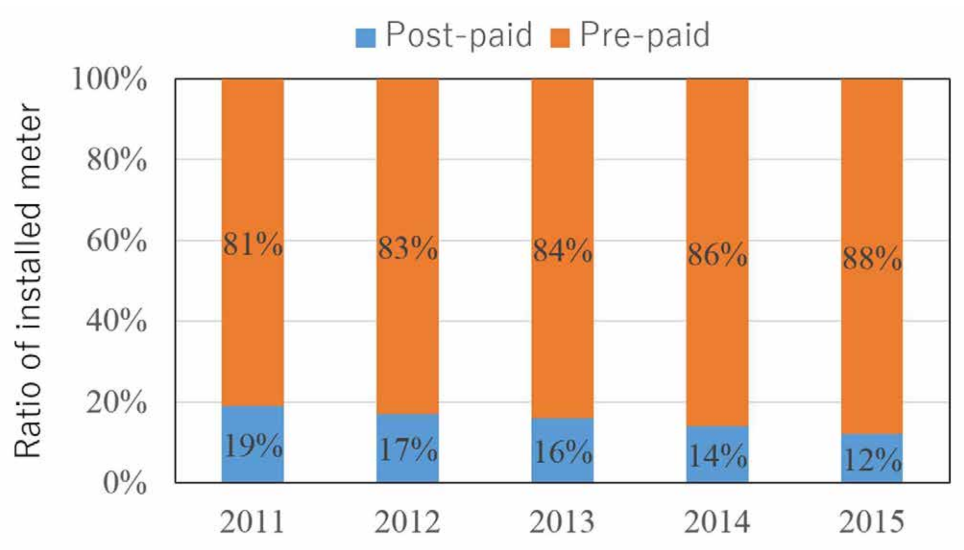
Source: JICA Study Team based on EDM information

Figure 7.7-13 Ratio of installed post-paid meter and pre-paid meter in Nampula ASC



Source: JICA Study Team based on EDM information

Figure 7.7-14 Ratio of installed post-paid meter and pre-paid meter in Nacala ASC



Source: JICA Study Team based on EDM information

Figure 7.7-15 Ratio of installed post-paid meter and pre-paid meter in the country

The flow of electricity tariff collection in the house installed post-paid meter is as follows;

1: EDM staff reads meter indicator

2: EDM staff distributes the payment slip to the customers

3: The customers pay at the nearest EDM office by the payment due date shown on the payment slip (Figure 7.7-16).

Source: JICA Study Team

Figure 7.7-16 Payment of electricity tariff at EDM office

If customer cannot pay by the payment due date, it may result in interruption of electricity supply. When customer inform EDM that they have completed payment, EDM restarts electricity supply within 7 days. EDM disconnects electricity supply up to 7 days as penalty and attempts to improve collection rate of electricity tariff. In case of Chubu Electric Power Co., Inc., if the customers pay after the regular payment period, overdue payment surcharges (0.03% per day) for the elapsed days will be added to their bill to be paid.

As mentioned above, the replacement of post-paid meters by pre-paid meters is being conducted in the country. If there is unpaid electricity tariff at the time of attaching post-paid meter, 50% of the usage amount is used for payment of the past debt at the time of purchase of the usage amount of the pre-paid meter, and EDM collects the past unpaid electricity tariff.

There are the following projects to improve collection rate of electricity tariff, which is supported by donors.

・SPEED (Support Program for Economic and Enterprise Development) project supported by USAID
Installation and calibration of meters will be promoted and "Meter-to-Cash" system which has functions of electricity tariff calculation and issuing the payment slips will be established. In addition, the capacity of EDM staff will be improved.

・SIGEM（*Sistema Integrado de Gestão da Electricidade de Moçambique*）development project supported by WB
SIGEM shares the information owned by each department of EDM throughout EDM. As of October 2017, the integration of the database of customer information, the introduction of the system of issuing the payment slip and the introduction of the system of electricity tariff collection, have been finished. The collection rate of electricity tariff has been improved from 77 percent in 2009 to 98 percent in 2016.

7.8 Investigation for the introduction of smart grid system

It is necessary to establish the basic technologies for design, operation and management of distribution facilities before the introduction of smart grid system.

7.8.1 Effect of the introduction of smart meter

The following effects can be expected by introducing smart meters.

・Reduction of labor cost and time required to meter reading work.
・Non-technical loss reduction by the improvement of metering accuracy.
・Rationalization of design of distribution facilities based on the measured value.
・Promotion of energy saving by visualization of electricity tariff and consumption.

7.8.2 Proposal for the introduction of smart grid

The following investigations are required in addition to proceeding with SIGEM development project.

①Selection of pilot area

・Validation of the effective performance of the operation with the introduction of smart meter and identification of the problems in actual operation

・Validation of the communication network system under network connection situation and identification of the problems in actual operation

②Cultivation of key person

・Validation of the communication network system and the operation and identification of the problems in actual operation

・Each ASC needs to work closely together to solve the problem, and key person takes a pivotal role for investigation through establishment of working group etc.

・Key person acquires knowledge on smart meters and takes a pivotal role for cooperation of each ASC.

・Key person facilitates explanatory meeting and working group and educates the staffs at each ASC.

7.8.3 Installation cost of smart meter

As of September 2017, the cost required to install smart meters to all customers with low voltage contract is 165 million USD as shown in Table 7.8-1. It is expected that installation cost of smart meter will increase with demand increase.

Table 7.8-1 Installation cost of smart meter to all customers with low voltage contract[90]

As of September, 2017

Tariff	The number of meters [unit]	Smart meter installation cost [USD]
Social	3,410	358,823
Domestic	1,431,243	150,605,078
General	133,128	14,008,629
Agriculture	104	10,944
Total	1,567,885	164,983,475

Source: JICA Study Team

90 Installation cost of smart meter consists of meter cost and ancillary cost as shown in Table 7.4-5 and Table 7.4-6. Unit price of single-phase meter is 48.3 USD and that of three-phase meter is 198.6 USD based on the data of ASCPM. It is assumed that single-phase contract customers accounted for 90% and three-phase contract customers accounted for 10% among all low voltage contract customers, which is obtained from interview to Maputo province ASC.

Chapter 8 Electrification Plan

8.1 Energy strategy

Energy strategy provided by MIREME (*Estrategia do Sector de Energia 2009-2013*) shows the following policies for electrification.

・Electrification ratio, 50%, should be achieved by 2023.

・Electrification ratio in rural area should be improved by the expansion and reinforcement of distribution line.

・Distribution line should be expanded to off-grid electrified area.

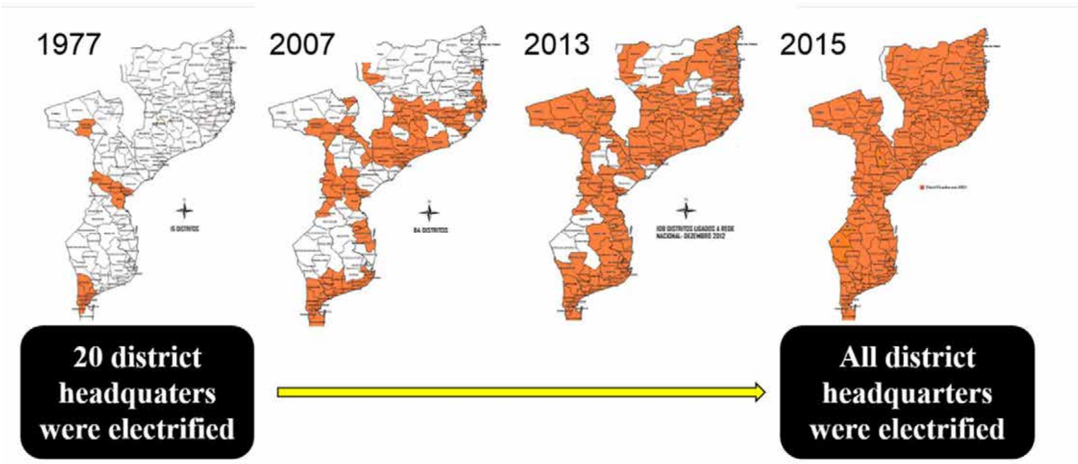
・Efficient electrification should be promoted utilizing on-grid and off-grid system.

・All the district headquarters (128) should be electrified.

The draft of the energy strategy has not been approved after 2014 and electrification has been implemented based on the above policy. Official target is to achieve universal access by 2030.

8.2 On-grid electrification

According to the government policy, 128 district headquarters were planned to connect to grid for electrification by 2014. Electrification for 128 district headquarters has been completed by 2015, as shown in Figure 8.2-1. For the future, the electrification target is planned to extend to small scale Administrative Post in step-by-step.



Source: JICA Study Team based on EDM information

Figure 8.2-1 Transition of electrified district headquarter

Figure 8.2-2 shows transition of electrification ratio for whole of country, north area, central area and south area. The average of national electrification ratio of has increased from 4.4% in 2002 to 25.9% in 2015. However, electrification ratio in north area and central area is still low.

Source: EDM Annual Report 2015

Figure 8.2-2　Transition of electrification ratio for whole of country, north area, central area and south area

Table 8.2-1 shows electrification ratio of each province. Electrification ratio in Maputo city reached 91.9%, but electrification ratio in Cabo Delgado, Niassa, Zambezia province, is still low. Disparities among cities and rural areas is getting wider. Although the grid to rural area should be extended to reduce disparities, the grid extension to low demand area may cause financial conditions worse due to low cost-effectiveness. Priority by on-grid electrification will be given as follows;

1: Local government, hospital and school

2: High population density area

3: Industry area and agriculture area

Since agriculture is economic foundation, high priority is given to the agriculture area with small energy consumption. Since low priority is given to low population density area and low cost-effectiveness area, on-grid electrification tends to slow down.

In the on-grid electrification project, if priority is given to the improvement of electrification ratio with low cost, the improvement of electrification ratio in the already electrified villages is more cost-effectiveness. On the other hand, if priority is given to the improvement of the number of electrified villages, electrification cost will increase due to extension of the distribution line to isolated villages. Prioritization depends on electrification policy.

Table 8.2-1 Transition of electrification ratio of each province

Província	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cabo Delgado	1%	1%	1%	2%	2.9%	3.5%	4.2%	5.2%	6.1%	7.7%	9.2%	10.3%	11.4%	11.9%
Niassa	2.2%	2.3%	2.5%	3.0%	4.7%	4.3%	5.4%	6.4%	7.1%	8.6%	9.6%	10.9%	12.4%	12.7%
Nampula	3.0%	3.1%	3.2%	4.1%	6.7%	8.8%	10.5%	12.2%	14.4%	16.5%	18.5%	19.8%	21.1%	21.5%
Norte	**2.3%**	**2.5%**	**2.6%**	**3.3%**	**5.4%**	**6.4%**	**7.8%**	**9.1%**	**10.7%**	**12.5%**	**14.2%**	**15.4%**	**16.7%**	**17.1%**
Zambézia	1.4%	1.6%	1.8%	2.2%	3.3%	4.3%	5.0%	6.0%	6.9%	8.0%	9.0%	9.9%	10.8%	11.0%
Tete	2.3%	2.5%	2.6%	3.2%	4.5%	5.2%	6.3%	7.5%	9.1%	10.8%	12.1%	13.0%	13.9%	15.4%
Manica	2.1%	2.4%	3.5%	4.3%	6.3%	7.0%	7.8%	8.7%	10.4%	12.4%	14.0%	16.1%	17.8%	18.4%
Sofala	3.9%	4.3%	5.4%	6.2%	8.9%	11.3%	13.2%	15.8%	19.1%	23.1%	26.4%	28.6%	29.5%	27.8%
Centro	**2.2%**	**2.4%**	**2.9%**	**3.5%**	**5.2%**	**6.2%**	**7.3%**	**8.6%**	**10.2%**	**12.1%**	**13.7%**	**15.0%**	**16.0%**	**16.5%**
Inhambane	1.6%	1.9%	2.2%	2.6%	4.3%	5.4%	5.1%	8.6%	10.3%	12.4%	14.3%	16.0%	18.1%	18.7%
Gaza	3.8%	4.8%	6.7%	8.0%	12.0%	14.5%	17.3%	20.8%	24.2%	28.3%	31.7%	35.3%	39.2%	40.3%
Map.Província	2.1%	2.8%	16.1%	20.6%	27.4%	35.7%	46.2%	55.2%	58.0%	67.0%	70.0%	73.3%	75.4%	79.1%
Map. Cidade	36.0%	38.4%	31.7%	34.3%	46.3%	57.0%	62.8%	71.6%	77.8%	84.1%	87.3%	88.6%	91.1%	91.9%
Sul	**10.6%**	**11.8%**	**13.6%**	**15.6%**	**21.5%**	**27.0%**	**31.4%**	**37.5%**	**41.1%**	**46.5%**	**49.4%**	**52.0%**	**54.8%**	**56.5%**
Total	**4.4%**	**4.9%**	**5.5%**	**6.5%**	**9.4%**	**11.2%**	**13.2%**	**15.6%**	**17.6%**	**20.3%**	**22.2%**	**23.7%**	**25.2%**	**25.9%**

Source: EDM Annual Report 2015

8.3 Off-grid electrification

MIREME proceeds off-grid electrification utilizing FUNAE as execution institute in cooperation with grid expansion by EDM. FUNAE was founded to promote electrification by renewable energy in 1997. As of September 2017, FUNAE achieved to electrify 180 villages, 790 schools and 690 clinics.

Table 8.3-1shows the energy access ratio counted by MIREME. Energy access ratio in 2014 is 45.3%. However, the energy access ratio does not necessarily represent the number of electrified houses. EDM is counted the number of contract as electrification ratio. On the other hand, MIREME calculates energy access ratio depending on whether people receive the benefits of electricity or not. For instance, when a school is electrified, the number of students are counted, and when a hospital is electrified, the number of patients are counted and when public lights on roads are electrified, people who live neighboring houses are counted. To unify the definition, EDM, MIREME and FUNAE has started discussion since October 2017.

Table 8.3-1 Energy access ratio counted by MIREME

[million people]

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Energy access ratio（%）	7	8	10	12	14	29	35	38	39	45.3
The number of customers conneced to on-grid（A）	1.5	1.7	1.8	2.1	2.9	3.5	4	5.7	6.3	6.7
The number of customers accessed to off-grid（B）	0.1	0.3	0.4	2.4	2.7	2.8	2.9	2.9	3.5	4.6
Total（A+B）	1.6	2.0	2.2	4.5	5.6	6.3	6.9	8.6	9.8	11.3

Source: MIREME Realizacoes do Sector da Energia 2005-2014

Table 8.3-2 is the list of area shifted from off-grid to on-grid. 69 areas have been connected to grid based on energy strategy.

Table 8.3-2 Area shifted from off-grid to on-grid

#	Province	District	Administrative Post	Year	Capacity [kW]
1	Cabo Delgado	Mocimboa da Praia	Mocimboa da Praia	2003	320
2	Cabo Delgado	Mueda	Mueda	2005	160
3	Cabo Delgado	Pemba Metuge	Metuge	2005	0
4	Cabo Delgado	Macomia	Mucojo	2006	38
5	Cabo Delgado	Macomia	Macomia	2007	38
6	Cabo Delgado	Mecufi	Murrebwe	2007	38
7	Cabo Delgado	Chiure	Mazeze	2008	38
8	Cabo Delgado	Chiure	Chiure-Velho	2008	320
9	Cabo Delgado	Meluco	Muaguide	2008	29
10	Cabo Delgado	Mocimboa da Praia	Mocimboa da Praia	2008	96
11	Cabo Delgado	Ibo	Ibo	2010	102
Subtotal (Cabo Delgado)					1179
12	Gaza	Chicualacuala	Chicualacuala	2005	0
13	Gaza	Manjacaze	Chalala	2007	38
Subtotal (Gaza)					38
14	Inhambane	Panda	Panda	2005	86
15	Inhambane	Zavala	Zandamela	2006	0
16	Inhambane	Mabote	Mabote	2008	123
17	Inhambane	Govuro	Save	2009	29
18	Inhambane	Massinga	Massinga	2009	29
19	Inhambane	Govuro	Vila Franca do Save	2010	56
20	Inhambane	Funhalouro	Funhalouro	2010	32
Subtotal (Inhambane)					355
21	Manica	Manica	Manica	2001	10
22	Manica	Mossurize	Dacata	2008	32
23	Manica	Gondola	Muda Serracao	2010	160
24	Manica	Machaze	Save	2010	58
25	Manica	Tambara	Nhacafula	2010	32
Subtotal (Manica)					292
26	Maputo	Maputo	Cidade de Maputo	2006	38
27	Maputo	Matutuine	Matutuine	2007	38
28	Maputo	Maputo	Matutuine	2008	0
29	Maputo	Magude	Motaze	2009	224
30	Maputo	Matutuine	Madjadjane	2010	32
Subtotal (Maputo)					332
31	Nampula	Nacaroa	Nacaroa	2001	0
32	Nampula	Lalaua	Lalaua	2006	0
33	Nampula	Moma	Larde	2006	0
34	Nampula	Angoche	Namaponda	2007	10
35	Nampula	Angoche	Namaponda	2009	87
36	Nampula	Mogincual	Liupo	2009	160
37	Nampula	Mogincual	Namige	2009	87
38	Nampula	Nampula-Rapale	Mutivaze	2009	32
39	Nampula	Ribaue	Cunle	2009	51
Subtotal (Nampula)					427
40	Niassa	Lago	Lago	2001	38
41	Niassa	Lago	Metangula	2006	0
42	Niassa	Lichinga	Lione-Chala	2008	38
43	Niassa	Maua	Maua	2008	160
44	Niassa	Sanga	Matchedje	2008	29
45	Niassa	Majune	Majune	2009	96
46	Niassa	Mavago	Mavago	2009	96
47	Niassa	Sanga	Sanga	2010	266
Subtotal (Niassa)					723
48	Sofala	Chibabava	Chibabava	2006	90
49	Sofala	Maringue	Maringue	2006	38
50	Sofala	Chibabava	Chibabava	2009	96
51	Sofala	Machanga	Mavinga	2009	87
52	Sofala	Muanza	Muanza	2009	87
53	Sofala	Gorongoza	Canda	2010	32
54	Sofala	Gorongoza	Vanduzi	2011	29
55	Sofala	Chemba	Mulima	2011	29
56	Sofala	Chemba	Chiramba	2011	44
57	Sofala	Dondo	Dondo	2011	29
58	Sofala	Machanga	Divinhe	2011	29
Subtotal (Sofala)					590
59	Tete	Changara	Changara	2005	0
60	Tete	Tsangano	Ntengo Wambalame	2006	38
61	Tete	DOA	Doa	2009	29
62	Tete	Mutarara	Inhangoma	2009	87
Subtotal (Tete)					154
63	Zambezia	Chinde	Chinde	2008	29
64	Zambezia	Morrumbala	Dere	2008	96
65	Zambezia	Chinde	Chinde	2009	160
66	Zambezia	Lugela	Tacuane	2009	19
67	Zambezia	Morrumbala	Chire	2009	19
68	Zambezia	Pebane	Naburi	2010	51
69	Zambezia	Gurue	Mepuagiua	2012	29
Subtotal (Zambezia)					403
Total (National)					4493

Source: JICA Study Team based on FUNAE information

8.3.1 FUNAE's policy for electrification

Table 8.3-3 shows electrification methods by FUNAE. Diesel generation had been utilized by 2009, however it is not used anymore since operation cost is high and electricity supply duration is limited.

Table 8.3-3 Electrification methods by FUNAE

Micro-grid	・Installed capacity is 5kW (about 25 households) by PV ・Fixed monthly electricity tariff
Mini-grid	・Installed capacity is about 500kW by PV or small hydro power ・Electricity tariff is collected according to usage
Stand-alone	・Independent PV supply system by each house ・Fixed monthly electricity tariff

Source: JICA Study Team

Off-grid electrification procedure is as follows;

1: Local governments collect request from their residents and communities and report to the provincial governments.

2: Provincial governments select prospective places and report to the ministry of finance.

3: Ministry of finance determines electrified area.

FUNAE staffs in local areas are in charge of coordinator. FUNAE takes charge of electrification area which is far from the existing grid.

To select project sites, FUNAE surveys sites in terms of availability of energy resources in advance, and categorizes surveyed area as follows.

①Areas with the potential for growth and development with a considerable population

These areas are electrified by micro-grid or mini-grid since these areas can be connected to the grid in the mid and long term.

②Areas with low population density

These areas are electrified by stand-alone system since micro-grid or mini-grid system can be installed in the mid and long term.

FUNAE's budget does not come from MIREME but ministry of finance. FUNAE is supported by government and donors. In addition, most of the budget is grant aid from donors therefore it varies every year.

8.3.2 FUNAE project list

FUNAE launched a portfolio of renewable energy projects[91], budgeted at 500 million USD, on September 19, 2017. It aims to invite the investment from not only government but also private financing.

The following items have been checked to create project list.

①Population density and its dispersion

[91] Renewable energy projects portfolio hydro and solar resources, FUNAE, September 2017

②Availability of energy resources

③Economic and social activities

④Existing infrastructures

⑤Existing projects

There are 332 hydro projects, equivalent to total of 1013.2MW and 343 solar projects. FUNAE is continuing to investigate and survey the project sites in detail and project list will be updated.

Table 8.3-4 shows the condition of hydro project survey.

Table 8.3-4 Condition of hydro project survey

Description	The number of villages	Hydro power capacity [MW]
Feasibility Study concluded	3	2.8
Pre-Feasibility Study concluded	5	2.2
Data Survey concluded	14	40.9
Survey to be done	300	967.3
Total	322	1013.2

Source: JICA Study Team based on FUNAE information

Table 8.3-5 is the list of 14 hydro projects (40.9MW) that data survey has been completed based on Renewable Energy. Detailed places and potential capacity (MW) are described in the list.

Table 8.3-5 List of 14 hydro projects that data survey has been completed based on Renewable Energy

Item	Provincia/ Province	Nome do Rio/River name	Número/Number (Atlas)	Nome do local/Local name	Latitude	Longitude	Potência/Capacity (MW)	Cota/Height max.	Cota/Height min.	Queda estimada/ Estimate head (m)
1	Nampula	Malema	9162	Canhunha	-15,09376	37,313744	2,407	721	696	25,00
2	Zambézia	Licungo	9356	Gurué	-15,42138	36,975978	1,404	1100	947	153,00
3	Tete	Luângua	1045	Namadende	-14,55016	33,32241	0,643	880	823	57,00
4	Tete	Luia	5120	Cantamo (Nkocomu)	-14,32829	33,045822	0,843	800	763	37,00
5	Tete	Luia	N/D	Cantamo (Mulowe)	-14,25704	33,110575	0,9	890	844	46,00
6	Tete	Revúbue	5028	Chimuala	-14,72456	34,240398	0,882	1060	1028	32,00
7	Tete	Mucumbudzi	N/D	Mapango	-14,98704	33,285711	1,974	676	664	12,00
8	Tete	Luângua	5097	Mapango	-15,04775	32,33902	1,974	440	399	41,00
9	Tete	Phonfi	5079	Katowe	-15,29392	33,77391	10,014	840	600	240,00
10	Manica	Luenha	1210	Guro	-17,03449	33,14776	9,904	404	384	20,00
11	Manica	Chinhica	1437	Cotine	-20,58272	32,840486	1,376	582	0	582,00
12	Manica	Munaiwa	N/D	Tsetsera	-19,43763	32,833356	N/D	0	916	916,00
13	Manica	Nhamucuarara	N/D	Nhamucuarara	-18,80878	32,835861	N/D	1122	1050	72,00
14	Manica	Púngue	1320	Tsetsera	-18,88584	33,94788	8,584	214	176	38,00
Total (MW)							**40,905**			

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-6 is the list of a part of hydro projects under investigation and survey. Detailed places and potential capacity (MW) are described in the list.

Table 8.3-6 List of a part of hydro projects under investigation and survey

Item	Nome/Name	Recurso/Resource	Potência/Capacity (MW)	Provincia/Province	Longitude	Latitude
1	1001	Hidrico	0,983	NIASSA	35,83245	-12,4414
2	1002	Hidrico	0,739	NIASSA	35,97346	-12,41538
3	1004	Hidrico	0,556	NIASSA	35,19396	-12,69479
4	1006	Hidrico	0,761	NIASSA	35,96532	-12,92708
5	1008	Hidrico	0,715	NIASSA	34,88856	-12,8291
6	1024	Hidrico	3,254	NIASSA	34,83747	-13,2375
7	1031	Hidrico	6,448	NIASSA	35,1755	-12,47455
8	1033	Hidrico	2,07	NIASSA	35,06099	-12,77791
9	1040	Hidrico	1,115	NIASSA	35,3664	-12,26768
10	1054	Hidrico	0,882	NIASSA	35,14385	-13,70299
11	1056	Hidrico	0,403	NIASSA	35,15991	-13,34386
12	1063	Hidrico	6,063	NIASSA	35,54328	-12,65309
13	1066_1	Hidrico	1,076	NIASSA	35,92707	-13,23901
14	1068	Hidrico	1,203	NIASSA	34,83728	-13,08418
15	1077	Hidrico	9,897	NIASSA	35,97198	-12,1605
16	1079	Hidrico	2,574	NIASSA	35,88852	-13,81677
17	1080_1	Hidrico	1,783	NIASSA	34,83424	-12,718
18	1088	Hidrico	0,698	NIASSA	34,79873	-13,02664
19	1089_1	Hidrico	0,885	NIASSA	35,0766	-12,48447
20	1094	Hidrico	0,442	NIASSA	35,16652	-13,36888
21	1095	Hidrico	1,238	NIASSA	35,08555	-13,48879
22	1107	Hidrico	9,944	NIASSA	35,64404	-12,41782
23	1107	Hidrico	13,981	NIASSA	35,60244	-12,47949
24	1110	Hidrico	9,842	NIASSA	35,91088	-12,21026
25	1113	Hidrico	1,905	NIASSA	34,84924	-13,08769
26	1115	Hidrico	0,734	NIASSA	34,88246	-13,0933
27	1117	Hidrico	0,387	NIASSA	34,90791	-13,07986
28	1124	Hidrico	1,639	NIASSA	35,53443	-12,1759
29	1129	Hidrico	0,574	NIASSA	35,26229	-12,33129
30	1130	Hidrico	0,489	NIASSA	35,2578	-12,44535
31	1133	Hidrico	3,117	NIASSA	35,11924	-12,7115
32	1134	Hidrico	3,043	NIASSA	35,13703	-12,63934
33	1135	Hidrico	10,039	NIASSA	35,18024	-12,56581
34	1135	Hidrico	11,971	NIASSA	35,18024	-12,56581
35	1137	Hidrico	4,064	NIASSA	35,14554	-12,41988
36	1139	Hidrico	5,724	NIASSA	35,1799	-12,20519
37	1145_1	Hidrico	0,322	NIASSA	34,82313	-13,11351
38	1146	Hidrico	0,606	NIASSA	34,81468	-13,18543
39	1147	Hidrico	3,509	NIASSA	34,87783	-13,26084
40	1152	Hidrico	1,893	NIASSA	34,94798	-13,37147
41	1153	Hidrico	0,407	NIASSA	34,97902	-13,40061
42	1193	Hidrico	1,075	NIASSA	34,87934	-13,41232
43	1194	Hidrico	0,292	NIASSA	34,84228	-13,36133
44	1195	Hidrico	0,313	NIASSA	34,80409	-13,29229

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-7 shows the number of villages, primary school and clinic in each province, which should be electrified by off-grid system. 111 villages will be electrified by micro-grid of mini-grid, 81 villages will be electrified by stand-alone system, 141 villages are being categorized. The number of non-electrified school and clinic is 968 and 280, respectively.

Table 8.3-7 The number of villages, primary school and clinic in each province, which should be electrified by off-grid system

Province	The number of villages			The number of facilities	
	Micro or Mini-grid	Stand-alone	To be classified	Primary school	Clinic
Niassa	10	6	4	35	32
Cabo Delgado	42	1	3	-	16
Nampula	17	4	8	81	143
Zambezia	18	14	0	280	35
Sofala	2	5	4	223	19
Tete	4	1	8	-	-
Manica	9	13	28	183	21
Inhambane	1	6	5	166	14
Gaza	5	24	64	-	-
Maputo	3	7	17	-	-
Total	111	81	141	968	280

Source: JICA Study Team based on FUNAE information

Table 8.3-8 to Table 8.3-17 shows the lists of electrification method by off-grid system in each province.

Table 8.3-8 List of electrification method by off-grid system in Niassa province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de Sistema
1	Niassa	Metarica	Nacumua	Mepuera	Solar	Individual
2	Niassa	Metarica	II Congresso	Nova Madeira	Solar	Individual
3	Niassa	Majune	Metomone	Lochesse	Solar	Mini-redes
4	Niassa	Ngaúma	Massangulo	Chissimbir	Solar	Mini-redes
5	Niassa	Sanga	Macaloge	Capunda	Solar	Individual
6	Niassa	Lichinga	Lichinga Sede	Micoco	Solar	Mini-redes
7	Niassa	Maúa	Maúa-sede	Chapalango	Solar	Mini-redes
8	Niassa	Lago	Mesumba	Chia	Solar	Individual
9	Niassa	Lago	Mesumba	Ngo	Solar	Mini-redes
10	Niassa	Majune	Nairubi	Nairubi	Solar	Mini-redes
11	Niassa	Mecanhelas	Insaca	Chissaua	Solar	Mini-redes
12	Niassa	Lago	Maniamba	Mazogo Issa	Solar	Mini-redes
13	Niassa	Lago	Maniamba	Mazogo Lualesse	Solar	Mini-redes
14	Niassa	Lago	Maniamba	Liziunga	Solar	Mini-redes
15	Niassa	Sanga	II Congresso	Matchedje	Solar	Individual
16	Niassa	Mecanhelas	Insaca	Iataria	Solar	Individual

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-9 List of electrification method by off-grid system in Cabo Delgado province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de instalação
1	Cabo Delgado	Meluco	Meluco	Minhanha	Solar	Mini-redes
2	Cabo Delgado	Namuno	Namuno-Sede	Matamataua	Solar	Mini-redes
3	Cabo Delgado	Nangade	Ntamba	N'konga	Solar	Mini-redes
4	Cabo Delgado	Nangade	Litingina	Itanda	Solar	Mini-redes
5	Cabo Delgado	Quissanga	Mahate	Napuda	Solar	Mini-redes
6	Cabo Delgado	Quissanga	Mahate	Linde	Solar	Mini-redes
7	Cabo Delgado	Chiúre	Mazeze	Mmala	Solar	Mini-redes
8	Cabo Delgado	Balama	Balama	Metata	Solar	Mini-redes
9	Cabo Delgado	Montepuez	Mputo	Ntapata	Solar	Mini-redes
10	Cabo Delgado	Metuge	Metuge	Namitewe	Solar	Mini-redes
11	Cabo Delgado	Namuno	Namuno-Sede	Nanrapa	Solar	Mini-redes
12	Cabo Delgado	Namuno	Namuno-Sede	Meculane	Solar	Mini-redes
13	Cabo Delgado	Nangade	Ntamba	Muiha	Solar	Mini-redes
14	Cabo Delgado	Nangade	Ntamba	Namuende	Solar	Mini-redes
15	Cabo Delgado	Quissanga	Mahate	Arimba	Solar	Mini-redes
16	Cabo Delgado	Quissanga	Mahate	Ntororo	Solar	Mini-redes
17	Cabo Delgado	Quissanga	Mahate	Cagembe	Solar	Mini-redes
18	Cabo Delgado	Quissanga	Mahate	Songueia	Solar	Mini-redes
19	Cabo Delgado	Mueda	Negomano	Chilinde	Solar	Mini-redes
20	Cabo Delgado	Ancuabe	Ancuabe	Ngeue	Solar	Mini-redes
21	Cabo Delgado	Mocimba da Praia	Quelimane	Maunde	Solar	Mini-redes
22	Cabo Delgado	Macomia	Chai	Tandacua	Solar	Mini-redes
23	Cabo Delgado	Montepuez	Mirate	Mirate-Sede	Solar	Mini-redes
24	Cabo Delgado	Montepuez	Mputo	Mputo-Sede	Solar	Mini-redes
25	Cabo Delgado	Meluco	Meluco	Ravia	Solar	Mini-redes
26	Cabo Delgado	Metuge	Metuge-Sede	Messanja-Velha	Solar	Mini-redes
27	Cabo Delgado	Namuno	Meloco	Muatuca	Solar	Mini-redes
28	Cabo Delgado	Nangade	Ntamba	Chiduadua	Solar	Mini-redes
29	Cabo Delgado	Nangade	Ntamba	Nhanga	Solar	Mini-redes
30	Cabo Delgado	Palma	Quionga	Namoto	Solar	Mini-redes
31	Cabo Delgado	Quissanga	Mahate	Nakoba	Solar	Mini-redes
32	Cabo Delgado	Quissanga	Mahate	Namange	Solar	Mini-redes
33	Cabo Delgado	Mueda	Negomano	Ninga	Solar	Mini-redes
34	Cabo Delgado	Balama	Balama	M'paka	Solar	Mini-redes
35	Cabo Delgado	Macomia	Quiterajo	Quiterajo-Sede	Solar	Individual
36	Cabo Delgado	Namuno	Machoca	Machoca-Sede	Solar	Mini-redes
37	Cabo Delgado	Nangade	Ntamba	Ntoli	Solar	Mini-redes
38	Cabo Delgado	Palma	Quionga	Quionga-Sede	Solar	Mini-redes
39	Cabo Delgado	Chiúre	Namogelia	Namogelia-Sede	Solar	Mini-redes
40	Cabo Delgado	Chiúre	Mazeze	Mazeze	Solar	Mini-redes
41	Cabo Delgado	Montepuez	Nairoto	Nairoto-Sede	Solar	Mini-redes
42	Cabo Delgado	Mueda	Ngapa	Namatil	Solar	Mini-redes
43	Cabo Delgado	Mueda	Ngapa	Ngapa-Sede	Solar	Mini-redes

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-10 List of electrification method by off-grid system in Nampula province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de Sistema
1	Nampula	Larde	Larde-Sede	Moneia	Solar	Mini-redes
2	Nampula	Nacala-a-Velha	Nacala-a-Velha	Nahipa	Solar	Mini-redes
3	Nampula	Mogincual	Namige	Perequexo	Solar	Mini-redes
4	Nampula	Nacaroa	Muchico	Saua-Saua	Solar	Individual
5	Nampula	Malema	Malema-Sede	Nataleia	Solar	Mini-redes
6	Nampula	Mecuburi	Muite	Issipi	Solar	Mini-redes
7	Nampula	Lalaua	Lalaua-Sede	Naculue	Solar	Mini-redes
8	Nampula	Muecate	Muculuone	Muculuone-Sede	Solar	Individual
9	Nampula	Muecate	Muculuone	Gracio	Solar	Mini-redes
10	Nampula	Murrupula	Nihessiue	Ligonha	Solar	Individual
11	Nampula	Moma	Macone	Mucorroge	Solar	Mini-redes
12	Nampula	Moma	Mocone	Npago	Solar	Mini-redes
13	Nampula	Monapo	Netia	Natete	Solar	Mini-redes
14	Nampula	Nacala-Porto	Mahelene	Mahelene-Sede	Solar	Mini-redes
15	Nampula	Nacala-Porto	Mahelene	Matalane	Solar	Mini-redes
16	Nampula	Angoche	Aube	Marcacao	Solar	Individual
17	Nampula	Mogovolas	Iuluti	Iuluti-Sede	Solar	Mini-redes
18	Nampula	Mecuburi	Muite	Muite-Sede	Solar	Mini-redes
19	Nampula	Malema	Malema-Sede	Murralelo	Solar	Mini-redes
20	Nampula	Memba	Mazua	Mazua-Sede	Solar	Mini-redes
21	Nampula	Erati	Alua	Alua-Sede	Solar	Mini-redes
22	Nampula	Larde	Mucuale	Mucuale	Solar	Mini-redes
23	Nampula	Erati	Namiroa	Namiroa	Solar	Mini-redes

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-11 List of electrification method by off-grid system in Zambezia province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de Sistema
1	Zambézia	Alto Molócuè	Nauela	Nauela	Solar	Mini-redes
2	Zambézia	Gilé	Alto Ligonha	Muiane	Solar	Individual
3	Zambézia	Ile	Ile	Nampevo	Solar	Individual
4	Zambézia	Ile	Mulevala	Chiraco	Solar	Individual
5	Zambézia	Ile	Ile	Mungulama/Hatxue	Solar	Mini-redes
6	Zambézia	Lugela	Tacuane	Tacuane	Solar	Mini-redes
7	Zambézia	Lugela	Munhamade	Munhamade	Solar	Individual
8	Zambézia	Maganja da Costa	Maganja da Costa	Cariua	Solar	Individual
9	Zambézia	Milange	Majaua	Zalimba	Solar	Individual
10	Zambézia	Milange	Milange	Vulalo	Solar	Mini-redes
11	Zambézia	Milange	Mongue	Mongue	Solar	Individual
12	Zambézia	Mocuba	Namajavira	Alto Benfica	Solar	Individual
13	Zambézia	Mocuba	Namajavira	Namajavira	Solar	Individual
14	Zambézia	Mopeia	Campo	Campo	Solar	Mini-redes
15	Zambézia	Morrumbala	Chire	Chire	Solar	Mini-redes
16	Zambézia	Namacurra	Namacurra	Malei	Solar	Individual
17	Zambézia	Namacurra	Macusse	Furquia	Solar	Mini-redes
18	Zambézia	Namacurra	Macusse	Maxixine	Solar	Mini-redes
19	Zambézia	Namarroi	Regone	Regone	Solar	Individual
20	Zambézia	Pebane	Mulela Mualama	Namanla	Solar	Mini-redes
21	Zambézia	Pebane	Pebane	Nicadine	Solar	Individual
22	Zambézia	Pebane	Mulela Mualama	Alto Maganha	Solar	Mini-redes
23	Zambézia	Pebane	Mulela Mualama	Malema	Solar	Individual
24	Zambézia	Pebane	Naburi	Tomeia	Solar	Individual
25	Zambézia	Pebane	Naburi	Naburi	Solar	Mini-redes
26	Zambézia	Derre	Machido	Machido	Solar	Mini-redes
27	Zambézia	Mocuba	Muaquiua	Muaquiua	Solar	Mini-redes
28	Zambézia	Gilé	Alto Ligonha	Alto Ligonha	Solar	Mini-redes
29	Zambézia	Molumbo	Corromana	Corromana	Solar	Mini-redes
30	Zambézia	Milange	Mongue	Mongue	Solar	Mini-redes
31	Zambézia	Mocubela	Bajone	Bajone	Solar	Mini-redes
32	Zambézia	Mocubela	Alto Mutabide	Alto Mutabide	Solar	Mini-redes

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-12 List of electrification method by off-grid system in Sofala province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de Sistema
1	Sofala	Buzi	Estaquinha	Chissinguana	Solar	Mini-redes
2	Sofala	Gorongosa	Marringue	Gumbalansai	Solar	Individual
3	Sofala	Muanza	Galinha	Nhansato	Solar	Mini-redes
4	Sofala	Chibabava	Muxungue	Panja	Solar	Individual
5	Sofala	Buzi	Buzi Sede	Inhamuchindo	Solar	Individual
6	Sofala	Chibabava	Goonda	3 de Fevereiro	Solar	Individual
7	Sofala	Machanga	Divinhe	Divinhe	Solar	Individual
8	Sofala	Maringue	Canxixe	Canxixe	Solar	Mini-redes
9	Sofala	Buzi	Nova Sofala	Nova Sofala	Solar	Individual
10	Sofala	Cheringoma	Inhaminga	Inhaminga	Solar	Individual

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-13 List of electrification method by off-grid system in Tete province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de Sistema
1	Tete	Maravia	Chinthopo	Chinthopo	Solar	Individual
2	Tete	Marara	Boraoma	Boraoma	Solar	Mini-redes
3	Tete	Macanga	Namadende	Namadende	Solar	Mini-redes
4	Tete	Chifunde	Bolimo	Bolimo	Solar	Mini-redes
5	Tete	Changara	Goba	Goba	Solar	Mini-redes

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-14 List of electrification method by off-grid system in Inhambane province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de Sistema
1	Inhambane	Inhambane	Cidade de Inhambane	Ilha de Inhambane	Solar	Individual
2	Inhambane	Mabote	Mabote	Tsumbo	Solar	Individual
3	Inhambane	Zavala	Zandamela	Chitondo	Solar	Individual
4	Inhambane	Mabote	Chechangue	Chitanga	Solar	Mini-redes
5	Inhambane	Vilanculos	Mapinhane	Belane	Solar	Individual
6	Inhambane	Panda	Panda	Mawaela	Solar	Individual
7	Inhambane	Mabote	Zimane	Tessolo	Solar	Individual
8	Inhambane	Inharrime	Inharrime	Coche	Solar	Individual
9	Inhambane	Inharrime	Inharrime	Dovela	Solar	Individual
10	Inhambane	Inharrime	Inharrime	Mazonda	Solar	Individual
11	Inhambane	Inharrime	Mocumbi	Mussana	Solar	Individual
12	Inhambane	Inharrime	Inharrime	Nhacobo	Solar	Individual
13	Inhambane	Inharrime	Inharrime	Coguno	Solar	Individual
14	Inhambane	Inharrime	Inharrime	Mejoote	Solar	Individual
15	Inhambane	Inharrime	Dongane	Dongane	Solar	Individual

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-15 List of electrification method by off-grid system in Manica province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de Sistema
1	Manica	Macate	Macate	Maconha	Solar	Individual
2	Manica	Manica	Messica	Nhaucaca	Solar	Mini-redes
3	Manica	Macossa	Nguawala	Nguawala - Sede	Solar	Individual
4	Manica	Guro	Nhamassonge	Tanad	Solar	Individual
5	Manica	Sussundenga	Sussundenga	Nhaurombe	Solar	Individual
6	Manica	Gondola	Mudima	Mudima	Solar	Mini-redes
7	Manica	Gondola	Chiongo	Chiongo	Solar	Individual
8	Manica	Mossurize	Dacata	Bagonhe	Solar	Individual
9	Manica	Guro	Guro Sede	Bunga	Solar	Mini-redes
10	Manica	Guro	Guro Sede	Sanga	Solar	Mini-redes
11	Manica	Macate	Macate	Chissassa	Solar	Individual
12	Manica	Macossa	Macossa	Rio dos Elefantes	Solar	Individual
13	Manica	Manica	Messica	Chinhambuzi	Solar	Individual
14	Manica	Macate	Zembe	Zembe Sede	Solar	Mini-redes
15	Manica	Macossa	Nhamangua	Nhamangua - sede	Solar	Individual
16	Manica	Guro	Mungari	Chivuli	Solar	Mini-redes
17	Manica	Bárué	Choa	Nhauroa	Solar	Individual
18	Manica	Bárué	Catandica	Chiuala/Honde	Solar	Mini-redes
19	Manica	Tambara	Buzua	Búzua	Solar	Mini-redes
20	Manica	Bárué	Nhamapassa	Nhamapassa	Solar	Mini-redes
21	Manica	Bárué	Choa	Choa - Sede /Nhabuto	Solar	Individual
22	Manica	Guro	Mandie	Mandie sede (Novo local)	Solar	Mini-redes
23	Manica	Mossurize	Chaiva	Chaiva	Solar	Mini-redes
24	Manica	Mossurize	Chiurairue	Garágua	Solar	Individual
25	Manica	Machaze	Save	Save	Solar	Individual
26	Manica	Tambara	Nhacolo	Nhacolo	Solar	Mini-redes
27	Manica	Messica	Chinhambuzi	Chinhambuzi	Solar	Mini-redes

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-16 List of electrification method by off-grid system in Gaza province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de Sistema
1	Gaza	Manjacaze	Nguzene	Nguzene	Solar	Individual
2	Gaza	Manjacaze	Mazucane	Mazucane	Solar	Individual
3	Gaza	Manjacaze	Chibonzane	Machulane	Solar	Individual
4	Gaza	Manjacaze	Chidenguele	Betula	Solar	Individual
5	Gaza	Manjacaze	Chidenguele	Dengoine	Solar	Individual
6	Gaza	Bilene	Mazivila	Olombe	Solar	Individual
7	Gaza	Bilene	Macuane	Chitlango	Solar	Individual
8	Gaza	Chibuto	Godide	Chipadja	Solar	Individual
9	Gaza	Chibuto	Alto Changane	Maqueze	Solar	Mini-redes
10	Gaza	Chibuto	Alto Changane	Funguane	Solar	Individual
11	Gaza	Mapai	Mapai	Mapai-Rio	Solar	Individual
12	Gaza	Chicualacuala	Eduardo Mondlane	Chicualcuala-rio	Solar	Individual
13	Gaza	Chicualacuala	Pafuri	Coguma	Solar	Individual
14	Gaza	Mabalane	Combomune	Combomune - Rio	Solar	Mini-redes
15	Gaza	Guijá	Nalazi	Sede	Solar	Machambas
16	Gaza	Guijá	Nalazi	Mbala-vala	Solar	Individual
17	Gaza	Massangena	Massangena -sede	Mapanhe	Solar	Individual
18	Gaza	Massangena	Massangena -sede	Mucanbene	Solar	Mini-redes
19	Gaza	Massangena	Mavue	Mavue	Solar	Individual
20	Gaza	Massangena	Mavue	Siqueto	Solar	Individual
21	Gaza	Mandlakazi	Xlhalala	Mussengue	Solar	Mini-redes
22	Gaza	Mandlakazi	Macuacua	Chilatanhane	Solar	Individual
23	Gaza	Mandlakazi	Mazucane	Manguzi A	Solar	Individual
24	Gaza	Mandlakazi	Nguzene	Nguzene-sede	Solar	Individual
25	Gaza	Mandlakazi	Nguzene	Banze	Solar	Individual
26	Gaza	Mandlakazi	Nguzene	Cumbane	Solar	Individual
27	Gaza	Massingir	Zulo	Chitar/Macuachane	Solar	Machambas
28	Gaza	Chokwe	Chilembene	Chiduachine	Solar	Individual
29	Gaza	Chokwe	Chilembene	Marrambajane	Solar	Machambas
30	Gaza	Chokwe	Lionde	Bombofo	Solar	Individual
31	Gaza	Chokwe	Macarretane	Punguine	Solar	Mini-redes
32	Gaza	Chokwe	Macarretane	Soveia	Solar	Individual
33	Gaza	Mabalane	Mabalane Sede	Chinhequete	Solar	Individual
34	Gaza	Mabalane	Mabalane Sede	Tsocate	Solar	Individual
35	Gaza	Mabalane	Mabalane Sede	Muginge	Solar	Individual
36	Gaza	Mabalane	Mabalane Sede	Gerez	Solar	Individual

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-17 List of electrification method by off-grid system in Maputo province

#	Provincia	Distrito	Posto Administrativo	Localidade/Aldeia	Recurso	Tipo de instalação
1	Maputo	Magude	Mahele	Mahele Sede	Solar	Individual
2	Maputo	Magude	Magude Sede	Macubulane Sede	Solar	Individual
3	Maputo	Magude	Mapulanguene	Sede	Solar	Mini-redes
4	Maputo	Marracuene	Machubo	Machubo	Solar	Individual
5	Maputo	Manhiça	Calanga	Calanga	Solar	Individual
6	Maputo	Magude	Mapulanguene	Mapulanguene	Solar	Individual
7	Maputo	Magude	Panjane	Panjane	Solar	Individual
8	Maputo	Magude	Magude	Matsandzane	Solar	Individual
9	Maputo	Magude	Motaze	Marula	Solar	Individual
10	Maputo	Moamba	Sabié	Pessene	Solar	Mini-redes
11	Maputo	Moamba	Sabié	Macaene	Solar	Individual
12	Maputo	Matutuine	Catembe	Hindane	Solar	Individual
13	Maputo	Namacha	Namaacha	Matsequenha	Solar	Individual
14	Maputo	Namacha	Namaacha	Musuazi	Solar	Individual
15	Maputo	Namacha	Namaacha	Chicochana	Solar	Individual
16	Maputo	Namacha	Namaacha	Livivene	Solar	Mini-redes
17	Maputo	Namacha	Namaacha	Bamassango	Solar	Individual
18	Maputo	Namacha	Namaacha	Mugude	Solar	Individual
19	Maputo	Namacha	Namaacha	Kala-kala	Solar	Individual
20	Maputo	Namacha	Namaacha	Kassimati	Solar	Individual
21	Maputo	Boane	Boane	Ambrosio	Solar	Individual
22	Maputo	Manhiça	Chichongue	Dzongune	Solar	Individual
23	Maputo	Manhiça	Chichongue	Lagoa Pati	Solar	Individual
24	Maputo	Marracuene	Marracuene	Xefina	Solar	Individual
25	Maputo	Marracuene	Marracuene	Mbelele	Solar	Individual
26	Maputo	Marracuene	Marracuene	Taula	Solar	Individual
27	Maputo	Marracuene	Marracuene	Maganza	Solar	Individual

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-18 is the list of a part of non-electrified schools.

Table 8.3-18 List of a part of non-electrified schools

#	Província/ Province	Distrito/District	P. Administrativo/ Administrative post	Escolas/Schools
1	Niassa	Chimbonila	Lione	EPC de Machemba
2	Niassa	Chimbonila	Lione	EPC de Naconda
3	Niassa	Chimbonila	Lione	EPC de Macassangilo
4	Niassa	Cuamba	Lurio	EPC de Muicuna
5	Niassa	Cuamba	Lurio	EPC de Mortuela
6	Niassa	Cuamba	Lurio	EPC de Melomba
7	Niassa	Lago	Cobue	EPC de Ngoo
8	Niassa	Lago	Cobue	EPC dev Ngofi
9	Niassa	Lago	Cobue	EPC de Ntumba
10	Niassa	Lago	Cobue	EPC de Chigoma
11	Niassa	Lago	Cobue	EPC de Lupilichi
12	Niassa	Lago	Cobue	EPC de Lussefa
13	Niassa	Lago	Lunho	EPC de Chia
14	Niassa	Lago	Lunho	EPC de Mbamba
15	Niassa	Mandimba	Messissi	EPC de Rachilone
16	Niassa	Mandimba	Messissi	EPC de Chitingi
17	Niassa	Mandimba	Messissi	EPC de Minicua
18	Niassa	Maua	Ntepia	EPC de Missao
19	Niassa	Maua	Ntepia	EPC de Quareia1
20	Niassa	Maua	Ntepia	EPC de Chicoco
21	Niassa	Maua	Maiaca	EPC de Maiaca
22	Niassa	Mepuera	Mecunica	EPC de Muhosso
23	Niassa	Metarica	Mecunica	EPC de Mecunica
24	Niassa	Nipepe	Tamica	EPC de Manlia
25	Niassa	Nipepe	Tamica	EPC de Metarica-Lurio
26	Niassa	Nipepe	Tamica	EPC de Uachila
27	Niassa	Nipepe	Tamica	EPC de Napaula
28	Niassa	Nipepe	Tamica	EPC de Cololo
29	Niassa	Nipepe	Tamica	EPC de Mucocota
30	Niassa	Mecanhelas	Chiuta	EPC Chiuta
31	Niassa	Mecula	Mussoma	EPC Mussoma
32	Niassa	Marrupa	Tumpue	EPC Tumpue
33	Niassa	Marrupa	Messenguece	EPC Messenguece
34	Niassa	Maua	Queta	EPC Queta
35	Niassa	Majune	MaTucuta	EPC MaTucuta
36	Nampula	Angoche	Angoche	ESG de Aube
37	Nampula	Angoche	Angoche	EPC de Gêlo
38	Nampula	Angoche	Angoche	EPC de Morrua
39	Nampula	Angoche	Angoche	EPC de Mulapane
40	Nampula	Angoche	Angoche	EPC de Lipuene

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

Table 8.3-19 is the list of a part of non-electrified clinics.

Table 8.3-19 List of a part of non-electrified clinics

#	Nome/Name	Distrito/District	P. Administrativo/ Administrative Post	Centro de Saúde/Health Center
1	Niassa	Chimbonila	Chala	CS de Ute
2	Niassa	Cuamba	Malapa	CS de Mucuapa
3	Niassa	Lago	Lupilichi	CS de Chia
4	Niassa	Lago	Lupilichi	CS de Lupilichi
5	Niassa	Lago	Lupilichi	CS de Ngoo
6	Niassa	Lago	Lupilichi	CS de Ntumba
7	Niassa	Lago	Ngooo	CS Ngooo
8	Niassa	Lago	Lupiliche	CS Lupiliche
9	Niassa	Lago	Micucue	CS Micucue
10	Niassa	Lichinga	Malica	CS Malica
11	Niassa	Lichinga	Lione	CS Lione
12	Niassa	Lichinga	Machomane	CS Machomane
13	Niassa	Mandimba	Lissete	CS Lissete
14	Niassa	Marrupa	Tumpue	CS Tumpue
15	Niassa	Maua	Maiaca	CS de Muhumbua
16	Niassa	Maua	Maua-Sede	CS de Queta
17	Niassa	Maua	Ntepiha	CS de Muhoco
18	Niassa	Metarica	Metarica	CS de Necunica
19	Niassa	Metarica	Navumua	CS de Niputa
20	Niassa	Metarica	Nacumua	CS Nacumua
21	Niassa	Mecanhelas	Mecumera	CS Mecumera
22	Niassa	Mecanhelas	Muhurune	CS Muhurune
23	Niassa	Mecula	Gomba	CS Gomba
24	Niassa	Mecula	Matondovela	CS Matondovela
25	Niassa	Muembe	Lutueza	CS Lutueza
26	Niassa	Muembe	Nzizi	CS Nzizi
27	Niassa	Nipepe	Tamica	CS de Manliha
28	Niassa	Ngauma	Luelele	CS Luelele
29	Niassa	Ngauma	Chiguatha	CS Chiguatha
30	Niassa	Sanga	7 de Setembro	CS 7 de Setembro
31	Niassa	Sanga	Malemia	CS Malemia
32	Niassa	Sanga	Malemia	CS Malemia
33	Cabo Delgado	Cabo Delgado	Cabo Delgado	CS Cabo Delgado
34	Cabo Delgado	Balama	Balama - Sede	CS Balama - Sede
35	Cabo Delgado	Chiure	Chiure - Velho	CS Chiure Velho
36	Cabo Delgado	Ibo	Ibo Sede	CS Ibo Sede
37	Cabo Delgado	Macomia	Quiterajo	CS Piquewe
38	Cabo Delgado	Macomia	Mucojo	CS Mucojo
39	Cabo Delgado	Mocimboa da Praia	Diaca	CS Diaca
40	Cabo Delgado	Meluco	Meluco- Sede	CS Raiva

Source: FUNAE Renewable energy projects portfolio hydro and solar resources, September 2017

8.4 Electrification business by Solar Works

Solar Works is commercial based company which was established in January 2016 at Matola city and started business in September 2016. This company's target is using only photovoltaic power for electrification. Solar Works has no relationship with EDM, FUNAE and MIREME. As of April 2017, there is a projection that 3,000 houses per year can be electrified, which is equivalent to 0.06% electrification ratio increase. Solar Works said that they want to enlarge the business area to the whole country while investigating economic condition.

8.5 On-grid electrification cost

JICA Study Team focus on on-grid electrification which is estimated by EDM demand.

Table 8.5-1 shows the conditions for estimation of on-grid electrification cost. Figure 8.5-1 shows the number of electrified households for achieving universal access. Table 8.5-2 shows the on-grid electrification cost to achieve universal access.

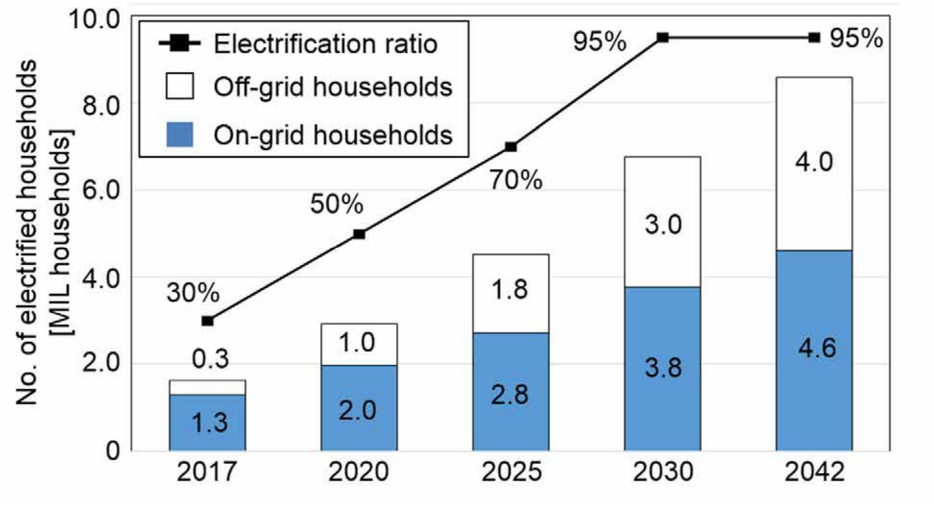
Total electrification cost is 4,950 million USD (198 million USD per year which is 32 times as much as EDM distribution budget in 2016). To achieve universal access, support by government and donors for on-grid electrification project, and cooperation with off-grid electrification project, is important.

Table 8.5-1 Conditions for estimation of on-grid electrification cost

The target of electrification ratio	95% by 2030 will be achieved and will be continued thereafter
Population (as of 2016)	27,000,000
Person in household (as of 2016)	5
The number of households (as of 2016)	5,400,000
Population growth	2%
The number of electrified households per year by EDM on-grid system	110,000
Ratio of the household number (as of 2017)	On-grid: 80% Off-grid: 20%
On-grid electrification cost per household	1,500USD[92]
Shift from off-grid system to EDM on-grid system	20% off-grid customers

Source: JICA Study Team

[92] Development of NESP to Accelerate Universal Access to Energy in Mozambique by 2030, World Bank



Source: JICA Study Team

Figure 8.5-1 The number of electrified households for achieving universal access

Table 8.5-2 On-grid electrification cost

	2030	2042
The number of electrified households (accumulated from 2017) [million households]	3.8	4.6
Electrification cost (accumulated from 2017) [million USD]	3,750	4,950

Source: JICA Study Team

8.6 Procedure of on-grid electrification

Figure 8.6-1 shows non-electrified house even though there is distribution line near the house. One of the countermeasures is to preferentially electrify such houses with reduced cost. There are technical reasons such as shortage of transformer capacity, besides lack of payment capacity of electricity tariff.

The following items is proposed to accelerate on-grid electrification;

・Grasp of potential demand (FUNAE does not focus on houses near the distribution line)

・Management by waiting list of electricity supply

According to WB study, electrification system can be selected based on the distance from the distribution line, demand per household and population density as shown in Table 8.6-1. In addition to WB study, it is important to review the electrification method in consideration of distribution development plan, since route of distribution line and distance from EDM grid to a customer, depends on F/S result of new distribution substation. F/S will be conducted in consideration of demand per household and population density, since new distribution substation should be installed at the center of customers. The combination WB study and distribution development plan contributes to select the area to be electrified by EDM on-grid system.

Source: JICA Study Team

Figure 8.6-1 Non-electrified house in Murrupula area

Table 8.6-1 Criteria between on-grid electrification and off-grid electrification by WB report

			Indicative Design Parameters		
System	**Methodology**	**Settlement Type**	**D = Distance from EDM Grid**	**P = Demand per household (kVA)**	**Population Density**
On-grid	Connection of new users to existing LV network (220 – 400V)	Urban and peri-urban	D < 10m	3.0 < P < 5.0	High
	Densification (LV and urban MV extension)	Urban and peri-urban	10m<D<5km	3.0 < P < 5.0	High
	3-phase rural MV (main and laterals) and LV extension	Rural	5km<D<30km	2.0 < P < 3.0	High
	3-phase rural MV (main), SWER (19kV) for laterals and LV extension	Rural	10km<D<30km	1.0 < P < 2.0	Medium
Off-grid	Mini-grid; i.e. centralized generation and LV network	Rural	D > 30km	0.1 < P < 1.0	Medium
	Solar home system (SHS)	Rural	D > 30km	0.1	Low

Source: Development of NESP to Accelerate Universal Access to Energy in Mozambique by 2030, World Bank

Chapter 9 Economic and Financial Analysis

9.1 Financial Status of EDM

9.1.1 Title

The 2016 nominal power tariff of EDM has remained at a lower level than that of 2003. In addition, the ratio of the power purchase against the total supply costs has been increasing for the recent few years, which will give a significant impact on the EDM finance. EDM has difficulties in gaining the positive profits. Moreover, the operating profit has been negative figures since 2015. On the other hand, the investment needs for transmission and distribution facilities have been increasing due to the demand increase. Whereas the cash flow from the operating activities is a positive figure, the funding for capital expenditure is difficult to secure. The current ratios for the last few years have been less than 1.0, which gives a significant issue for the repayment of the debt.

The power tariff of EDM have adjusted three times from 2015 to 2017. The power supply costs however cannot be recovered due to the local currency depreciation against the US dollars, decrease of the power purchase from HCB, increase of power purchase from IPPs, and the increasing operational expenses. In addition, the payment arrears to HCB, debt payments and the receivables from other parties such as ZESCO have been increasing. The financial problems are not at a critical stage.

It is indispensable to invest in the transmission and distribution facilities in order to increase the access rate as well as rehabilitate and renew the obsolete facilities. A first priority to achieve this is to regain the financial position at the operation basis. It is desirable to put efforts in the loss reduction and improvement of profitability as well as adjusting the power tariff.

The EDM financial statements and the result of analysis are shown following Table 9.1-1, Table 9.1-2, Table 9.1-3 and Table 9.1-4.

Table 9.1-1 EDM Balance Sheet

Balance Sheet

	2016	2015	2014	2013	2012	2011	2010
Assets							
Non Current Assets							
Tangible assets	63,189,472,995	48,016,306,505	41,255,857,830	36,511,814,333	33,446,393,103	30,310,838,430	28,591,771,012
Financial assets available for sale	168,747,489	269,596,914	243,717,335	196,668,383	197,749,699	197,249,699	197,252,199
Financial assets held to maturity	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000	8,000,000
Other financail assets	2,981,884,802	1,787,939,555	1,276,700,000	1,276,700,000	-	-	
Deferred tax assets	-	209,413,608					
Total Non Current Assets	**66,348,105,286**	**50,291,256,582**	**42,784,275,165**	**37,993,182,716**	**33,652,142,802**	**30,516,088,129**	**28,797,023,211**
Current Assets							
Inventories	1,306,968,205	1,365,537,386	1,393,296,396	1,103,439,337	906,344,746	787,521,706	754,398,760
Trade and other receivables	9,753,442,955	3,169,759,114	619,568,225	309,490,414	427,570,904	363,796,222	386,998,349
Other financial assets	2,157,445,054	1,194,134,419	385,606,686	332,993,544	367,658,026	587,869,820	197,707,418
Other current assets	4,953,753,818	1,273,208,370	837,570,607	1,041,242,477	1,072,877,218	1,086,476,963	834,813,660
Cash and cash equivalents	4,371,708,869	3,447,122,724	2,844,118,989	2,850,661,246	2,090,211,165	1,792,313,734	3,140,570,540
Total Current Assets	**22,543,318,901**	**10,449,762,013**	**6,080,160,903**	**5,637,827,018**	**4,864,662,059**	**4,617,978,445**	**5,314,488,727**
Total Assets	**88,891,424,187**	**60,741,018,595**	**48,864,436,068**	**43,631,009,734**	**38,516,804,861**	**35,134,066,574**	**34,111,511,938**
Equity and Liabilities							
Equity							
Share capital	6,197,199,566	6,197,199,566	6,197,199,566	6,197,199,566	6,197,199,566	6,197,199,566	6,197,199,570
Supplementary capital	4,619,748,508	4,289,897,392	4,188,925,865	3,862,178,622	3,645,925,473	236,869,246	42,621,640
Legal reserve	348,631,502	348,631,502	348,631,502	204,262,996	183,358,234	55,853,602	127,061,441
Accumulated profits	1,939,245,322	3,884,582,856	8,124,141,538	8,336,689,811	8,368,052,954	8,391,033,776	7,682,302,826
Net Income	- 983,432,916	- 1,945,337,534	- 61,173,844	- 68,179,767	-	-	-
Total Equity	**12,121,391,982**	**12,774,973,782**	**18,797,724,627**	**18,532,151,228**	**18,394,536,227**	**14,880,956,190**	**14,049,185,477**
Non Current Liabilities							
Provisions	6,788,800,640	6,695,576,267	1,692,745,620	1,444,394,847	1,190,524,770	1,156,482,571	1,014,443,150
Bank Loans	-	1,501,012,588	2,684,080,400	2,340,585,354	1,137,763,764	1,265,005,624	1,722,191,885
Trade payables	508,992,064	-	102,313,978	123,413,109	196,310,974	271,431,441	67,259,405
Other financial liabilities	25,758,142,582	14,981,797,351	8,058,266,160	6,470,519,812	5,408,616,754	7,901,838,525	8,214,882,767
Other non current liabilities	8,697,178,696	7,684,575,580	6,851,596,160	5,876,617,214	4,532,491,643	2,598,059,701	2,131,463,780
Deferred tax	2,428,526,963	2,666,123,225	3,248,113,162	3,336,235,067	3,315,679,012	3,233,043,469	3,164,794,482
Total Non Current Liabilites	**44,181,640,945**	**33,529,085,011**	**22,637,115,480**	**19,591,765,403**	**15,781,386,917**	**16,425,861,331**	**16,315,035,469**
Current Liabilities							
Provisions	567,008,739	398,683,219	241,266,506	278,636,966	322,864,471	159,800,395	142,589,730
Bank Loans	23,952,195,383	10,017,532,681	4,760,360,754	3,659,657,158	451,704,355	421,954,746	432,752,934
Trade payables	323,774,767	1,046,465,717	415,170,804	450,244,768	2,887,225,640	2,651,670,839	2,763,258,334
Other financial liabilities	7,331,132,071	2,636,126,108	1,618,208,503	774,147,656	512,486,044	366,612,368	144,472,393
Other current liabilites	414,280,300	338,152,077	394,589,394	344,406,556	166,601,207	227,210,705	264,217,601
Total Current Liabilities	**32,588,391,260**	**14,436,959,802**	**7,429,595,961**	**5,507,093,104**	**4,340,881,717**	**3,827,249,053**	**3,747,290,992**
Total Liabilities	**76,770,032,205**	**47,966,044,813**	**30,066,711,441**	**25,098,858,507**	**20,122,268,634**	**20,253,110,384**	**20,062,326,461**
Total Equity and Liabilities	**88,891,424,187**	**60,741,018,595**	**48,864,436,068**	**43,631,009,735**	**38,516,804,861**	**35,134,066,574**	**34,111,511,938**

Source: EDM Data

Table 9.1-2 EDM Profit and Loss Statement

Income Statement

	2016	2015	2014	2013	2012	2011	2010
Revenue	29,122,396,974	16,348,819,781	10,739,768,055	9,913,415,208	8,495,613,932	7,352,388,971	6,270,414,680
Cost of Sales	- 22,269,768,340	- 9,810,414,744	- 3,792,157,002	- 3,542,568,207	- 2,791,670,628	-2460513712	- 2,181,928,080
Gross Result	**6,852,628,634**	**6,538,405,037**	**6,947,611,053**	**6,370,847,001**	**5,703,943,304**	**4,891,875,259**	**4,088,486,600**
Personnel Cost	- 3,124,740,674	- 2,439,981,013	- 2,005,917,411	- 1,787,770,680	- 1,693,434,352	- 1,391,462,519	- 1,315,992,160
Supply and Services (to third party)	- 2,372,463,418	- 2,285,428,059	- 2,377,534,670	- 2,131,860,960	- 2,038,779,398	- 1,472,902,015	- 1,216,477,910
Depreciations and Amortizations	- 2,900,794,329	- 3,046,764,306	- 2,360,113,731	- 1,980,736,464	- 1,421,696,912	- 1,385,527,781	- 1,228,555,766
Loss due to impairment	- 26,245,947	-	-	- 1,782,967	-	-	-
Provisions	- 543,143,663	- 838,983,413	- 374,457,403	- 339,506,307	- 306,951,641	- 248,390,486	- 234,544,740
Loss due to fair value	- 307,439,961	- 158,508,352	- 160,780	- 1,091,516	-	-	-
Other earnings and operational loss	- 6,476,602	647,831,549	271,793,813	241,171,939	123,856,873	174,859,143	- 33,150,143
	- 9,281,304,594	**- 8,121,833,594**	**- 6,846,390,182**	**- 6,001,576,955**	**- 5,337,005,430**	**- 4,323,423,658**	**- 4,028,720,719**
Operational Result	**- 2,428,675,960**	**- 1,583,428,557**	**101,220,871**	**369,270,046**	**366,937,874**	**568,451,601**	**59,765,881**
Financial Income	7,022,881,398	2,327,393,367	425,518,877	288,441,193	421,028,739	1,046,978,430	461,451,620
Financial Expense	- 5,605,820,988	- 3,459,101,940	- 598,591,723	- 605,454,262	- 488,680,811	- 793,235,769	- 848,907,700
(Expense)/Revenue of Liquid Finance	**1,417,060,410**	**- 1,131,708,573**	**- 173,072,846**	**- 317,013,069**	**- 67,652,072**	**253,742,661**	**- 387,456,080**
Income beofre Tax	**- 1,011,615,550**	**- 2,715,137,130**	**- 71,851,975**	**52,256,977**	**299,285,802**	**822,194,262**	**- 327,690,199**
Income Tax	28,182,634	769,799,596	10,678,131	- 120,436,744	- 194,761,993	- 184,671,153	- 26,012,186
Net Income	**- 983,432,916**	**- 1,945,337,534**	**- 61,173,844**	**- 68,179,767**	**104,523,809**	**637,523,109**	**- 353,702,385**

Source：EDM Data

Table 9.1-3 EDM Cash Flow Statement

Cashflow Statement

	2016	2015	2014	2013	2012	2011	2010
Cashflow from Operating Activities							
Profit before tax	-983,432,916	-1,945,337,534	-61,173,844	-68,179,767	299,285,803	637,523,110	-353,702,385
Adjustments:	528,465,193						
Depreciation	2,900,794,329	3,046,764,306	2,360,113,731	1,980,736,465	1,421,696,912	1,385,527,781	1,228,555,766
Amortization of donations/ Others	827,173			-	-45,974,469	-	-
Gains on disposal of tangible assets				-	-	-	-
Provisions	261,549,894	606,546,186	210,980,313	209,642,572	197,106,275	248,390,486	234,544,740
Profit before tax after adjustment	**2,708,203,673**	**1,707,972,958**	**2,509,920,200**	**2,122,199,270**	**1,872,114,521**	**2,271,441,377**	**1,109,398,121**
Increase in inventories	32,323,214	27,759,030	-289,857,059	-197,094,591	-118,823,040	-33,122,946	-72,843,990
(Increase)/decrease in trade and othe receivables	-6,891,123,802	-	-	-	-63,774,682	-25,525,040	281,769,773
Decrease/(incerase) in other financial assets	-2,157,255,882	-3,493,865,585	-441,125,106	-1,047,019,343	220,211,794	-	-
Decrease/(incerase) in other current assets	-3,680,545,448	-645,051,390	203,671,870	31,634,741	13,599,745	-251,663,303	-233,761,840
Increase trade paybles		-	-	-	160,434,334	-	-
Increase in other financial liabilities	13,934,662,697	13,095,530,488	3,432,021,214	2,102,488,769	145,873,675	31,976,749	2,707,979,397
Decrease in other current liabilities	1,249,218,895	194,552,166	937,039,879	1,543,985,443	-60,609,498	697,013,357	1,053,279,515
Cash flow generated by operations	**5,195,483,347**	**10,886,897,667**	**6,351,670,998**	**4,556,194,289**	**2,169,026,849**	**2,690,120,194**	**4,845,820,976**
Tax paid			-	-	-236,755,856	-	-
Interest paid			-	-	-160,293,501	-	-
Net Cashflow from Operating Activites	**5,195,483,347**	**10,886,897,667**	**6,351,670,998**	**4,556,194,289**	**1,771,977,492**	**2,690,120,194**	**4,845,820,976**
Cashflow from Investing Activites							
Acquisition of tangible assets	-18,074,787,991	-9,807,212,981	-7,104,157,227	-5,046,157,692	-4,557,161,633	-3,142,792,997	-4,675,347,629
Interest received	-122,112,494	-25,879,579	-47,048,952	1,081,316	88,200,187	120,719,216	90,974,630
Dividends received			-	-	28,100,000	-	-500,000
Net Cash Utilized in Investing Activities	**-18,196,900,485**	**-9,833,092,560**	**-7,151,206,179**	**-5,045,076,376**	**-4,440,861,446**	**-3,022,073,781**	**-4,584,872,999**
Cashflow form Financing Activities							
Loan Granted			-	-	-	-547,175,578	440,910,012
Borrwoing for investment	13,596,152,165	-551,772,899	308,421,082	1,201,362,003	1,973,907,879	-	-
Agreements on retrocession obtained			-	-	1,093,601,977	-	-
Net repayment on bank loans			-	-	-97,492,252	-224,474,704	-137,258,520
Payments on financial leases			-	-	-3,236,220	-	-
Accessory benefits	329,851,116	100,971,525	326,747,243	216,253,149			-
Payment of dividend				-10,458,381			-
Net Cash from Financing Activities	**13,926,003,281**	**-450,801,374**	**635,168,325**	**1,407,156,771**	**2,966,781,384**	**-771,650,282**	**303,651,492**
Decrease in cash and cah equivalents	**924,586,143**	**603,003,733**	**-164,366,856**	**918,274,684**	**297,897,430**	**-1,103,603,869**	**564,599,469**
Cash and cash equivalent at the beginning of the year	3,447,122,726	2,844,118,993	3,008,485,849	2,090,211,165	1,792,313,734	3,140,570,540	2,351,739,650
Cash and cash equivalent at the end of the year	**4,371,708,869**	**3,447,122,726**	**2,844,118,993**	**3,008,485,849**	**2,090,211,164**	**2,036,966,671**	**2,916,339,119**

Source: EDM Data

Table 9.1-4 EDM Financial Statement Analysis

Category	Evaluation Indicator	Unit	2016	2015	2014	2013	2012	2011
Profitability	Operating Income Ratio	%	-31.87	-49.68	-63.75	-60.54	-62.82	-58.80
	Profit Margin Ratio before Tax	%	-3.47	-16.61	-0.67	0.53	3.52	11.18
	Profit Margin Ratio	%	-3.38	-11.90	-0.57	-0.79	1.23	8.67
Turnover	Total Asset Turnover Ratio	ratio	-0.01	-0.03	0.00	0.00	0.00	0.02
	Accounts Receivable Turnover Ratio	ratio	4.51	8.63	23.12	26.90	21.47	19.59
Stability	Current Ratio	ratio	0.69	0.72	0.82	1.02	1.12	1.21
	Quick Ratio	ratio	0.13	0.24	0.38	0.52	0.48	0.47
	Long-term Fixed Assets Ratio	%	89.96	88.68	98.87	99.28	100.47	89.47
	Debt Equity Ratio	%	86.36	78.97	61.53	57.53	52.24	57.65
	Interest Coverage Ratio	ratio	-0.18	-0.78	-0.12	0.09	0.61	1.04
Growth	Sales Growth Rate	%	78.13	52.23	8.34	16.69	15.55	17.26
Overall Profitability	Rate of Return on Equity	%	-15.87	-31.39	-0.99	-0.93	1.69	10.29
	Rate of Return on Assets	%	-8.81	-9.86	-1.43	-1.64	-1.04	-0.45

Source: Compiled by JST based on EDM Data

The financial statement analysis shows that EDM does not show the sufficient profit margin and field the expected profit. With respect to the utilization and turnover of assets, EDM fails to achieve the sufficient result. In addition, the debt repayment also has difficulties for the short-term position due to the insufficient financial stability. However, the number of customers and the sales of electricity have been increasing, it is expected the growing trend will continue given the solid demand increase. It is however considered that the funding arrangement will be increasing important in order to meet the capital needs for the expansion of facilities.

9.2 EDM Strategy for Financial Management

9.2.1 EDM Financial Management Issues

The management issues of EDM can be summarized below.

Table 9.2-1 EDM Financial Issues

Category	Issues
1. Revenue	(a) Insufficient tariff level to cover investment needs
	(b) Unstable revenue from power export
	(c) Challenges in reduction of technical and non-technical loss
	(d) Negative impact of electrification on finance
2. Financing	(a) Scenarios for securing debt financing from cooperating partners
	(b) Opportunity for public and private partnership
	(c) Increasing needs for power system expansion (G, T, D & rural electrification)
3. Financial Management	(a) Volatility and management of foreign currency (e.g. debt services, revenue in foreign currency)
	(b) Significant impact of power purchase from IPPs on EDM finance

Source: JST

As summarized in the above the financial issues of EDM are wide-ranging and large. Due to the low-level electricity tariff, EDM has constraints on the revenue side and also uncertainty in the marginal increase of the revenue from the new investment in the facilities because of the diminishing return on investment. Regarding the funding side, one of the greatest issues is the financial procurement of the low interest loans for meeting the demand increase. In addition, the financial management faces the increasing costs of power purchase from IPPS and the fluctuation of the exchange rate.

9.2.2 EDM Financial Strategy

The company strategy of EDM has been described in the Corporate Business Plan (2015-2019). The overview for the financial strategy can be summarized in Table 9.2-2.

Table 9.2-2 EDM Strategy for Financial Management

<table>
<tr><th>Pilar</th><th>Challenges</th><th>Consequences</th><th>Goals</th><th>Area-Objectives</th><th>Objectives</th></tr>
<tr><td rowspan="6">Financial Strength and Business Profitability</td><td rowspan="3">Insufficient funding for growth and non-cost reflective tariffs</td><td rowspan="3">Needed investments on infrastructure and modernization are costly and delayed</td><td rowspan="3">Higher availability of funding</td><td>Cost-recovery mechanisms</td><td>Design, negotiate and implement cost-recovery mechanisms such as tariffs, benefits, exemptions and subsidies</td></tr>
<tr><td>Increase of earnings</td><td>Increase earnings through the intensification of energy sales and the growth of business</td></tr>
<tr><td>Modernization of financing</td><td>Mobilize concessional financial sources, development and commercial funding sources for investment on growth and modernization</td></tr>
<tr><td rowspan="3">High losses and low business efficiency</td><td rowspan="3">Impaired financial capability and costly operations, damages reputation</td><td rowspan="3">Increased quality and business efficiency</td><td>Loss reduction</td><td>Design and implement structures and programs to ensure the reduction of technical and commercial losses</td></tr>
<tr><td>Financial planning and management</td><td>Design and implement tools and procedures to ensure the reduction of costs and higher efficacy in the use of the company's resources.</td></tr>
<tr><td>Planning effectiveness</td><td>Improve the efficacy and the quality of planning.</td></tr>
</table>

Source: Corporate Business Plan of Electricidade de Moçambique 2015-2019

The strategies emphasized in the strategy include (i)the loss reduction, (ii)improvement of financial management, and (iii)enhancement of revenue from the sales increase. On the funding side, the necessary funds will be secured through establishing the revenue increase mechanism such as electricity tariff adjustment, and the promotion of concessional loans.

The actions to implement these strategies are established in Table 9.2-3.

Table 9.2-3 EDM Actions

Item	Lines of Action
LA27: Tariffs on new electricity generation	Promote the implementation of preferential tariffs for acquisition of energy for consumption within the country from new generation projects
LA8: Consumption intensification	Maximize the current system capacity to identify and connect new clients on the existing networks with special emphasis on clients of negotiated tariffs, high consumption consumers such as hotels and commercial industries.
LA9: New businesses	Promote the financial participation of the company in lucrative business based on stringent risk and benefit analysis.
LA16: Cost reduction	Introduce stringent cost cutting measures and guarantee good financial and material management
LA17: Financial processes	Introduce an integrated Financial Management System and a restructuring of the financial area by developing the processes and internal procedures, which guarantee the optimization of financial resources
LA10: Funding sources	Guarantee and ensure the Government aid in participating in financial deals, capital injection and drawing financial agreements with other institutions of a commercial nature on development or concessional
LA11: Funding critical projects	Guarantee and ensure Government financial aid on the implementation of critical projects (emergencies and short term) to guarantee the continuous supply of energy to EDM clients on accelerated growth zones, special economic zones and free zones
LA29: PPAs	Negotiate and establish purchases and sale agreement of energy tariffs to ensure the business sustainability

Source: Corporate Business Plan of Electricidade de Moçambique 2015-2019

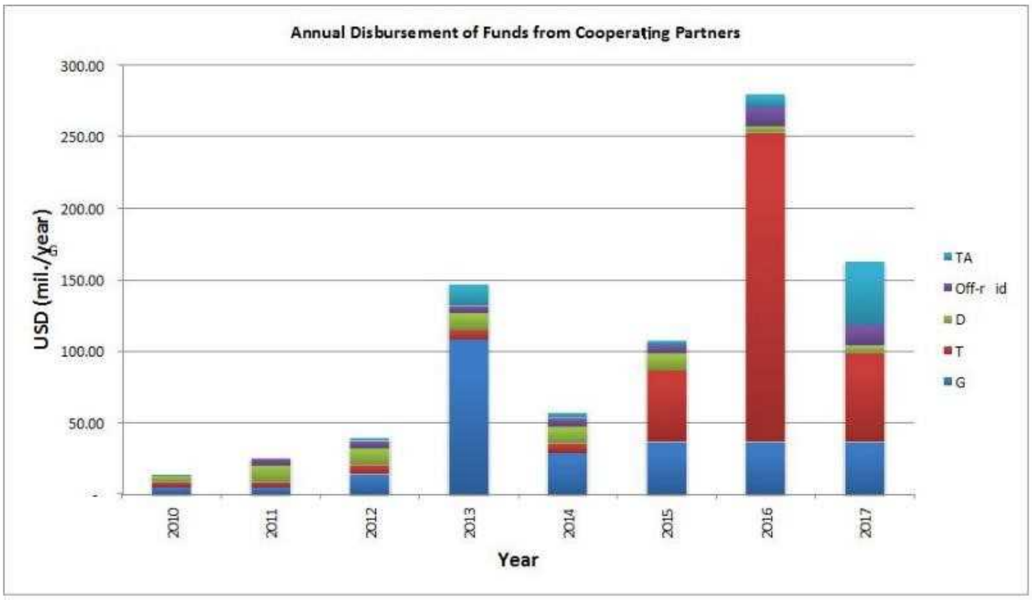
EDM has set up the key performance indicators for measure the financial improvement. These include the financial indicators such as average selling price, power supply costs, profit ratios, debt equity ratio, profit margin. EDM however has not achieved the targets because of the insufficient profits as of April 2017.

9.2.3 Perspectives for Funding

The financial institutions that provide debt financing include JICA, World Bank, Belgium government, Kuwait government, Norway government and Exim Bank of India. The borrowing conditions from these banks are concessional, providing favorable conditions for the power development. EDM has also debt financing from the commercial banks such as DBSA, BCI, Standard Bank and BancABC.

It is expected that the future financial procurement would be made from the international financial institutions and the bilateral cooperating partners. These financial institutions are also interested in the development and the investment needs of the power sector. The financial analysis in the following sections will provide a direction for the financial scenarios in the future.

The trend of donor financing until 2017 is illustrated in the chart below. The total disbursement until 2017 appears to be USD 100 to 200 million on average, which include the financial assistance in generation, transmission, distribution, electrification and technical assistance. The expected capital size for the future development will be larger than the current level. It is therefore expected that the EDM and government will coordinate with the financial institutions for funding the future development.



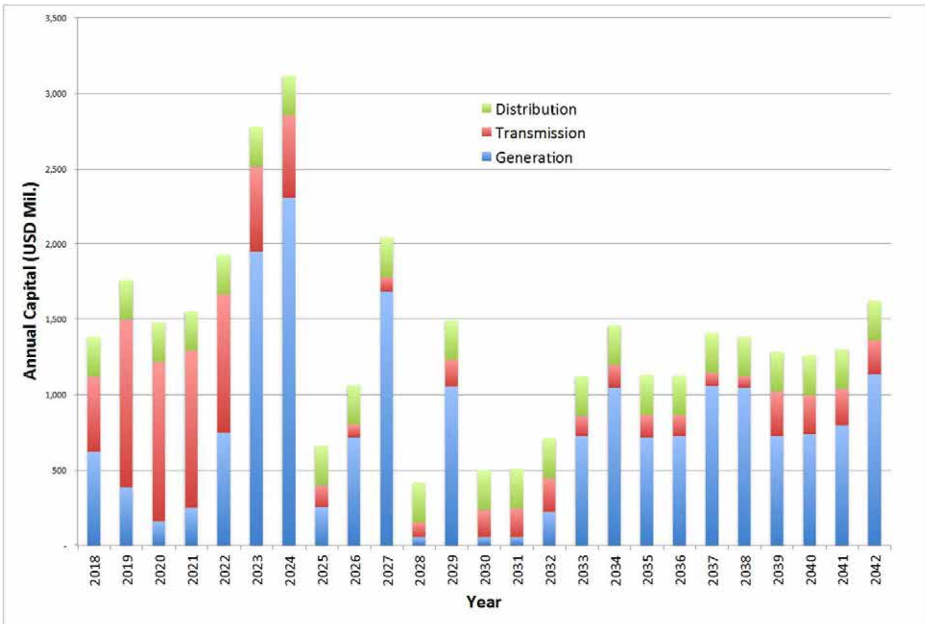
Source：Prepared by JST by materials of donor meeting

Figure 9.2-1 Trend of Donor Financing

9.3 Long-term Investment Plan

9.3.1 Schedule for Investment Fund

The long-term investment plan is developed in view of the timely development of the generation, transmission and distribution facilities to secure the necessary supply capacity to meet the projected future demand in the base case. The periods for the preparation and construction for each project is considered after the commissioning year is established. The long-term investment plan is illustrated in the below chart including the generation, transmission and distribution development plans.



Source: JST

Figure 9.3-1 Investment Schedule

The characteristics of the funding schedule are the large portion of the total funding in the period until 2024. This is due to the target year of the commissioning of Mphanda Nkuwa power plant, when the funding is necessary for the investment in the generation and associated transmission facilities. In addition, after 2033 there remains a high-level investment needs for distribution network and the generation development to meet the increasing demand.

9.3.2 Financial Sources

Among the capital investment projects, those projects that have been secured funding include the generation projects such as Temane, CTM and Mocuba. Other projects to be in operation after 2023 remain unfunded at this point. With respect to the transmission investment, Mozambique-Malawi transmission project and the transmission associated with Temane project have already secured financing. On the other hand, other key projects have not been funded at the time of the Study. It is necessary to prepare for the project implementation to meet the planned schedule, which include the various technical studies, legal procedures and capital procurement. These processes have been identified as important steps to implement the planned investment. EDM expects the concessionary donor funding for the investment, and will coordinate with the donors in due course of project planning.

9.3.3 Organizational Setup for Investment

The organizations in charge of investment are categorized into two groups of government organizations and private companies. The government organizations in Mozambique include HCB, MOTRACO and FUNAE in addition to EDM. Since FUNAE is mainly in charge of the off-grid power supply, the business scope of FUNAE is not included in the Study. The developments by the joint venture of government organizations and PPP with private entities are also implemented.

Considering the amount of funds necessary for the 25-year investment, the capital mobilization by EDM alone would be limited to cover all the investment. Thus, it will be important to collaborate and demarcate the investment with the private sector and the non-EDM government organizations. The current transmission and distribution businesses are dominated by EDM. It is unlikely in a short-run for private sector to participate in the transmission and distribution in Mozambique. The current power supply regime will also remain the same for a certain period of time. On the other hand, the generation business has already attracted the private sector investment, the operation by the non-EDM government organizations. It is therefore expected that the investment by those organizations will increase. The assumption of the Study is that the investment in generation subsector will be predominantly by non-EDM government organizations and private sector whereas the transmission and distribution will be invested by EDM.

9.4 Financial Management Strategy of EDM

9.4.1 Mid- and Long-term Target of EDM Finance

The financial strategy of EDM is, as mentioned earlier, wide-ranging and comprehensive. The major items are expected to be indicators to monitor the performance and reflect on the managerial decision-making. These management indicators can be summarized in the below.

Table 9.4-1 Financial Management Indicators

Issue Category	Management Indicator	Long-term Target
1. Profitability	Rate of Return on Assets (ROA)	8%
	Operating Income Ratio	20%
	Sales Growth per Investment on Distribution System	The discrepancy at each office from the target is less than 10%.
	Power Supply Loss	11% (Distribution 7%, Transmission 4%)
2. Fund Procurement	Schedule of Private Investment Projects	Discrepancy with corporate management plan
	Interest Coverage Ratio	3.0
3. Financial Management	Average Bulk Supply Cost	Procurement costs will be less than 10% of corporate management plan.
	Trend of Average Power Tariff in USD term	Power tariff to be adjusted so that the discrepancy from corporate plan is less than 10%.

Source: JICA Study Team

9.4.2 Strategy to Achieve Targets

The first priority to achieve the financial targets is to stabilize the revenue basis to recover the power supply costs. The EDM finance was historically deteriorated by the increase of the power purchase costs from IPPs and hence the increase of the supply costs of EDM. The power tariff on the other hand was not adjusted until 2015. In addition, the tariff is further decreased in the US dollar term due to the depreciation of the Mozambique metical. Due to the low power tariff, EDM cannot recover the power supply costs with the negative margin. Thus, the first priority to increase the power tariff to the level that can recover the supply costs. The power tariff adjustment also needs to take the exchange rate fluctuation into considerations so that EDM can transfer the risk to the end-users.

The corporate performance of EDM will also need to be improved in parallel with the adjustment of power tariff. This includes the investment on loss reduction, introduction of donor financing to reduce the capital costs for new investment, increase of power supply from HCB to reduce the bulk supply costs, the study of possibility to increase the power import from neighboring countries. Emergency power purchase from private sector may be required to address the power shortage in the future. In the past EDM’s finance was deteriorated by the high costs of emergency power purchase from private sector. It is thus necessary to plan and implement investment projects in a timely manner. It is also effective to consider the utilization of power pool and the increase of power purchase from HCB. These measures are expected to reduce the power supply costs and increase the revenue basis for EDM.

9.5 Financial Analysis

9.5.1 Overview

The financial analysis basically projects the corporate finance until 2042 for EDM and evaluates the financial position. The analysis is based on the optimized investment plan until 2042 including the generation, transmission and distribution subsectors. The expected debt financing and development costs are considered for the analysis. The revenue was also projected by the expected power tariff increase in the future to study the profitability of EDM.

With respect to the investment by private sector such as generation projects, appropriate power purchase prices are estimated for the EDM’s costs. On the other hand, the EDM’s investments such as transmission and distribution facilities consider the financing and investing by EDM. The off-grid electrification is excluded from the scope of study of financial analysis for EDM because the investment in off-grid electrification will be made by FUNAE.

If the power generated by EDM is exported by EDM, the power sales is directly accounted for the EDM finance. On the other hand, power export by private sector would be outside of the EDM accounts and be excluded from the financial projection of EDM.

9.5.2 Assumptions

The assumptions for the analyses are the following and coordinated with EDM.

(a) Currency and Exchange Rate

The currency for study is US dollars. The revenue from the domestic end-users are in MZM and converted into USD at the exchange rate of each year. The exchange rates until 2019 are estimated by the rates in recent years. The rates after 2020 were projected by the consumer price index of US and Mozambique.

Table 9.5-1 Exchange Rates (MZM/USD)

Year	2017	2018	2019	2020	2021	2022	2023	2024
Exchange Rate	62.0	62.0	62.0	68.2	75.0	81.0	87.5	94.5

The rates after 2025 are calculated by the differences between the consumer price indexes of Mozambique and those of US.

Source：JST

(b) Investment Plan for Generation

The investment plan is based on the 25-year facility investment plan to meet the power demand by JST. The projects implemented by EDM are included in the EDM investment plan whereas those investments by non-EDM organizations will be excluded from the EDM investment plan. It is then assumed that EDM purchase power from non-EDM organizations. The investment for each year of an investment project is assumed to be the same amount throughout the project years, leveling the costs over the construction years. The total investment costs from 2018 to 2042 will be USD 17,915 mil. at 2017 price.

(c) Investment Plan for Transmission

The investment plan for transmission is also developed based on the 25-year facility investment plan in a similar manner with generation. The investment amount is the summation of each individual project. The total investment costs from 2018 to 2042 will be USD 5,797 mil. at 2017 price.

(d) Investment Plan for Distribution

The total investment costs from 2018 to 2042 will be USD 56,625 mil. at 2017 price. The distribution development costs cover the rehabilitation and new expansion plan of distribution facilities.

(e) Operation Period

The operation periods for generation plants are 40 years and 25 years for hydro and thermal plants, respectively. The operation periods for transmission and distribution are 30 years and 25 years, respectively.

(f) Operation and Maintenance (O&M) Costs and Fuel Costs

The O&M costs for generation facilities and fuel costs are estimated by the actual data in Mozambique and similar facilities in other countries.

(g) Power Purchase Price from IPPs

EDM's ongoing power purchases from IPPs are quoted from the existing contract prices. The power purchase prices for new additional contracts are estimated by the construction and O&M costs of new plants as well as the contracts of similar plants. The ongoing purchase from the generation plants include HCB, GIGAWATT and the new plant include Temane. The prices of power import from neighboring countries are estimated by the recent power trade data.

(h) Power Export Price

The power export prices from EDM to others are estimated by the recent trading data. These include the power trade in SAPP and power sales to BPC, LEC and ZESCO. The average export price is estimated to be 9 US cent/kWh.

(i) Power Sales

The power sales are estimated by the power demand forecast data. The financial analysis uses the demand of the base case. The sales are expected to grow from 3,773GWh in 2018 to 21,847 GWh in 2052.

(j) Transmission and Distribution Losses

The transmission losses are projected based on the current system losses and the loss reduction target and projection in the next 25 years. The current losses in 2017 are assumed to be 7.0% and 19.0% for transmission and distribution, respectively. The losses are expected to be decreased every year, and assumed to reach 4.0% and 7.0% for transmission and distribution, respectively. The costs for loss reductions are assumed to be included in the investment plans.

(k) Power Tariff

The power tariffs assume the expected adjustment scenario based on the current 2017 data. The expectation is to increase the power tariff from 2018 to 2021 to reach the economic level tariff to recover the costs. After 2022 the power tariffs will be adjusted every year considering the consumer price index and power supply costs in order to sustain the EDM operation. Since the long-run increase of consumer prices is estimated to be 10%, the tariff increase will be a little bit higher than the CPI increase. The resulting power tariffs will be discussed at the later section of the report.

Table 9.5-2 Annual Average Power Tariff Increase (Base Case)

Year	2018	2019	2020	2021	2022	2023	2024	2025
Annual Increase (%)	30.0	15.0	17.0	21.0	19.0	19.0	19.0	10.0
Year	2026	2027	2028	2029	2030	2031	2031	2033
Annual Increase (%)	10.0	10.0	7.0	7.0	7.0	9.0	9.0	9.0
Year	2034	2035	2036	2037	2038	2039	2040	2041
Annual Increase (%)	12.0	12.0	12.0	14.0	14.0	14.0	11.0	11.0
Year	2042							
Annual Increase (%)	11.0							

Source: JST

(l) Consumer Price Increase

The CPI is projected by the estimate of the price increases in Mozambique.

Table 9.5-3 Consumer Price Index

Year	2018	2019	2020	2021	2022	2023	2024	…	2042
CPI（%）	15.0	12.0	12.0	10.0	10.0	10.0	10.0		10.0

Source：JST

(m) Depreciation

The fixed assets are to be depreciated by the fixed amount every year for each facility. The depreciation years are the operation years shown in the above.

(n) Debt Financing

The debt financing conditions are estimated by the recent similar financing.

Table 9.5-4 Debt Financing Conditions

Item	Repayment Period	Grace Period	Interest Rate (%)
Debt from commercial banks	10 years	0 years	8.0%
Debt from donor agencies	25years	5 years	3.0%

Source：JST

(o) Interest During Construction (IDC)

IDC is included in the project costs and depreciated over the operation period.

(p) Tax and Public Dues

Corporate tax is estimated to be 32 %, which is current corporate tax rate.

9.5.3 Results of Financial Analysis

The results of financial analyses will be examined from the viewpoints of addressing the increasing the financial requirements to secure the power supply by EDM over the next 25 years.

(1) Investment Capital for Development

The analysis assumes that the funds for new generation plants will be prepared by private sector and/or non-EDM government organizations, and the funds for transmission and distribution will be prepared by EDM.[1]

[1] Considering the funding needs to all sub-sectors of generation, transmission and distribution, it is expected that the funding needs for a single fiscal year will be greater than USD 3.0 billion. This funding level appears to be difficult to secure by EDM based on the current EDM financial statements. Therefore, the investment and financing by government agencies and private companies other than EDM are considered to be necessary. With respect to the distribution sub-sector, there are legal restrictions for private participation. It would be also difficult to demarcate the roles between EDM and others due to the duplication/coordination of service provision. Thus the participation in business by other companies than EDM is not considered realistic at the moment.

The total investment needs for generation, transmission and distribution amount to approximately USD 30,000 million. The feasibility of investment will need to be examined in the development plans of each specific project. At this point, there is no clear scenario to secure the total amount over the next 25 years. The future study will examine the bankability and possible funding scheme for each project.

(2) Necessary Funds by EDM and non-EDM Organizations

The funds necessary for EDM will be approximately USD 500 million on average every year for the next 25 years. The possible funding source will be concessional loans from donors. The prospects for this size of funding are not firm at the moment, except a few transmission and distribution projects. It is not possible to judge whether the funds can be mobilized in case the government guarantees are required in particular.

Most of the private investment projects are not structured yet at the moment either. The financing for equity and debt will be examined in the future.

(3) Financial Forecast for EDM

The projections for sales and revenue of EDM are as shown in the below charts.
The base case is based on the generation development plan (power export: 20% and renewables:10%) and the base case of transmission and distribution development. The base case assumes that the short-term power import from 2018 to 2022 to fill the supply gap. The comparison case expects the increase of power purchase from HCB from 2018 to 2022 to increase the supply.

While the construction of new generation plants by EDM during this period may not be possible, the emergency power purchase from private sector would be expensive and hence deteriorate the EDM finance. Therefore, the power imports and power purchase from HCB would be a better solution to address the power shortage.

The analyses assume the power tariff adjustment to produce positive net income every year to sustain the EDM operation. All the power supply costs are to be recovered from the power sales by adjusting the tariff level every year.

The analyses deal two cases[2] , namely;

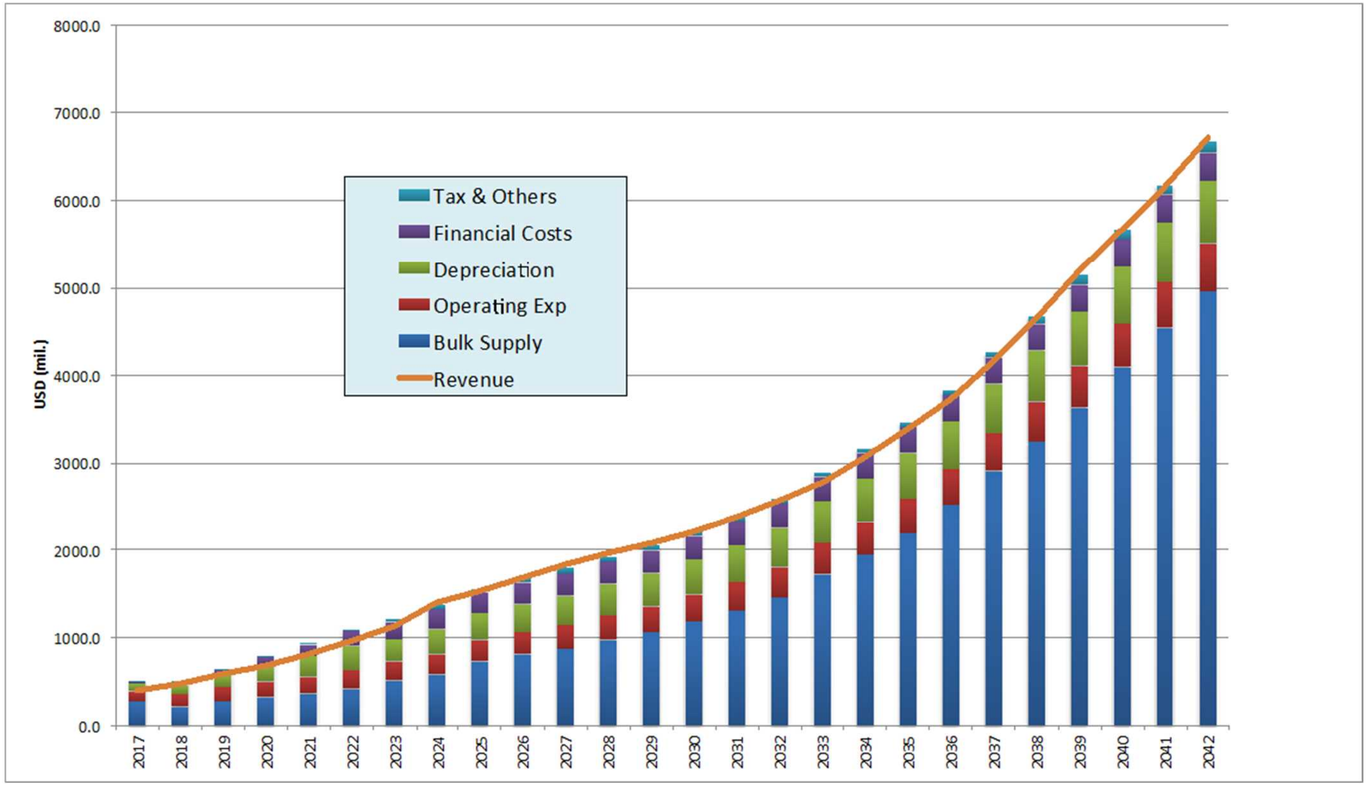
(a) Base Case（Power shortage of 2018-2022 will be supplied by power import.）

(b) Comparison Case (Power shortage of 2018-2022 will be supplied by power purchase from HCB.)

With respect to the transmission sub-sector, except for special cases, it seems to be difficult for operators other than EDM to participate in the business due to interference with operation with the existing EDM network. Accordingly, it is expected that business other than EDM will participate in the power generation sector. It is difficult to estimate the extent to which companies other than EDM can participate in the generation project at the moment. With any private and/or other government organizations' participation in generation business, EDM would be able to allocate more funds to transmission and distribution businesses.
Also, for the sake of convenience of financial analysis, it is assumed that the cost of fund arrangements by private sector and government organizations other than EDM is higher than EDM. It would be possible to estimate the upper side of the power tariffs if the investment in generation is made by private and/or government organizations other than EDM. Therefore, this analysis assumes that the investment in generation sub-sector is by private and/or government organizations other than EDM thereby estimating a safety side of the power tariff in the future.

[2] The base scenario for generation development is power export: 20% and renewables: 10%

The major items of the analysis result for the base case are shown in Figure 9.5-1, Table 9.5-5, Table 9.5-6, and Table 9.5-7.



Source: JST

Figure 9.5-1 Costs and Revenue (Base Case)

Table 9.5-5 Profit and Loss Statement (Base Case)

Profit and Loss Statement USD million	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenue																										
Electricity Sales																										
Tariffbound Electricity Sales	292.7	415.9	521.1	602.1	717.8	855.3	1,017.2	1,207.6	1,323.3	1,448.2	1,582.9	1,681.2	1,783.9	1,891.4	2,040.8	2,199.9	2,369.1	2,619.4	2,894.1	3,195.6	3,589.5	4,030.1	4,523.0	4,940.8	5,380.8	5,865.1
Large Customer Sales	21.7	30.4	36.6	44.0	53.5	63.4	74.3	86.5	96.4	107.2	119.0	130.3	142.6	155.8	171.2	187.8	205.6	226.9	250.0	274.9	303.5	334.4	367.9	401.2	435.9	473.8
Total Revenue	400.9	486.0	591.0	683.2	811.7	962.1	1,137.7	1,407.4	1,541.8	1,686.5	1,842.7	1,962.7	2,081.2	2,213.4	2,390.6	2,579.2	2,779.9	3,066.0	3,379.1	3,721.7	4,161.4	4,651.1	5,197.0	5,668.8	6,165.0	6,710.4
Operational Expenses																										
Bulk Supply Expenses																										
HCB	55.4	76.7	79.2	81.0	105.6	83.8	85.9	76.7	78.2	79.8	81.4	83.0	84.7	86.3	88.1	89.8	91.6	93.5	95.3	97.2	99.2	101.2	103.2	105.3	107.4	109.5
IPP Contracts	203.5	121.9	180.4	224.2	235.7	314.4	404.3	480.6	628.2	702.9	765.3	863.5	947.0	1,065.2	1,184.3	1,334.5	1,595.8	1,813.5	2,056.7	2,375.2	2,758.0	3,089.9	3,473.7	3,927.7	4,373.9	4,785.0
Total Bulk Supply Expenses	270.6	211.5	274.2	322.0	359.9	418.6	512.0	580.6	731.2	808.9	874.3	975.7	1,062.5	1,184.1	1,306.8	1,460.6	1,725.7	1,947.3	2,194.5	2,517.2	2,904.2	3,240.4	3,628.9	4,087.7	4,538.9	4,955.2
Total Operational Expenses	390.2	353.0	434.8	500.3	553.0	624.9	729.7	811.5	972.6	1,062.3	1,140.5	1,255.2	1,356.7	1,493.3	1,631.7	1,802.3	2,083.7	2,322.9	2,588.4	2,930.1	3,336.5	3,693.0	4,105.4	4,587.7	5,062.5	5,504.1
EBITDA	10.7	133.0	156.3	182.9	258.7	337.2	408.0	595.9	569.2	624.3	702.2	707.5	724.5	720.1	758.9	776.9	696.2	743.1	790.6	791.6	824.9	958.1	1,091.6	1,081.2	1,102.5	1,206.4
Total Depreciation	-87.1	-104.1	-139.7	-187.6	-237.7	-281.4	-252.6	-286.8	-305.7	-322.1	-339.4	-357.2	-379.3	-401.9	-425.5	-451.1	-473.0	-496.1	-519.7	-543.3	-564.8	-585.8	-618.7	-650.5	-682.1	-713.4
Profit after Tax	-92.7	2.5	-33.0	-91.6	-107.1	-111.5	-43.5	58.1	16.9	38.4	76.4	65.6	58.7	36.3	42.2	32.4	-60.5	-42.2	-23.2	-49.8	-40.8	47.9	113.8	80.7	69.7	115.8
Profit for the Year	-90.7	14.4	-19.2	-77.8	-92.1	-95.0	-15.1	84.6	44.3	67.2	107.3	91.8	91.4	69.8	80.3	74.2	-15.1	6.9	29.5	6.6	19.2	111.6	181.1	151.6	144.3	194.1

Source: JST

Table 9.5-6 Balance Sheet (Base Case)

Balance Sheet	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Assets																										
Long Term Assets																										
Capital Investment Plan																										
Generation	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0
Transmission	111.8	620.8	1,778.8	2,902.6	4,032.7	5,050.6	5,684.7	6,314.1	6,480.5	6,583.3	6,699.1	6,819.7	7,045.4	7,277.0	7,527.7	7,830.5	8,013.1	8,223.1	8,437.4	8,639.9	8,772.1	8,885.8	9,340.3	9,751.9	10,142.7	10,513.5
Distribution	207.1	207.1	207.1	512.8	824.6	1,142.6	1,467.0	1,797.9	2,135.4	2,479.6	2,830.7	3,188.9	3,554.2	3,926.8	4,306.9	4,694.5	5,089.9	5,493.3	5,904.7	6,324.3	6,752.3	7,188.9	7,634.2	8,088.4	8,551.7	9,024.3
Other	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
Accumulated Depreciation	-39.0	-71.5	-142.7	-263.6	-434.5	-652.2	-904.0	-1,189.9	-1,495.0	-1,816.7	-2,155.7	-2,512.5	-2,891.5	-3,293.1	-3,718.2	-4,169.0	-4,641.6	-5,137.4	-5,656.8	-6,199.7	-6,764.2	-7,349.9	-7,968.5	-8,619.1	-9,301.2	-10,014.6
Total Long Term Assets	1,463.2	1,870.0	2,928.3	4,170.0	5,374.1	6,428.6	7,134.4	7,808.0	8,006.1	8,131.1	8,258.6	8,380.2	8,591.9	8,794.1	8,999.4	9,238.8	9,343.8	9,461.0	9,566.9	9,645.8	9,641.2	9,605.7	9,886.8	10,102.1	10,274.1	10,404.1
Current Assets																										
Total Current Assets	119.1	181.3	294.2	380.1	503.6	666.4	877.4	1,230.0	1,461.3	1,712.2	1,972.7	2,161.0	2,341.2	2,486.3	2,663.3	2,833.3	2,907.5	3,024.5	3,165.6	3,284.6	3,414.1	3,654.2	3,985.0	4,248.2	4,521.8	4,879.9
Total Assets	1,582.2	2,051.4	3,222.5	4,550.0	5,877.6	7,095.0	8,011.8	9,038.0	9,467.4	9,843.3	10,231.3	10,541.2	10,933.2	11,280.5	11,662.7	12,072.1	12,251.2	12,485.5	12,732.5	12,930.3	13,055.4	13,259.9	13,871.9	14,350.3	14,795.9	15,284.0
Liabilities																										
Long Term Liabilities																										
Project Funding																										
Donor Funding Soft Loans	418.5	928.2	2,122.0	3,547.2	4,978.9	6,300.4	7,239.3	8,159.7	8,569.2	8,864.7	9,122.5	9,338.9	9,633.6	9,911.1	10,195.0	10,520.7	10,715.3	10,926.1	11,125.5	11,297.2	11,381.9	11,428.9	11,802.4	12,117.3	12,395.5	12,638.1
Total Long Term Liabilities	851.0	1,355.1	2,546.0	3,950.1	5,366.9	6,680.9	7,612.8	8,528.0	8,932.9	9,225.2	9,481.3	9,697.7	9,994.2	10,274.8	10,566.3	10,897.9	11,099.3	11,318.1	11,526.7	11,708.8	11,805.1	11,865.8	12,255.0	12,586.4	12,881.7	13,142.4
Current Liabilities																										
Total Current Liabilities	236.9	187.5	187.0	188.2	191.0	189.5	189.4	215.9	196.1	212.5	237.0	238.7	242.7	239.6	250.2	253.7	246.7	255.3	264.2	273.4	282.8	315.1	356.7	352.1	358.1	391.5
Shareholders Equity																										
Equity	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8
Suplementary capital	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9
Legal Reserve	13.1	13.8	13.8	13.8	13.8	13.8	13.8	18.1	20.3	23.6	29.0	33.6	38.2	41.7	45.7	49.4	49.4	49.7	51.2	51.5	52.5	58.1	67.1	74.7	81.9	91.6
Total Shareholders Equity	494.3	508.7	489.5	411.7	319.6	224.6	209.5	294.1	338.4	405.6	513.0	604.8	696.2	766.0	846.2	920.4	905.3	912.1	941.7	948.2	967.4	1,079.0	1,260.1	1,411.8	1,556.1	1,750.1
Total Liabilities	1,582.2	2,051.4	3,222.5	4,550.0	5,877.6	7,095.0	8,011.8	9,038.0	9,467.4	9,843.3	10,231.3	10,541.2	10,933.2	11,280.5	11,662.7	12,072.1	12,251.2	12,485.5	12,732.5	12,930.3	13,055.4	13,259.9	13,871.9	14,350.3	14,795.9	15,284.0

Source: JST

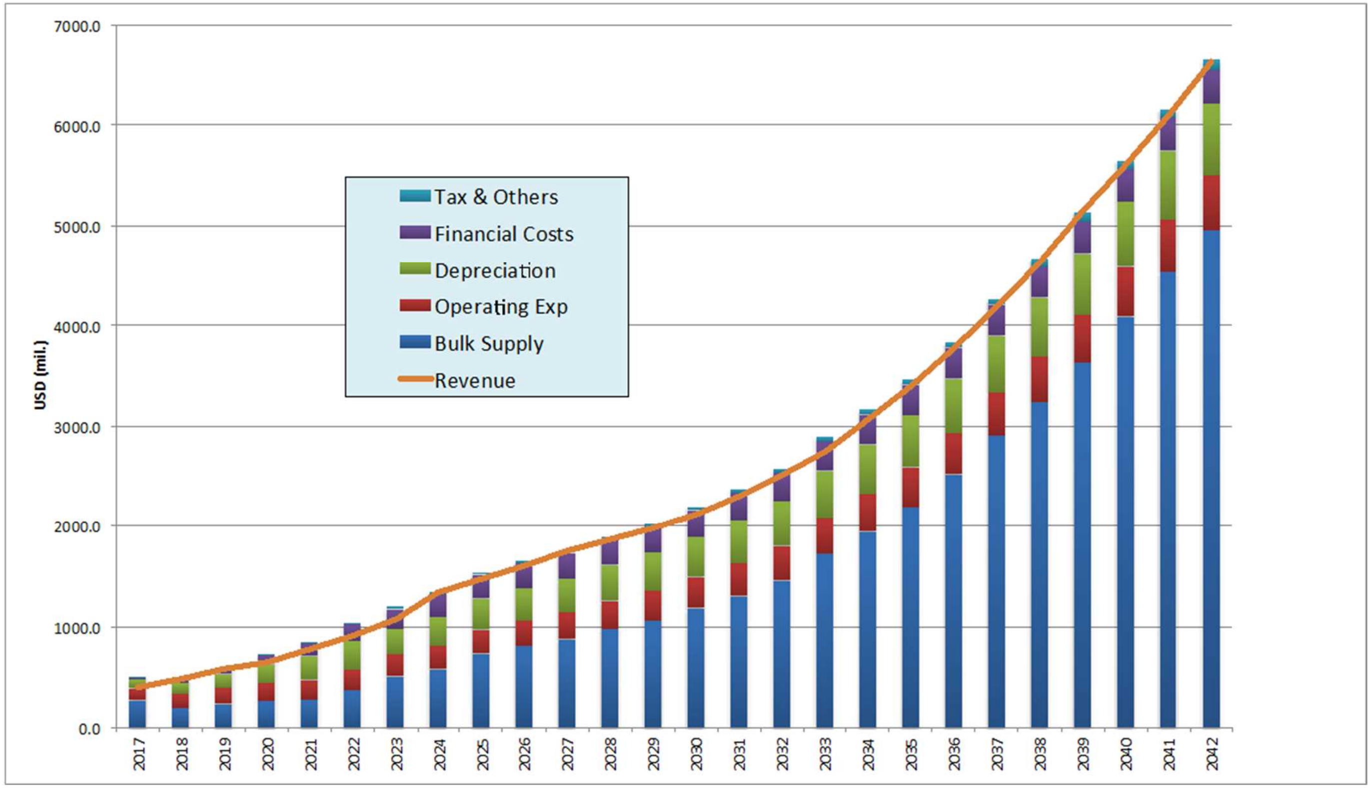
Table 9.5-7 Cash Flow Statement (Base Case)

Cash Flow Statement	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Cash Flow from Operations													
Earning before Tax (EBT)	-92.7	3.7	-33.0	-91.6	-107.1	-111.5	-43.5	85.4	24.9	56.4	112.4	96.5	86.4
Adjustments													
Depreciation	87.1	104.1	139.7	187.6	237.7	281.4	252.6	286.8	305.7	322.1	339.4	357.2	379.3
Increase in Stores	1.3	-5.1	-8.0	-8.8	-8.3	-7.5	-6.6	-6.8	-6.0	-6.1	-6.4	-6.7	-7.3
(Increase)/Decrease in Debtors	-9.7	-11.1	-11.7	-9.8	-13.9	-16.4	-19.3	-22.6	-13.9	-15.0	-16.2	-12.1	-12.7
Increase/(Decrease) in Creditors	6.5	-3.0	-4.5	-4.5	-2.6	-6.4	-4.4	-5.3	-4.3	2.4	2.4	2.5	2.5
Net Cash Flow from Operations	**-31.6**	**96.5**	**94.2**	**77.6**	**110.7**	**145.4**	**183.7**	**343.2**	**283.8**	**357.2**	**419.9**	**408.6**	**425.9**
Cash Flow from Investments													
Capital Expenditure													
Transmission	0.0	509.0	1,158.0	1,123.8	1,130.1	1,018.0	634.0	629.5	166.4	102.8	115.8	120.6	225.7
Distribution	0.0	0.0	0.0	305.7	311.8	318.0	324.4	330.9	337.5	344.2	351.1	358.1	365.3
Investment Income													
Interest													
Dividends	2.0	11.9	13.8	13.8	15.0	16.5	28.4	26.5	27.4	28.8	30.9	26.2	32.7
Sale of Long Term Financial Assets	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net Cash Flow from Investments	**-13.1**	**-499.1**	**-1,184.2**	**-1,415.5**	**-1,426.8**	**-1,319.5**	**-930.0**	**-933.9**	**-476.5**	**-418.2**	**-436.0**	**-452.6**	**-558.4**
Cash Flow from Financing													
Debt Finance													
Donor Funding - Soft Loans	119.8	509.8	1,198.0	1,429.5	1,441.8	1,336.0	958.4	960.4	503.9	447.0	466.9	478.8	591.1
Commercial Funding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Debt Repayment													
Exisiting Loans	10.3	13.1	13.1	23.0	16.9	11.0	9.8	8.8	7.8	6.9	6.2	5.5	4.8
Donor Funding	0.0	0.0	4.3	4.3	10.2	14.5	19.5	40.0	94.3	151.5	209.2	262.4	296.3
Commercial Funding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cash Flow from Financing	**110.6**	**498.5**	**1,181.3**	**1,402.9**	**1,415.5**	**1,311.3**	**929.9**	**912.5**	**402.7**	**289.5**	**252.6**	**212.0**	**291.1**
Periods Cash Flow	**65.9**	**96.0**	**91.3**	**65.1**	**99.4**	**137.2**	**183.7**	**321.8**	**210.0**	**228.5**	**236.4**	**168.0**	**158.6**
Opening Balance	**-114.5**	**-48.6**	**47.3**	**138.6**	**203.7**	**303.1**	**440.3**	**623.9**	**945.7**	**1,155.8**	**1,384.3**	**1,620.7**	**1,788.7**
Closing Balance	**-48.6**	**47.3**	**138.6**	**203.7**	**303.1**	**440.3**	**623.9**	**945.7**	**1,155.8**	**1,384.3**	**1,620.7**	**1,788.7**	**1,947.4**

Cash Flow Statement	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Cash Flow from Operations													
Earning before Tax (EBT)	53.3	62.0	47.7	-60.5	-42.2	-23.2	-49.8	-40.8	70.5	167.4	118.6	102.5	170.3
Adjustments													
Depreciation	401.9	425.5	451.1	473.0	496.1	519.7	543.3	564.8	585.8	618.7	650.5	682.1	713.4
Increase in Stores	-7.6	-8.0	-8.4	-8.5	-9.0	-9.4	-9.7	-10.0	-10.4	-11.7	-12.1	-12.4	-13.0
(Increase)/Decrease in Debtors	-13.3	-18.2	-19.4	-20.7	-30.1	-33.1	-36.2	-47.0	-52.5	-58.6	-50.1	-52.8	-58.0
Increase/(Decrease) in Creditors	2.6	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.1	3.1	3.2	3.2
Net Cash Flow from Operations	**418.7**	**457.2**	**465.1**	**382.5**	**430.4**	**470.6**	**464.8**	**485.0**	**612.3**	**714.5**	**675.6**	**704.4**	**803.9**
Cash Flow from Investments													
Capital Expenditure													
Transmission	231.6	250.7	302.8	182.6	210.0	214.2	202.5	132.2	113.7	454.5	411.6	390.9	370.8
Distribution	372.6	380.1	387.7	395.4	403.3	411.4	419.6	428.0	436.6	445.3	454.2	463.3	472.6
Investment Income													
Interest													
Dividends	33.5	38.1	41.8	45.4	49.1	52.7	56.4	60.0	63.7	67.3	71.0	74.6	78.3
Sale of Long Term Financial Assets	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net Cash Flow from Investments	**-570.7**	**-592.7**	**-648.7**	**-532.6**	**-564.3**	**-572.9**	**-565.8**	**-500.3**	**-486.6**	**-832.5**	**-794.8**	**-779.6**	**-765.1**
Cash Flow from Financing													
Debt Finance													
Donor Funding - Soft Loans	604.2	630.8	690.5	578.0	613.4	625.6	622.1	560.3	550.3	899.8	865.8	854.2	843.3
Commercial Funding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Debt Repayment													
Exisiting Loans	4.3	3.7	3.3	2.9	2.5	2.2	1.9	1.1	0.0	0.0	0.0	0.0	0.0
Donor Funding	326.7	346.9	364.7	383.4	402.6	426.2	450.4	475.6	503.2	526.4	550.9	575.9	600.8
Commercial Funding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cash Flow from Financing	**274.4**	**284.4**	**323.8**	**193.1**	**209.8**	**198.8**	**171.5**	**85.3**	**48.8**	**375.4**	**316.9**	**280.3**	**244.7**
Periods Cash Flow	**122.4**	**148.9**	**140.1**	**43.0**	**75.8**	**96.4**	**70.6**	**70.0**	**174.5**	**257.4**	**197.7**	**205.1**	**283.6**
Opening Balance	**1,947.4**	**2,069.8**	**2,218.7**	**2,358.9**	**2,401.9**	**2,477.7**	**2,574.1**	**2,644.7**	**2,714.7**	**2,889.2**	**3,146.6**	**3,344.3**	**3,549.4**
Closing Balance	**2,069.8**	**2,218.7**	**2,358.9**	**2,401.9**	**2,477.7**	**2,574.1**	**2,644.7**	**2,714.7**	**2,889.2**	**3,146.6**	**3,344.3**	**3,549.4**	**3,833.0**

Source: JST

The analysis results of comparison case are shown in Figure 9.5-2, Table 9.5-8, Table 9.5-9, and Table 9.5-10.



Source: JST

Figure 9.5-2 Costs and Revenue (Comparison Case)

Table 9.5-8 Profit and Loss Statement (Comparison Case)

Profit and Loss Statement USD million	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Revenue																										
Electricity Sales																										
Tariffbound Electricity Sales	292.7	415.9	512.0	571.4	681.2	811.7	965.3	1,146.1	1,255.9	1,374.3	1,502.2	1,595.4	1,692.9	1,794.9	1,963.4	2,145.6	2,342.4	2,613.0	2,912.8	3,245.0	3,613.1	4,021.0	4,473.1	4,886.3	5,321.4	5,800.4
Large Customer Sales	21.7	30.4	36.1	42.4	51.7	61.5	72.3	84.3	94.1	104.8	116.3	127.5	139.6	152.6	168.6	186.0	204.7	226.6	250.3	276.1	303.9	334.0	366.5	399.7	434.4	472.2
Total Revenue	*400.9*	*486.0*	*581.5*	*650.8*	*773.3*	*916.6*	*1,083.8*	*1,343.7*	*1,472.0*	*1,610.2*	*1,759.4*	*1,874.2*	*1,987.2*	*2,113.8*	*2,310.6*	*2,523.1*	*2,752.2*	*3,059.3*	*3,398.1*	*3,772.3*	*4,185.3*	*4,641.4*	*5,145.7*	*5,612.9*	*6,104.1*	*6,644.1*
Operational Expenses																										
Bulk Supply Expenses																										
HCB	55.4	76.7	79.2	81.0	105.6	83.8	85.9	76.7	78.2	79.8	81.4	83.0	84.7	86.3	88.1	89.8	91.6	93.5	95.3	97.2	99.2	101.2	103.2	105.3	107.4	109.5
IPP Contracts	202.2	104.0	138.9	162.8	152.5	264.6	399.3	480.6	628.2	702.9	765.3	863.5	947.0	1,065.2	1,184.3	1,334.5	1,595.8	1,813.5	2,056.7	2,375.2	2,758.0	3,089.9	3,473.7	3,927.7	4,373.9	4,785.0
Total Bulk Supply Expenses	269.3	193.6	232.8	260.6	276.8	368.8	507.0	580.6	731.2	808.9	874.3	975.7	1,062.5	1,184.1	1,306.8	1,460.6	1,725.7	1,947.3	2,194.5	2,517.2	2,904.2	3,240.4	3,628.9	4,087.7	4,538.9	4,955.2
Total Operational Expenses	*388.9*	*335.0*	*393.3*	*438.9*	*469.8*	*575.1*	*724.7*	*811.5*	*972.6*	*1,062.3*	*1,140.5*	*1,255.2*	*1,356.7*	*1,493.3*	*1,631.7*	*1,802.3*	*2,083.7*	*2,322.9*	*2,588.4*	*2,930.1*	*3,336.5*	*3,693.0*	*4,105.4*	*4,587.7*	*5,062.5*	*5,504.1*
EBITDA	12.0	150.9	188.2	212.0	303.5	341.6	359.1	532.2	499.4	548.0	618.9	618.9	630.6	620.5	678.9	720.8	668.6	736.4	809.7	842.2	848.8	948.4	1,040.3	1,025.2	1,041.6	1,140.0
Total Depreciation	*-87.1*	*-104.1*	*-139.7*	*-187.6*	*-237.7*	*-281.4*	*-252.6*	*-286.8*	*-305.7*	*-322.1*	*-339.4*	*-357.2*	*-379.3*	*-401.9*	*-425.5*	*-451.1*	*-473.0*	*-496.1*	*-519.7*	*-543.3*	*-564.8*	*-585.8*	*-618.7*	*-650.5*	*-682.1*	*-713.4*
Profit after Tax	-91.4	14.7	-0.8	-61.8	-61.1	-105.3	-90.3	15.6	-44.5	-20.2	18.8	3.8	-10.9	-50.6	-23.4	-15.0	-95.4	-56.4	-11.9	-6.9	-23.9	36.8	74.2	37.4	22.6	64.5
Profit for the Year	-89.4	26.6	13.0	-48.0	-46.1	-88.8	-61.9	42.1	-17.1	8.6	49.7	30.0	21.8	-17.1	14.7	26.8	-50.0	-7.4	40.8	49.5	36.1	100.4	141.5	108.3	97.2	142.8

Source: JST

Table 9.5-9 Balance Sheet (Comparison Case)

Balance Sheet	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Assets																										
Long Term Assets																										
Capital Investment Plan																										
Generation	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0
Transmission	111.8	620.8	1,778.8	2,902.6	4,032.7	5,050.6	5,684.7	6,314.1	6,480.5	6,583.3	6,699.1	6,819.7	7,045.4	7,277.0	7,527.7	7,830.5	8,013.1	8,223.1	8,437.4	8,639.9	8,772.1	8,885.8	9,340.3	9,751.9	10,142.7	10,513.5
Distribution	207.1	207.1	207.1	512.8	824.6	1,142.6	1,467.0	1,797.9	2,135.4	2,479.6	2,830.7	3,188.9	3,554.2	3,926.8	4,306.9	4,694.5	5,089.9	5,493.3	5,904.7	6,324.3	6,752.3	7,188.9	7,634.2	8,088.4	8,551.7	9,024.3
Other	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
Accumulated Depreciation	-39.0	-71.5	-142.7	-263.6	-434.5	-652.2	-904.0	-1,189.9	-1,495.0	-1,816.7	-2,155.7	-2,512.5	-2,891.5	-3,293.1	-3,718.2	-4,169.0	-4,641.6	-5,137.4	-5,656.8	-6,199.7	-6,764.2	-7,349.9	-7,968.5	-8,619.1	-9,301.2	-10,014.6
Total Long Term Assets	*1,463.2*	*1,870.0*	*2,928.3*	*4,170.0*	*5,374.1*	*6,428.6*	*7,134.4*	*7,808.0*	*8,006.1*	*8,131.1*	*8,258.6*	*8,380.2*	*8,591.9*	*8,794.1*	*8,999.4*	*9,238.8*	*9,343.8*	*9,461.0*	*9,566.9*	*9,645.8*	*9,641.2*	*9,605.7*	*9,886.8*	*10,102.1*	*10,274.1*	*10,404.1*
Current Assets																										
Total Current Assets	*119.1*	*200.5*	*339.9*	*455.5*	*625.0*	*794.1*	*958.2*	*1,248.4*	*1,430.2*	*1,612.5*	*1,806.4*	*1,930.9*	*2,043.0*	*2,111.8*	*2,220.4*	*2,347.6*	*2,402.2*	*2,505.0*	*2,657.4*	*2,819.3*	*2,965.7*	*3,189.4*	*3,467.2*	*3,685.4*	*3,910.0*	*4,214.9*
Total Assets	1,582.2	2,070.6	3,268.2	4,625.5	5,999.1	7,222.7	8,092.6	9,056.4	9,436.4	9,743.6	10,065.0	10,311.1	10,634.9	10,905.9	11,219.8	11,586.4	11,746.0	11,966.0	12,224.3	12,465.0	12,606.9	12,795.0	13,354.1	13,787.5	14,184.2	14,619.0
Liabilities																										
Long Term Liabilities																										
Project Funding																										
Donor Funding Soft Loans	418.5	928.2	2,122.0	3,547.2	4,978.9	6,300.4	7,239.3	8,159.7	8,569.2	8,864.7	9,122.5	9,338.9	9,633.6	9,911.1	10,195.0	10,520.7	10,715.3	10,926.1	11,125.5	11,297.2	11,381.9	11,428.9	11,802.4	12,117.3	12,395.5	12,638.1
Total Long Term Liabilities	*851.0*	*1,355.1*	*2,546.0*	*3,950.1*	*5,366.9*	*6,680.9*	*7,612.8*	*8,528.0*	*8,932.9*	*9,225.2*	*9,481.3*	*9,697.7*	*9,994.2*	*10,274.8*	*10,566.3*	*10,897.9*	*11,099.3*	*11,318.1*	*11,526.7*	*11,708.8*	*11,805.1*	*11,865.8*	*12,255.0*	*12,586.4*	*12,881.7*	*13,142.4*
Current Liabilities																										
Total Current Liabilities	*235.6*	*193.3*	*187.0*	*188.2*	*191.0*	*189.5*	*189.4*	*195.9*	*188.1*	*194.5*	*209.9*	*209.7*	*215.1*	*222.6*	*230.4*	*238.5*	*246.7*	*255.3*	*264.2*	*273.4*	*282.8*	*309.8*	*338.1*	*331.7*	*336.0*	*367.4*
Shareholders Equity																										
Equity	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8	187.8
Suplementary capital	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9	126.9
Legal Reserve	13.1	14.4	15.1	15.1	15.1	15.1	15.1	17.2	17.2	17.6	20.1	21.6	22.7	22.7	23.4	24.8	24.8	24.8	26.8	29.3	31.1	36.1	43.2	48.6	53.5	60.6
Total Shareholders Equity	*495.6*	*522.2*	*535.2*	*487.2*	*441.1*	*352.3*	*290.4*	*332.5*	*315.4*	*324.0*	*373.7*	*403.7*	*425.6*	*408.5*	*423.2*	*450.0*	*400.0*	*392.6*	*433.4*	*482.9*	*519.0*	*619.4*	*760.9*	*869.3*	*966.5*	*1,109.2*
Total Liabilities	1,582.2	2,070.6	3,268.2	4,625.5	5,999.1	7,222.7	8,092.6	9,056.4	9,436.4	9,743.6	10,065.0	10,311.1	10,634.9	10,905.9	11,219.8	11,586.4	11,746.0	11,966.0	12,224.3	12,465.0	12,606.9	12,795.0	13,354.0	13,787.5	14,184.2	14,619.0

Source: JST

Table 9.5-10 Cash Flow Statement (Comparison Case)

Cash Flow Statement	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Cash Flow from Operations																										
Earning before Tax (EBT)	-91.4	21.6	-0.8	-61.8	-61.1	-105.3	-90.3	23.0	-44.5	-20.2	27.7	5.6	-10.9	-50.6	-23.4	-15.0	-95.4	-56.4	-11.9	-6.9	-23.9	54.1	109.2	55.0	33.2	94.9
Adjustments																										
Depreciation	87.1	104.1	139.7	187.6	237.7	281.4	252.6	286.8	305.7	322.1	339.4	357.2	379.3	401.9	425.5	451.1	473.0	496.1	519.7	543.3	564.8	585.8	618.7	650.5	682.1	713.4
Increase in Stores	1.3	-5.1	-8.0	-8.8	-8.3	-7.5	-6.6	-6.8	-6.0	-6.1	-6.4	-6.7	-7.3	-7.6	-8.0	-8.4	-8.5	-9.0	-9.4	-9.7	-10.0	-10.4	-11.7	-12.1	-12.4	-13.0
(Increase)/Decrease in Debtors	-9.7	-11.1	-10.6	-7.3	-13.2	-15.6	-18.3	-21.5	-13.3	-14.3	-15.5	-11.5	-12.1	-12.6	-20.4	-22.1	-23.9	-32.5	-36.0	-39.8	-44.0	-48.7	-54.0	-49.6	-52.2	-57.4
Increase/(Decrease) in Creditors	6.5	-3.0	-4.5	-4.5	-2.6	-6.4	-4.4	-5.3	-4.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.1	3.1	3.2	3.2
Net Cash Flow from Operations	**-30.3**	**114.4**	**121.7**	**109.9**	**157.4**	**152.5**	**137.8**	**281.9**	**235.1**	**289.3**	**354.0**	**345.4**	**358.4**	**343.0**	**386.6**	**419.6**	**359.7**	**413.8**	**479.0**	**504.2**	**504.9**	**599.6**	**666.2**	**631.1**	**656.0**	**751.3**
Cash Flow from Investments																										
Capital Expenditure																										
Transmission	0.0	509.0	1,158.0	1,123.8	1,130.1	1,018.0	634.0	629.5	166.4	102.8	115.8	120.6	225.7	231.6	250.7	302.8	182.6	210.0	214.2	202.5	132.2	113.7	454.5	411.6	390.9	370.8
Distribution	0.0	0.0	0.0	305.7	311.8	318.0	324.4	330.9	337.5	344.2	351.1	358.1	365.3	372.6	380.1	387.7	395.4	403.3	411.4	419.6	428.0	436.6	445.3	454.2	463.3	472.6
Investment Income																										
Interest																										
Dividends	2.0	11.9	13.8	13.8	15.0	16.5	28.4	26.5	27.4	28.8	30.9	26.2	32.7	33.5	38.1	41.8	45.4	49.1	52.7	56.4	60.0	63.7	67.3	71.0	74.6	78.3
Sale of Long Term Financial Assets	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net Cash Flow from Investments	**-13.1**	**-499.1**	**-1,184.2**	**-1,415.5**	**-1,426.8**	**-1,319.5**	**-930.0**	**-933.9**	**-476.5**	**-418.2**	**-436.0**	**-452.6**	**-558.4**	**-570.7**	**-592.7**	**-648.7**	**-532.6**	**-564.3**	**-572.9**	**-565.8**	**-500.3**	**-486.6**	**-832.5**	**-794.8**	**-779.6**	**-765.1**
Cash Flow from Financing																										
Debt Finance																										
Donor Funding - Soft Loans	119.8	509.8	1,198.0	1,429.5	1,441.8	1,336.0	958.4	960.4	503.9	447.0	466.9	478.8	591.1	604.2	630.8	690.5	578.0	613.4	625.6	622.1	560.3	550.3	899.8	865.8	854.2	843.3
Commercial Funding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Debt Repayment																										
Exisiting Loans	10.3	13.1	13.1	23.0	16.9	11.0	9.8	8.8	7.8	6.9	6.2	5.5	4.8	4.3	3.7	3.3	2.9	2.5	2.2	1.9	1.1	0.0	0.0	0.0	0.0	0.0
Donor Funding	0.0	0.0	4.3	4.3	10.2	14.5	19.5	40.0	94.3	151.5	209.2	262.4	296.3	326.7	346.9	364.7	383.4	402.6	426.2	450.4	475.6	503.2	526.4	550.9	575.9	600.8
Commercial Funding	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Cash Flow from Financing	**110.6**	**498.5**	**1,181.3**	**1,402.9**	**1,415.5**	**1,311.3**	**929.9**	**912.5**	**402.7**	**289.5**	**252.6**	**212.0**	**291.1**	**274.4**	**284.4**	**323.8**	**193.1**	**209.8**	**198.8**	**171.5**	**85.3**	**48.8**	**375.4**	**316.9**	**280.3**	**244.7**
Periods Cash Flow	**67.2**	**113.9**	**118.8**	**97.4**	**146.1**	**144.2**	**137.7**	**260.5**	**161.3**	**160.6**	**170.6**	**104.8**	**91.1**	**46.8**	**78.4**	**94.7**	**20.2**	**59.2**	**104.8**	**109.9**	**89.9**	**161.9**	**209.1**	**153.2**	**156.8**	**231.0**
Opening Balance	**-114.5**	**-47.4**	**66.5**	**185.4**	**282.8**	**428.8**	**573.1**	**710.8**	**971.3**	**1,132.6**	**1,293.2**	**1,463.8**	**1,568.6**	**1,659.7**	**1,706.4**	**1,784.8**	**1,879.5**	**1,899.7**	**1,958.9**	**2,063.7**	**2,173.6**	**2,263.5**	**2,425.4**	**2,634.5**	**2,787.7**	**2,944.5**
Closing Balance	**-47.4**	**66.5**	**185.4**	**282.8**	**428.8**	**573.1**	**710.8**	**971.3**	**1,132.6**	**1,293.2**	**1,463.8**	**1,568.6**	**1,659.7**	**1,706.4**	**1,784.8**	**1,879.5**	**1,899.7**	**1,958.9**	**2,063.7**	**2,173.6**	**2,263.5**	**2,425.4**	**2,634.5**	**2,787.7**	**2,944.5**	**3,175.5**

Source: JST

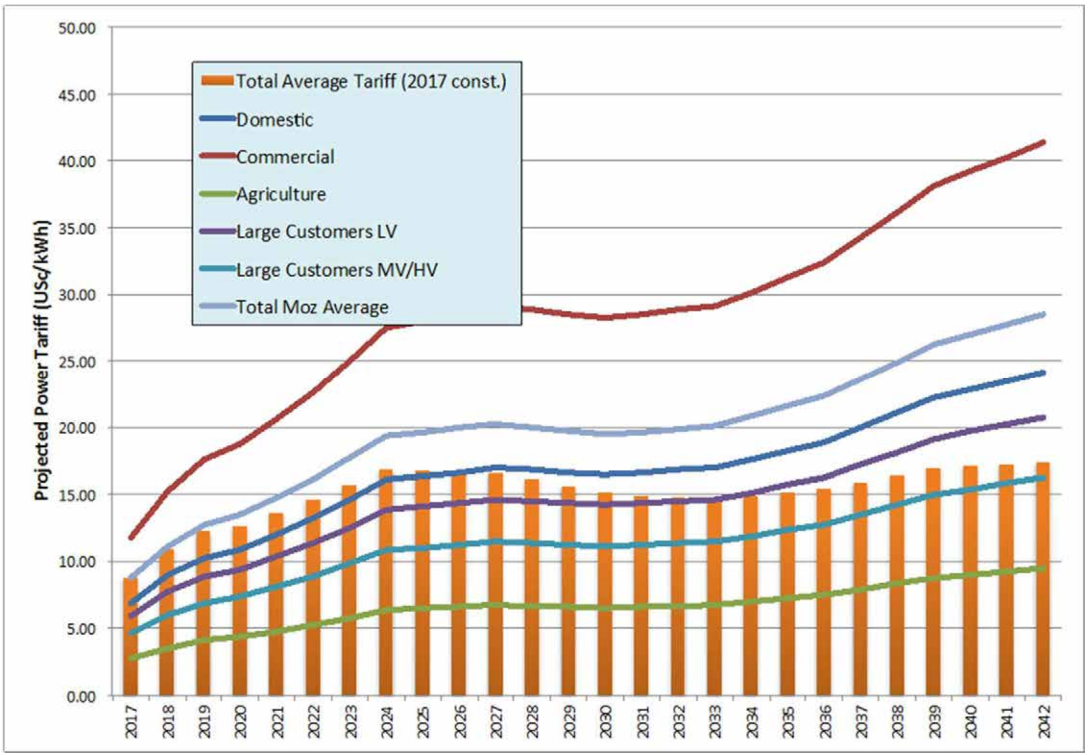
A common feature for these two cases is the increasing portion of the bulk power supply in the total costs. This is due to the trend of the increasing amount of power purchase from non-EDM organizations and private sector. The power purchase costs will therefore give a big impact on the corporate finance of EDM.

A difference between these two cases on the other hand is the measures to address the short-term power shortage until 2022. The base case expects to import the power from neighboring countries to fill the supply gap whereas the comparison case considers the additional power purchase from HCB to secure cheaper power purchase than the power import in the base case. The impact of the differences of the power purchase costs is clear. The comparison case will be able to reduce the tariff increase until 2022, compared with the base case. The impact on the expected power tariff will be discussed at the later part of the power tariff.

(4) Power Tariff Adjustment Scenario

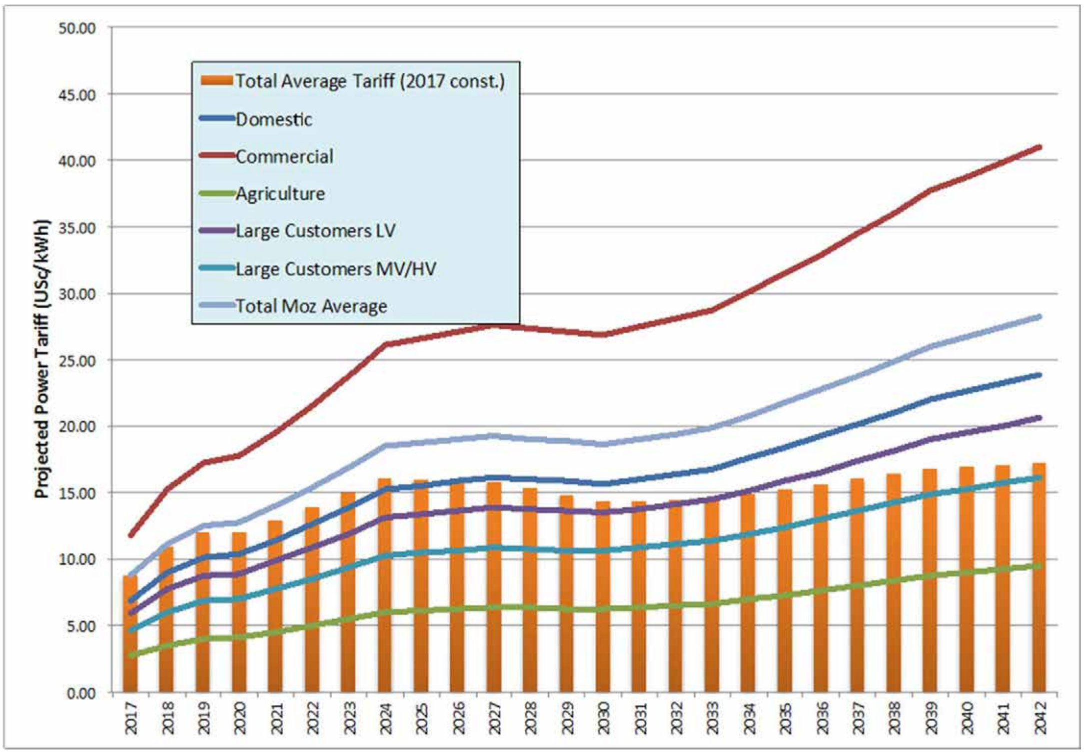
The analyses adjust the minimum power tariff to produce the annual net income to be close to the positive figure. The tariff adjustment schedule will be expected to follow the table below. The cases for the study are two; base case and comparison case.

The trend of the power tariff can be expected in Figure 9.5-3 and Figure 9.5-4.



Source: JST

Figure 9.5-3 Estimated Power Tariff (Base Case)



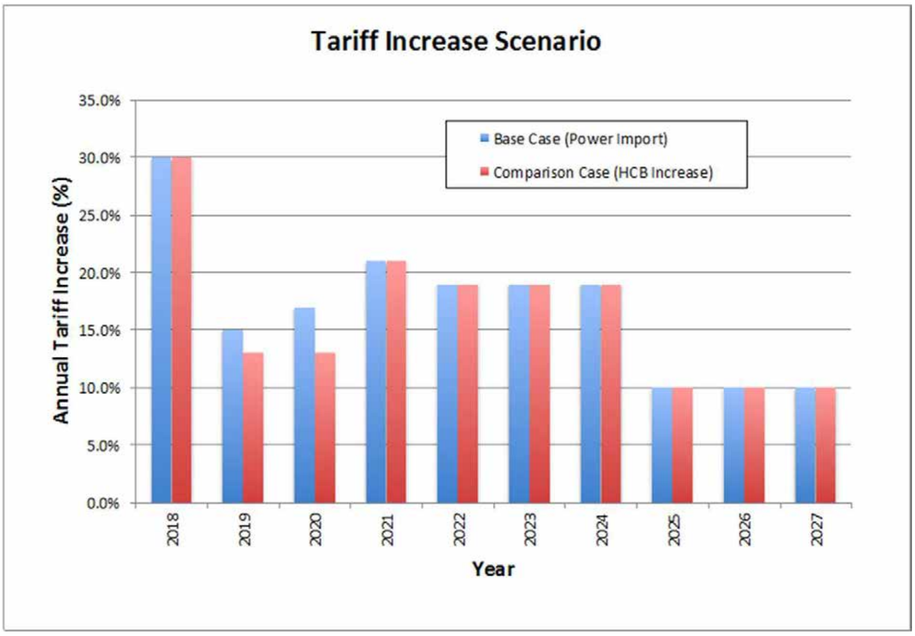
Source: JST

Figure 9.5-4 Estimated Power Tariff (Comparison Case)

The solid lines in the line chart show the nominal power tariffs for each consumer category for each year. The vertical lines of the bar chart indicate the average real power tariff for each consumer category for each year.

The overview of the power tariff until 2042 shows the necessity to increase the power tariff every year to recover the development and power supply costs. From 2018 to 2024 the power tariff will have to be continuously increased in a real term to reach the economic tariff level. The expected breakeven tariff level would be approximately 14 US cent/kWh at 2017 price. The power tariff will also need to be increased to a slightly higher level of 16 US cent/kWh towards the year 2042.

The comparison of the power tariff adjustment scenarios (2018-2027) can be evaluated by the annual average increase rate as follows.



Source: JST

Figure 9.5-5 Power Tariff Adjustment Scenario

The base case increases the power tariff at 30% in 2018, followed by 15% each year for 2019, 2020 and 2021. The comparison case expects to purchase power from HCB at a cheaper rate than the base case, and can reduce the required tariff increase compared with the base case. The annual required increase for 2019, 2020, and 2021 will be annually 13% for these three years, resulting in the milder tariff increase.

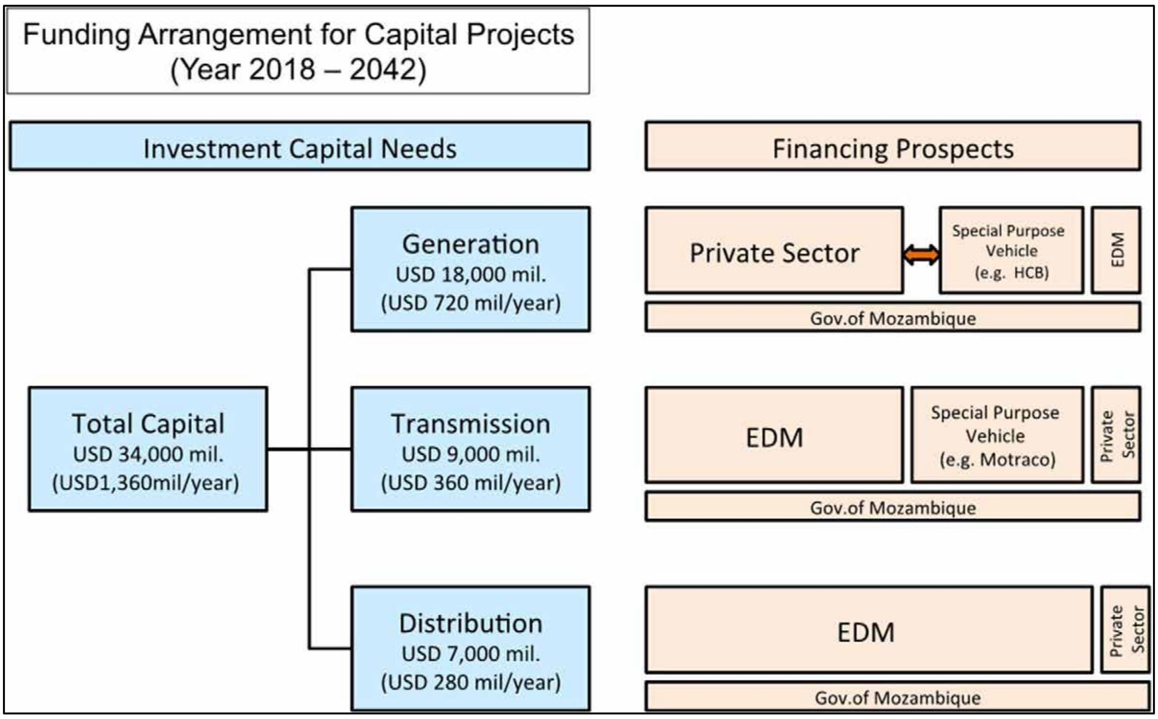
The overall annual tariff increases will be higher than 10%, which is assumed to be the consumer price annual increase in the long run. The additional power purchase from HCB for the period from 2018 to 2022 will provide a short-term positive economic impact by reducing the tariff increase needs. The mid-term and long-term requirements for the tariff increase remain at around more than 10% annually.

9.5.4 Organization for Project Implementation and Mobilization of Fund

The total investment needs for the next 25 years of 2018-2042 amount to USD 34 billion. It is not easy to expect that EDM alone can mobilize this size of finding. It is therefore considered necessary to study other options than ordinary financing arrangement by a state-owned-enterprise.

The fist point for consideration is to introduce investments from non-EDM organizations and companies. These could include HCB, Motraco, and private companies that have already experiences in Mozambique. These three parties have difference strengths, interests of management, approaches for risk issues and investment strategies. Thus it is expected that the discussions with these organizations would provide clues for participation in investments of subprojects.
HCB and private sector have experiences in generation business and Motraco is an expert in transmission. To realize the investments by there organizations, it is required to strengthen the investment policy and sector

regulations. These five parties of EDM, HCB, Motraco, private sector, the government would need to discuss the roles and responsibilities of each subproject in order to structure the project implementation. The overall structure of the investment is shown in the below figure.



Source: Prepared by JST

Figure 9.5-6 Organization for Project Implementation

The figure shows the demarcation of the development by subsector of generation, transmission and distribution. EDM could reduce the requirements of funding arrangement by having other parties in the investments. As mentioned earlier the private participation is a critical factor for realizing and implementing the framework. The roles of the government of Mozambique is also increasingly important.

9.5.5 Long Run Marginal Cost

The Long-Run Marginal Cost (LRMC) is the cost that minimizes the expenses to provide a unit of additional services (in case of power sector, kWh) by changing the production factors to yield an additional service including fixed assets. When assuming the long-term power supply, the optimum and most efficient resource allocation would be realized by establishing the service charge at the same level of LRMC. In power sector, the provision of services would be close to the natural monopoly in some cases and hence the competition principle may not work. It is understood therefore that it would be preferable to set the tariff at LRMC in order to allocate the resources efficiently.

The Study examines the power supply scenarios based on the demand forecast, and establishes the least-cost development plan that will provide the necessary services. LRMC can be estimated by calculating the marginal cost per kWh that will be necessary to provide the long-run power services. The cost is calculated by dividing the total development costs by the marginal demand increase for each year of 25 years.

The result of analysis is 4.19 US cent/kWh. This figure is higher than the cost of Mphanda Nkuwa and less than those of thermal power plants. This is due to the mixture of the optimum power plants where the hydropower accounts for approximately 65% of the total energy produced in the base case.

Table 9.5-11 Long Run Marginal Cost

Long-Run Marginal Cost

Item		Unit	Particular	Remarks
Total Discounted Incremental Energy Production	a	MWh	214,230,895	Total from 2017 to 2042
Total Discounted Costs for Energy Production	b	USD k	8,971,714	Capex, Fuel and OM costs; Total from 2017 to 2042
Total Costs per Incremental Energy	c = b/a	Usc/kWh	4.19	2017 price

Source: JST

LRMC is the cost required to recover the future investment costs. It is thus necessary to establish the power tariff at a higher rate than LRMC at least. It is also advisable to review the cost from time to time because the cost would differ depending on the factors such as changes in development plan and demand profile of on- and off- peaks.

9.5.6 Recommendations on Financial Strategy

The blow table summarizes the recommendations for improving financial management of power sector. The recommendations are categorized by organization and timeline for actions.

Table 9.5-12 Recommendations on Financial Strategy

Org.	Category	Timing		
		Short-term (2018-2022)	Mid-term (2023-2030)	Long-term (2031-2042)
EDM	Power Tariff	• To process the tariff adjustments for 2018 and 2019. 30% increase in 2018 is particularly critical for future development.	• To monitor the financial positions periodically and reflect in the tariff adjustments since this period concentrates the investment needs and hence the power tariff requirements.	• To pay close attentions to the revenue and cost data to review the tariff levels.
EDM	Implementation of Development Plan	• To establish the development strategies for sub-projects of generation, transmission and distribution. In particular on the mobilization of funds and financial strategy.	• To implement the EDM projects such as important strategic projects.	• To exchange views and information on sub-projects with the concerned organizations and companies, and to formulate the implementation plans.
EDM	Coordination with Related Organizations	• To decide the implementation framework for private investments and joint projects with HCB/Motraco. In particular the power purchase agreement and legal framework for joint implementation.	• To monitor the progress of private projects and joint projects with HCB/Motraco. To provide advise and assistance.	• To forecast the future financial positions for power sector.
MIREME/ MEF	Power Tariff	• To discuss at the cabinet the power adjustments for 2018 and 2019.	• To strengthen the function and capacity of the regulatory agency of power sector. This includes the power tariff, private investment and other sector regulatory issues.	• To examine the policy and implementation to export power to other countries.
MIREME/ MEF	Sector Regulation	• To study the measures to facilitate the private sector participation, and to improve/create the legislations. In particular the power purchase agreements and legal and financial matters.	• To follow up on the impact of the investment projects on the macro-economic situations.	• To study strengthening the power development policy with the primary energy development, and its synergy.
HCB	Implementation of Development Plan	• To establish the development strategy for large hydropower projects by establishing and strengthening the project teams for projects that will be commenced within 5 or 6 years.	• To implement large hydropower projects. To continuously exchange and provide information on the progress and situations of the project.	• To review the business development strategy for power projects, and study further collaborations with EDM.
Motraco	Implementation of Development Plan	• To study the implementation plans for large-scale transmission line projects with EDM. To establish and strengthen the project teams for projects that will be commenced within 5 or 6 years.	• To implement large-scale transmission line projects. To continuously exchange and provide information on the progress and situations of the project.	• To study further collaborations with EDM.

Source: Prepared by JST

Chapter 10 Environmental and Social Considerations

10.1 Legal and Institutional Framework

10.1.1 Policy and Legislation

Table 10.1-1 shows policies, laws and regulations on environmental and social considerations. “Environmental Framework Act (No. 20/97)” is an organic law on environment in Mozambique, provides a legal framework for the use and management of the environment, and aims to assure the sustainable development.

Table 10.1-1 Policies, Law and Regulations on Environmental and Social Considerations

Category	Name
Policy	National Environmental Policy (No. 5/1995)
	National Strategy and Action Plan of Biological Diversity of Mozambique (2015-2035)
	National Climate Change Adaptation and Mitigation Strategy 2012
	Poverty Reduction Strategy Paper 2011-2014
Law and Regulation	Environmental Framework Act (No. 20/97)
	Land Law (Law No. 19/1997)
	Forest and Wildlife Law (Law No. 10/1999)
	Biodiversity Conservation Law (Law No. 16/2014)
	Law for Protection of Cultural Assess (Law No. 10/1988)
	Regulations for Environmental Impact Assessment (Decree No.54/2015)
	Regulations for the Environmental Audit Process (Decrees No. 25/2011)
	Regulations for Environmental Inspections (Decree No. 11/2006)
	Regulations for Environmental Quality Standards and Effluent Emissions (Decree No. 18/2004, amended by Decree No. 67/2010)
	Regulations for the Management of Urban Solid Waste (Decree No. 94/2014)
	Regulations for the Management of Hazardous Waste (Decree No. 83/2014)
	Regulations for the Forest and Wildlife Law (Decree No. 12/2002)
	Environmental Regulations for Mining Activities (Decree No. 26/2004)
	Environmental Regulations for Petroleum Operations. (Decree No. 56/2010)
	Regulations for the Resettlement Process Resulting from Economic Activities (Decree No. 31/2012)

Source: JICA Study Team

10.1.2 Environmental standards

Environmental standards are set by “Regulations for Environmental Quality Standards and Effluent Emissions (Decree No. 18/2004, amended by Decree No. 67/2010)”. The standards on air and water quality are shown in Table 10.1-2 ~ Table 10.1-6. Mozambique has yet to establish national ambient noise guidelines.

Table 10.1-2 Ambient Air Quality Standards

Parameter	Time	Mozambique	Japan	WHO
Sulfur dioxide (SO2) (μg/m3)	1 hour	800	286	-
	24 hours	100	114	20
	Annual	40	-	-
Nitrogen dioxide (NO2) (μg/m3)	1 hour	190	-	200
	24 hours	-	82 – 113	
	Annual	10	-	40
Particulate Matter 10 (PM10) (μg/m3)	1 hour	-	200 (SPM)	-
	24 hours	-	100 (SPM)	50
	Annual	-	-	20
Total Suspended Particulate (TSP) (μg/m3)	24 hours	150	-	-
	Annual	60	-	-
Carbon monoxide (CO) (μg/m3)	1 hour	30,000	-	-
	8 hours	10,000	25,000	-
Ozone (O3) (μg/m3)	1 hour	160	129	-
	24 hours	50		100 (8 hours)
	Annual	70	-	-
Lead (Pb) (μg/m3)	1 hour	3	-	-
	24 hours	-	-	-
	Annual	0.5	-	-

Source: Regulations for Environmental Quality Standards and Effluent Emissions (Decree No. 67/2010), etc.

Table 10.1-3 Exhaust Gas Emission Standards for Thermal Power Plants

Pollutant		Sulfur oxide (SOx)	Nitrogen oxides (NOx)	Particulate Matter
Standard (mg/Nm3) (Mozambique)		2,000	Coal: 750 Diesel: 460 Gas: 320	100 (<50MW) 50 (>50MW)
Standard (mg/Nm3) (International Finance Corporation: IFC)	Natural Gas (all turbine types of Unit > 50MWth)	Not Applicable	51 (25 ppm)	Not Applicable
	Fuels other than Natural Gas (Unit > > 50MWth)	Use of 1% or less S fuel (Non-degraded air shed) Use of 0.5% or less S fuel (Degraded air shed (poor air quality))	152 (74 ppm)	50 (Non-degraded air shed) 30 (Degraded air shed (poor air quality))

Source: Regulations for Environmental Quality Standards and Effluent Emissions ((Decree No. 18/2004)

Table 10.1-4 Sea Water Quality Standards (General Items)

Parameter	Maximum acceptable concentration
Suspended Solids (SS)	Not identified
Oil	Not identified
Color, foul odor or turbid matter	Not identified
Artificial coloration	Not identified
Abrasive deposit	Not identified
BOD 5 (20□)	≤ 5mg/l
COD	≤ 6mg/l
pH	6.5 – 8.5

BOD: Biochemical Oxygen Demand

COD: Chemical Oxygen Demand

Source: Regulations for Environmental Quality Standards and Effluent Emissions (Decree No. 67/2010)

Table 10.1-5 Effluent Standards for Domestic Sewage

Parameter	Acceptable concentration
Color	Dilution 1:20 no color
Foul odor	Dilution 1:20 no foul odor
pH	6 – 9
Temperature (□)	35
COD (mg/l)	150
Total Suspended Solids (mg/l)	60
Total P (mg/l)	10
Total N (mg/l)	15

Source: Regulations for Environmental Quality Standards and Effluent Emissions ((Decree No. 18/2004)

Table 10.1-6 Effluent Guidelines

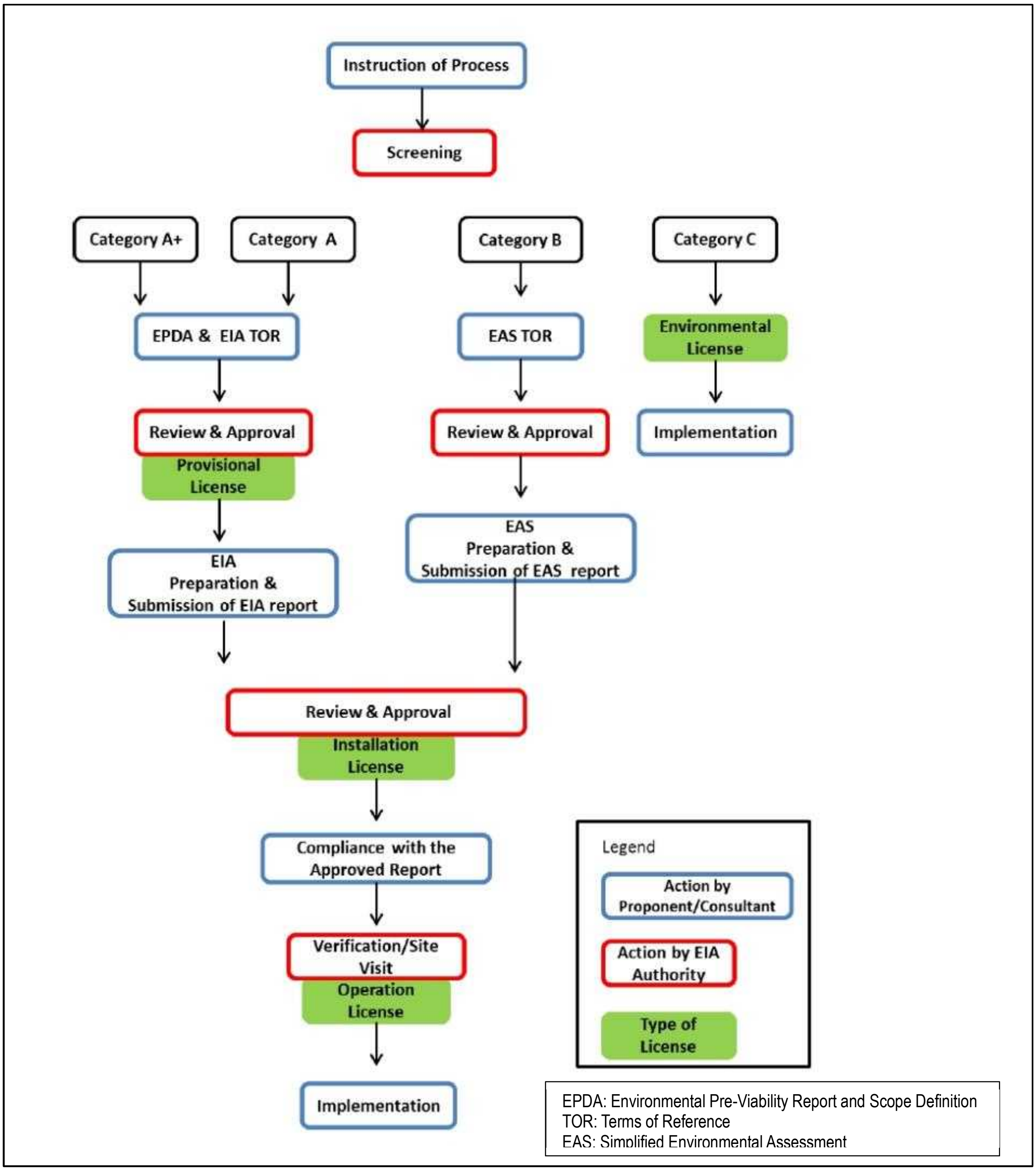
Parameter	Acceptable concentration
pH	6 – 9
Total Suspended Solids (mg/l)	50
Oil & Grease (mg/l)	10
Iron (mg/l)	1
Zinc (mg/l)	1
Chromium (mg/l)	0.5
Residual chlorine (mg/l)	0.2
Copper (mg/l)	0.5
Temperature increase by thermal discharge	3 degree Celsius or below

Source: Regulations for Environmental Quality Standards and Effluent Emissions ((Decree No. 18/2004)

10.1.3 Environmental Impact Assessment

The Environmental Impact Assessment (EIA) process and procedure are regulated in “Regulations for Environmental Impact Assessment (Decree No.54/2015)”. Proponents of all development projects need the environmental licenses from the Ministry of Land, Environment and Rural Development (MITADER) as governing agency of EIA for the implementation. The flowchart of EIA Procedure is shown in Figure 10.1-1.

In Mozambique, the EIA should be conducted only by experts or firms whose names and qualifications are registered by National Directorate of Environment under MITADER.



Source: Regulations for Environmental Impact Assessment (Decree No.54/2015), etc.

Figure 10.1-1 Flowchart of EIA Procedure

The EIA Regulations classify development projects into the following four categories. The regulation includes 4 annex lists of projects by the four categories.

Category A+: Projects are listed in Annex 1 and have complex and irreversible impacts on the environment. Projects in critical areas for biodiversity, and genetic modification, nuclear power, mineral development, natural gas development and projects with hazardous substance are listed in this category. The category A+ project is required to implement the EIA. To ensure the transparency, a third party review group consisting of external consultants and experts judges the EIA.

Category A: Projects are listed in Annex 2 and have significant impacts on the environment. Electric generation projects such as hydropower plant, thermal power plants, geo-thermal power plant and solar photovoltaic power, and construction of transmission line over 66kV listed in this category. The category A project is required to implement the EIA.

Category B: Projects are listed in Annex 3 and have potential impacts less adverse than those of Category A projects on the environment. Construction of transmission line less than 66kV in electric sector is listed in this category. Construction of transformer station is classified in this category in general. The category B project is required to implement the Simplified Environmental Assessment (EAS).

Category C: Projects are listed in Annex 4 and have minimal or little adverse impacts on the environment. Construction of 33kV transmission line in electric sector is listed in this category. The category C project is not required to implement the EIA or SEA.

Category A+, A and B projects require to hold stakeholder meetings according to the EIA regulation. The EIA regulation rules the following two time meetings.

- Preparation of Terms of Reference (TOR) for EIA stage: The proponent holds the meeting. The record of the meeting is submitted to MITADER with the Environmental Pre-Viability Report and Scope Definition (EPDA) and draft TOR.
- Preparation of EIA report stage: The proponent holds the meeting. The record of the meeting is attached to the EIA report.

10.1.4 Strategic Environmental Assessment

Official regulations and guidelines on Strategic Environmental Assessment (SEA) have not prepared yet in Mozambique.

10.1.5 Land Acquisition and Resettlement

Main laws and regulations on land acquisition and resettlement in Mozambique are as following:

- Land Law (Law No.19/1997)
- Regulations for the Resettlement Process Resulting from Economic Activities (Decree No. 31/2012)
- Regulations on Safety of High Tension Electric Line (Decree No.57/2011)

According to "Land Law", because all lands belong the state, the sale, transfer of ownership, mortgage by transfer and hypothec are not permitted. However, all the citizens (regardless of gender), corporate bodies and local communities have the right for use and benefit of land (Direito de Uso e Aproveitamento da Terra: DUAT). The land ownership of individuals and communities on the basis of traditional system and customary tenure is also permitted. In the case of and acquisition owing to public projects such as power and gas development projects, appropriate compensation to land users by the public or private proponent and land registration for the newly obtained land use right are obligated.

"Regulations for the Resettlement Process Resulting from Economic Activities" rules specific processes of resettlement. In the case of international cooperation projects, World Bank safeguard policy on involuntary resettlement is referred to prepare a resettlement action plan about items not mentioned in the regulation.

According to “Regulations on Safety of High Tension Electric Line”, Right of Ways (ROW) of maximum 30m for transmission line less than 66kV and maximum 50m for transmission line over 66kV are established as a necessary condition.

10.1.6 Comparison between Legislation in Mozambique and JICA Guidelines

Table 10.1-7 shows the comparison between current legislation in Mozambique in Mozambique and JICA Guidelines for Environmental and Social Considerations (April, 2010).

Table 10.1-7 Comparison between Legal Framework in Mozambique and JICA Guidelines

Item	Legislation in Mozambique	JICA Guidelines
Information disclosure	- Under EIA regulations, EIA report and other relevant documents become public documents.	- EIA report is disclosed to all stakeholders and locals and on JICA’s website.
Public participation	- The EIA regulations stipulate process of public participation throughout the preparation of EIA report. - Public participation is mandatory for all Category A+, A and B projects and must be held during scoping process and during preparation of EIA report. - The announcement of holding public consultation must be made 15 days prior to the consultation and all stakeholders must be invited for their opinions.	- Project proponents are encouraged to disclose information about their projects and consult with local communities and stakeholders (especially those directly affected). - In the case of Category A projects, JICA encourages project proponents to consult with local stakeholders about their understanding of development needs, the likely adverse impacts on the environment and society, and the analysis of alternatives at an early stage of the project. - In case of Category A projects, public consultations must be held twice; during scoping process and during preparation of EIA report. In case of Category B projects, consultations should be held when necessary.
	- The Regulations for the Resettlement Process Resulting from Economic Activities states that the preparation and approval of a Resettlement Plan precedes the issue of an environmental license under the environmental legislation. - The regulations stipulate items to be covered in a Resettlement Plan. Most of the items in the World Bank Safeguard Policy are covered under the regulations.	- For projects that will result in large-scale involuntary resettlement, a Resettlement Action Plan (RAP) also must be prepared and disclosed. - It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

Mitigation measures	- There is no specific policy on examination of mitigation measures. - The EIA regulations provide that an Environmental Management Plan (EMP) (including mitigation measures, impact monitoring, environmental education, accident prevention and emergency measures) must be included in EIA report. -The EIA regulations states that for Category A+, A and B projects, project proponents are responsible for periodic inspection and audit and must make sure the EMP are properly implemented.	- Multiple alternatives must be examined in order to avoid or minimize adverse impacts and to choose better project options. - In the examination of measures, priority is to be given to avoidance of environmental impacts; when this is not possible, minimization and reduction of impacts must be considered next. - Compensation measures must be ex mined only when impacts cannot be avoided by any of the aforementioned measures. - Appropriate follow-up plans and systems, such as monitoring plans and environmental management plans, must be prepared including the implementation costs and the financial methods to fund such costs. Plans for projects with particularly large potential adverse impacts must be accompanied by detailed environmental management plans.

Source: JICA Study Team

10.1.7 Institutional Framework

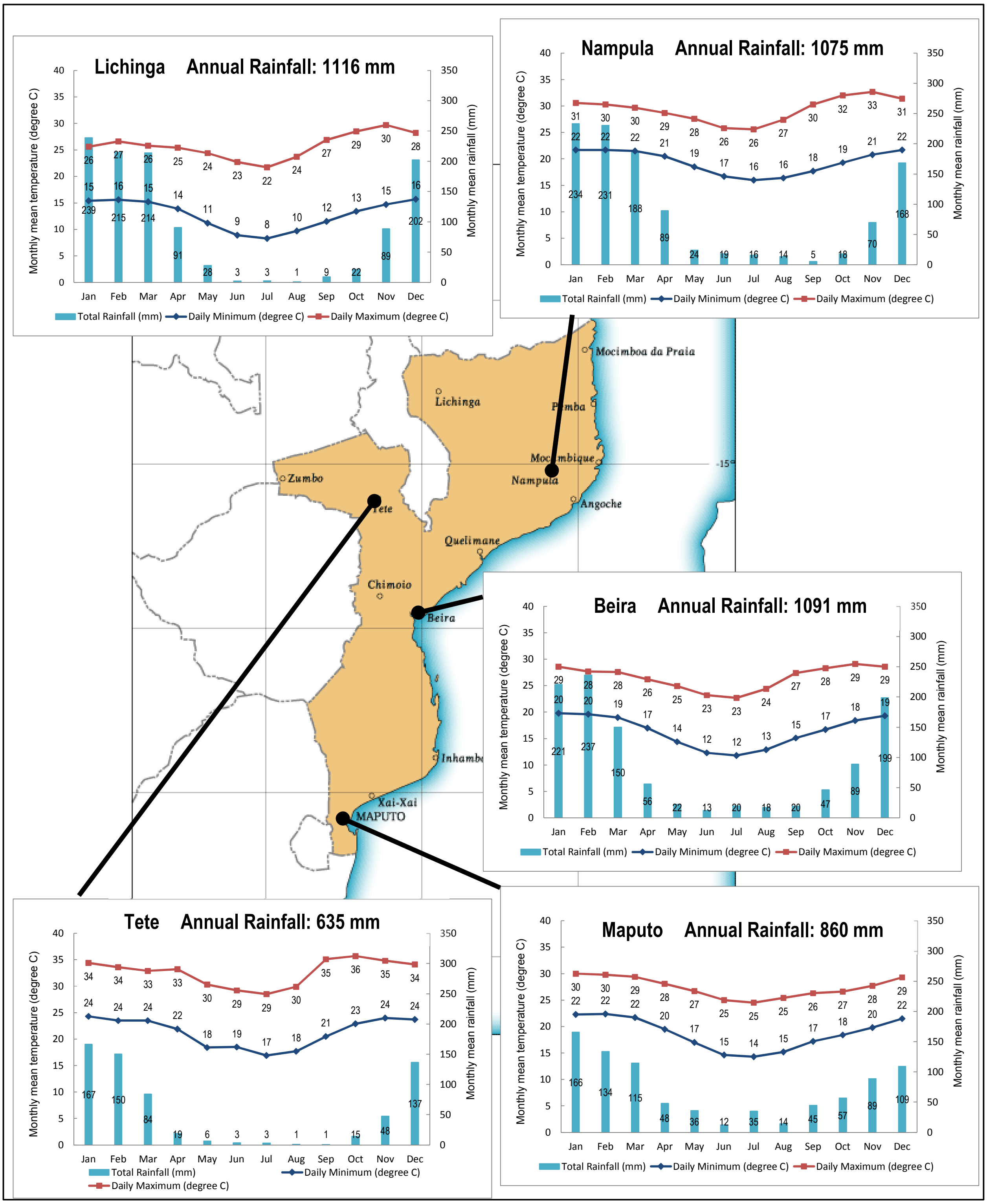
The Ministry of Land, Environment and Rural Development (MITADER) has jurisdiction over the environmental administration in Mozambique. MITADER was established as part of reorganization of government ministries in January, 2015 from the former Ministry of Coordination of Environmental Affairs (MICOA) established in 1995. The roles include management of land, forest and wildlife, comprehensive environmental conservation and rural development in addition to coordination among environmental sections in ministries. MITADER was take over duties and roles of National Directorate of Environment in the former MICOA with the same system. The environmental offices are established in each province and in charge of enforcement of EIA process for category B and C projects. National Environmental Quality Control Agency (AQUA) is in charge of environmental management, monitoring and audit.

In EDM, Environmental and Social Department is in charge of environmental management. The department supports environmental social considerations for foreign and locally funded projects implemented by EDM. The functions of the department include conducting environmental survey and land acquisition, preparing EIA reports and resettlement action plans, and implementation of environmental management plans.

10.2 Natural Environment and Social Condition

10.2.1 Climate

Because of the long extension of the territory of Mozambique, the climate differs from north to south, or coastal zone and high inland slightly. All of the land is located in subtropical climate zone. According to Köppen-Geiger climate classification, the climate divides into equatorial savannah in the most land, warm temperate climate with dry winter in the northern inland and steppe climate in the southern inland. Figure 10.2-1 shows monthly mean temperature and rainfall in main cities.

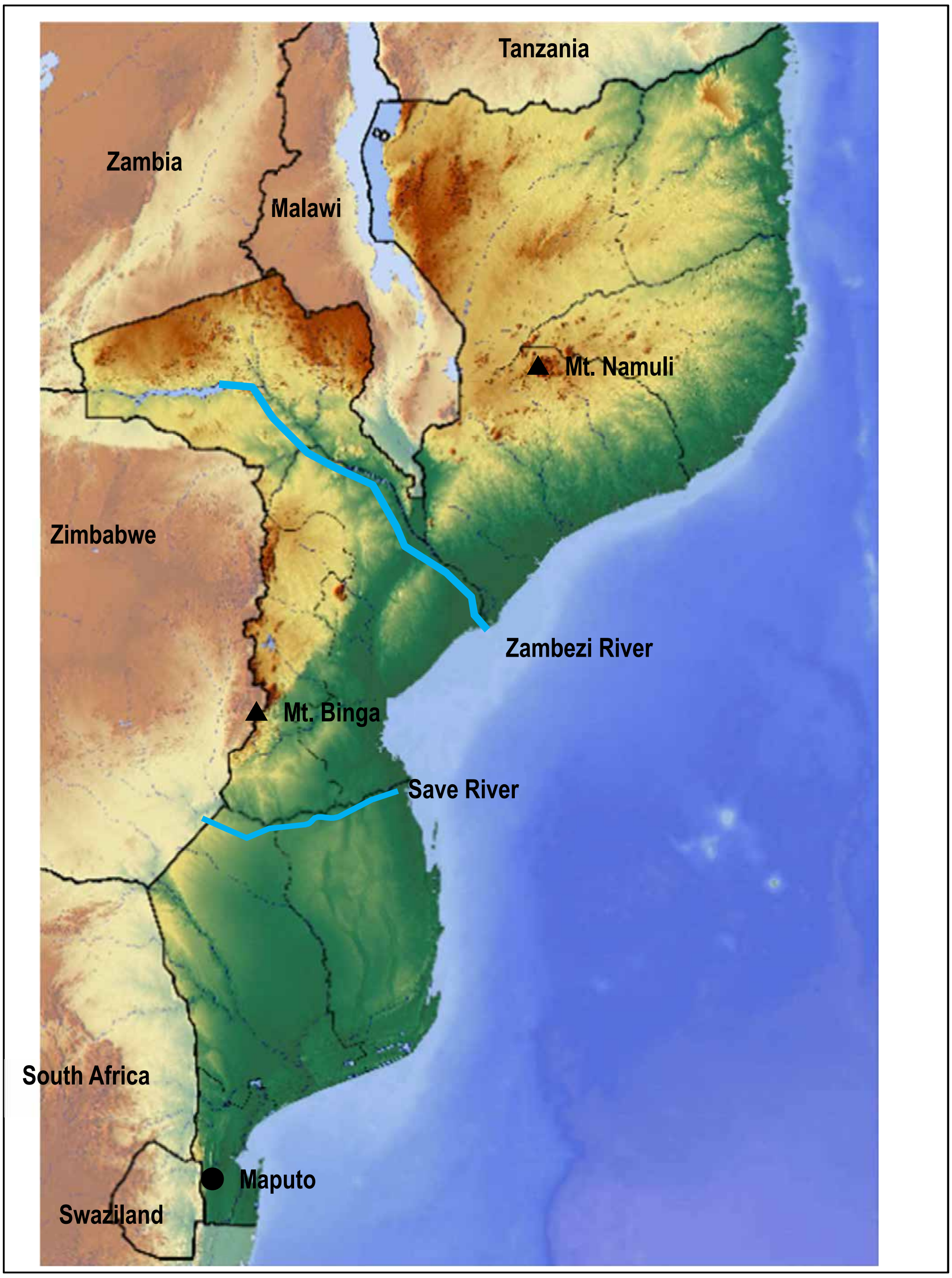


Source: Instituto Nacional de Meteorologia – Moçambique

Figure 10.2-1 Monthly Mean Temperature and Rainfall in Main Cities

10.2.2 Topographic Features

Mozambique is located in the southeast portion of Africa, borders on Tanzania, Malawi and Zambia in the north, Zimbabwe in the west, and South Africa and Swaziland in the south and faces Indian Ocean in the east. Zambezi River runs through the center of the country. The north area is plateau about 1,000 m above sea level. The south area is hilly grassland. The south area of Save River and downstream area of Zambezi River are plains. The highest point is Mount Binga (2,436 m) located in Manica province border with Zimbabwe, the next is Mount Namuli (2,419 m) located in Zambezia province, Northern region of Mozambique.

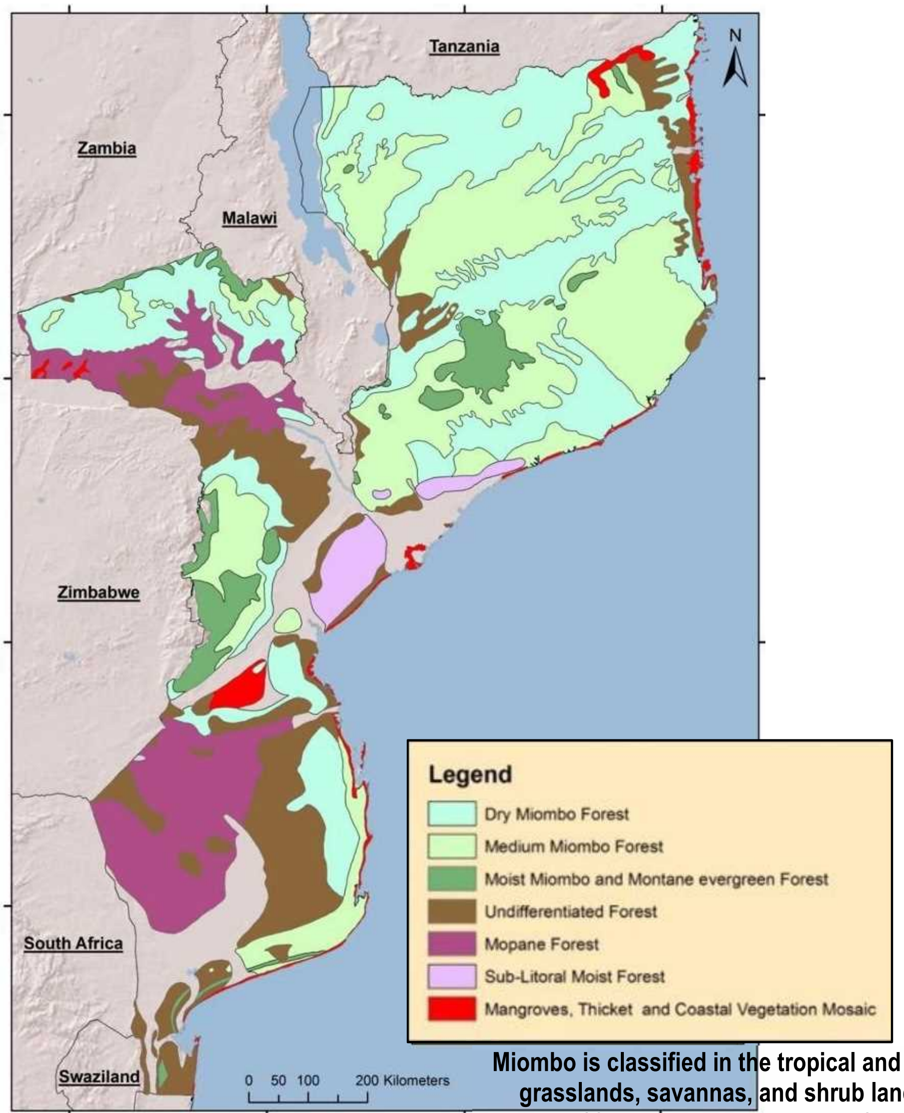


Source: JICA Study Team (Base Map: Wikimedia Commons)

Figure 10.2-2 Topographic Features in Mozambique

10.2.3 Vegetation

Distribution of vegetation in Mozambique is shown in Figure 10.2-3. The forest area in Mozambique covers about 40.1 million hectares (approximately 51% of national territory), while other woody formations (scrubs, thickets and forests with shifting cultivation) cover approximately 14.7 million of hectares, which correspond to 19% of the territory. At the local scale, there are other vegetation types such as coastal dune and littoral vegetation such as Mangroves and Acacia vegetation in the lowland. There are discontinuous stands of reed vegetation along most of the river beds. Dambos (vegetation in low and wet land) are another vegetation formation, which are very common at the base of the inselbergs and act as a buffer, capturing water and releasing it slowly throughout the year. Most of the dambos have been converted into rice fields, which are cultivated during the rainy season.



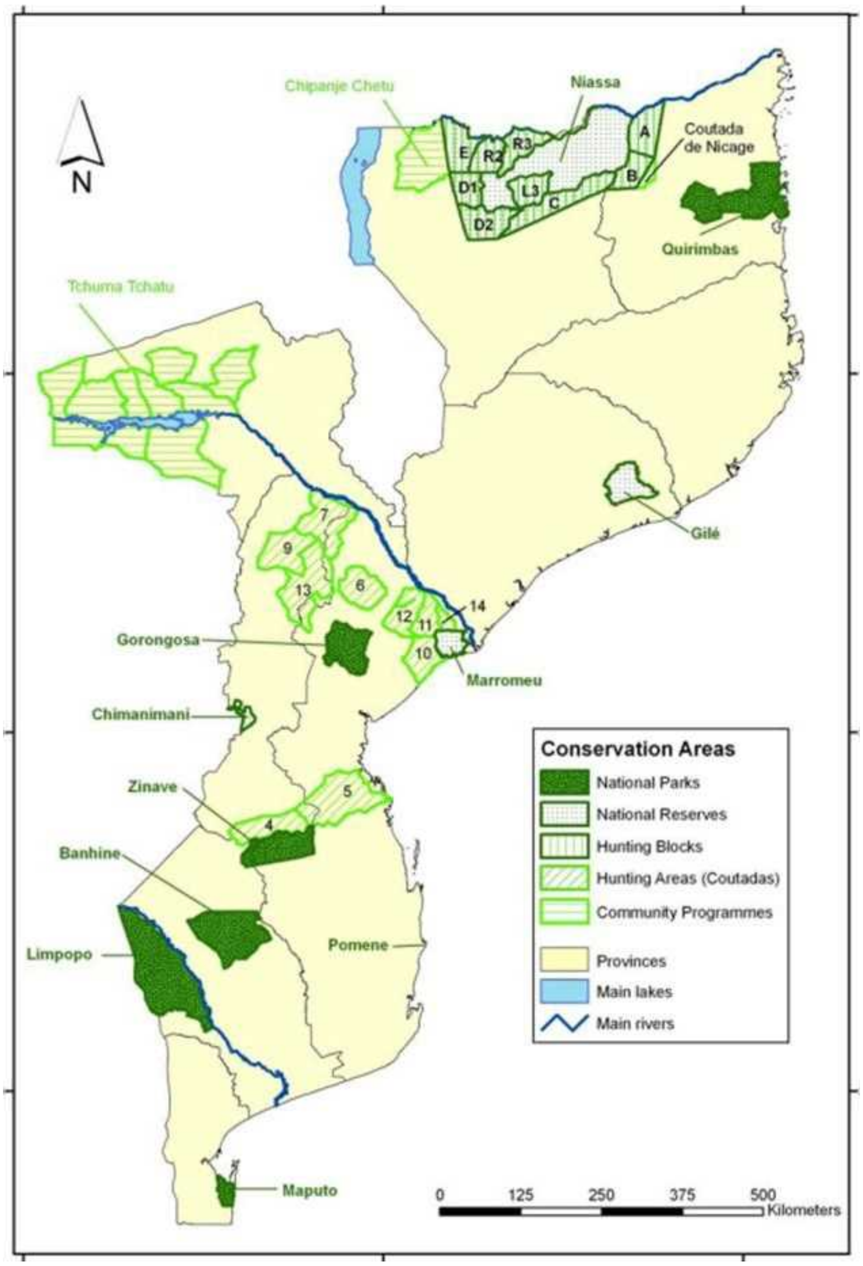
Miombo is classified in the tropical and subtropical grasslands, savannas, and shrub land.
Mopane (*Colophospermum mopane*) is a tree in the legume family and grows in hot, dry and low areas in southern Africa.

Source: Environmental and Social Management Framework for Mozambique Forest Investment Project, 2017 by World Bank

Figure 10.2-3 Distribution of Vegetation Types in Mozambique

10.2.4 Protected Area

There are 45 nationally protected areas, covering 16% of the country land. According to Biodiversity Conservation Law (Law No. 16/2014), the protected areas are classified into real protected areas (National Parks, National Reserves and Culturally valuable controlled areas) and protected areas for sustainable use (Nature special reserves, National environmental conservation areas, Hunting blocks and areas, National protected areas for special species and protected areas managed by communities or local governments). Moreover, there are two Ramsar Sites in the country, namely Niassa Lake area and Marromeu area. The protected areas in Mozambique are shown in Figure 10.2-4.



Source: Environmental and Social Management Framework for Mozambique Conservation Areas for Biodiversity and Sustainable Development Project, 2014 by World Bank

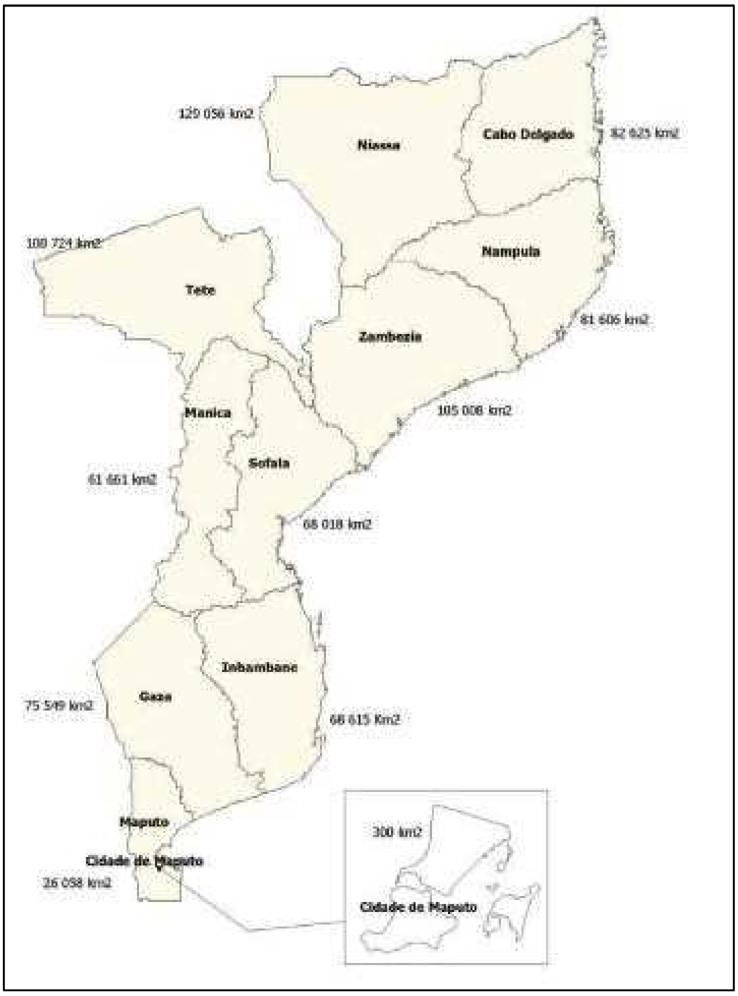
Figure 10.2-4 Protected Areas in Mozambique

10.2.5 Fauna and Flora

It is reported that Mozambique has about 5,500 plant species, out of which 250 are endemic, and 4,271 animal species (Insect: 72%, Bird: 17%, Mammal: 5%, Reptile: 4% and Amphibia: 2%). According to IUCN Red List (2015), there are 188 threatened animal species, with 11 critically endangered (Bird 4 species, Fresh water fish 3 species, Reptile 3 species and one mammal of Black rhinoceros), 41 endangered and 136 vulnerable species. 84 plant species are listed, with 4 critically endangered, 25 endangered and 55 vulnerable species. The list also reported that among the representative orders, there are 2 endemic plant species and 1 mammal species.

10.2.6 Administrative Divisions

Mozambique is divided into ten provinces (provincias) and one capital city (cidade capital) with provincial status. The provinces are subdivided into 148 districts (distritos) (as of 2016). The districts are further divided in "Postos Administrativos" (Administrative Posts) and then into Localidades (Localities), the lowest geographical level of the central state administration. Population and population density by province are shown in Table 10.2-1. The total population is 26,423,623, of which urban population is 8,468,799 (32 %), rural population is 17,954,824 (68 %).



Source: Instituto Nacional de Estatística – Moçambique

Figure 10.2-5 Province in Mozambique

Table 10.2-1 Population and Population Density by Province in 2016

Province	No. of District	Population		Area (km^2)		Population Density (people/km^2)
Maputo City	7	1,257,453	4.8%	300	0.04%	4,192
Maputo Province	8	1,782,380	6.7%	26,058	3.3%	68
Gaza	2	1,442,094	5.5%	75,709	9.5%	19
Inhambane	14	1,523,635	5.8%	68,615	8.6%	22
Sofala	13	2,099,152	7.9%	68,018	8.5%	31
Manica	10	2,001,896	7.6%	61,661	7.7%	32
Tete	13	2,618,913	9.9%	100,724	12.6%	26
Zambezia	17	4,922,651	18.6%	105,008	13.1%	47
Nampula	21	5,130,037	19.4%	81,606	10.2%	63
Cabo Delgado	17	1,923,264	7.3%	82,625	10.3%	23
Niassa	16	1,722,148	6.5%	129,056	16.1%	13
Total/Average	148	26,423,623	100%	799,380	100%	33

Source: Instituto Nacional de Estatística – Moçambique, etc.

(1) Maputo City

Maputo is a port city, with its economy centered on the harbor. According to an official census, the population is 1,250,000. However, the actual population is estimated more due to slum and unofficial residence. Cotton, sugar, chromite, sisal, copra, and hardwood are the chief exports. The city manufactures cement, pottery, furniture, shoes and rubber. An aluminum refining plant owned by Mozal is located in the city. The city is surrounded by Maputo Province, but is administered as its own province.

(2) Maputo Province

The area is the smallest in provinces in Mozambique. Its capital is Matola adjacent to Maputo City. It borders South African to the south and west, Swaziland to the southwest. The Maputo River flows into Maputo Bay to the southeast of Maputo. The Maputo Bay area to the southeast of Maputo is an important conservation area with many reefs and lakes including Maputo Elephant Game Reserve.

(3) Gaza Province

Most of the area lies in the basin of Limpopo River. Xai-Xai front onto the Indian Ocean is the capital. It borders South Africa to the west, and Zimbabwe to the northwest. The Limpopo railway, which connects Zimbabwe and Botswana to the port of Maputo, runs through the province. The province, including the towns of Xai-Xai and Chokwe, were greatly affected by the 2000 Mozambique flood.

(4) Inhambane Province

The province is mostly flat and located on the coast. The provincial capital is also called Inhambane front onto the Indian Ocean. The climate is more humid along the coast and dryer inland. The coast has a number of mangrove swamps. The province is the second largest grower of cashews (after Nampula), and also produces coconut and citrus fruit. The Inhambane Bay area is of some interest for tourism, with a number of beaches, and one of the last remaining populations of dugong in Mozambique.

(5) Sofala Province

The province is mostly flat and has mountainous areas in only the northwest. The city of Beira front onto the Indian Ocean., the provincial capital and Mozambique's third-largest city and the busiest port in the country, plays a key role in the local economy. Urema River forms the lagoon which are home to hundreds of hippopotamus. Principal exports include ores, tobacco, food products, cotton, hides and skins, with the chief imports including fertilizers, equipment and textiles, liquid fuels and wheat. In the 21st century, agricultural productivity in the province has shown significant improvement, reducing poverty.

(6) Manica Province

The province is located in mountainous area in the west of Mozambique and surrounded by Zimbabwe in the west, Chimoio is the capital of the province. The highest mountain in Mozambique, Mount Binga (2436 m), lies in this province near the border with Zimbabwe. The inhabitants practice subsistence farming. Main products are maize, cassava and goat meat. Agriculture is favored by the high rainfall and mild climate. The province is rich in terms of gold, copper and base metal. The province is located in the middle area between Beira port, the second largest port in Mozambique, and Harare, the capital of Zimbabwe, where the railway and main road runs through. Many farm workers from Zimbabwe have migrated to the province because of the conflicts in their country. The total number of such migrants is disputed and may range from 4,000 to 40,000.

(7) Tete Province

The province is located in the inland area and borders Malawi, Zimbabwe and Zimbabwe. It is surrounded by mountainous areas. Zambezi River runs through the middle area in the province. The Cahora Bassa Dam and lake are situated in the upstream area. Tete is the capital of the province and known as dry and one of the hottest city in Mozambique. The province has various climate and vegetation such as Baobab trees. A large amount of investment has been made portending to the development of coal resources such as Moatize coal in Tete city suburb and infrastructure required for mining and development.

(8) Zambezia Province

The province is mostly drained by the Zambezi River. The south and river mouth areas are flat. The inland area is mountainous terrain and has Mount Namuli (2419m) in the northern part. It borders Malawi to the northwest. The provincial capital is Quelimane. Much of the coast consists of mangrove swamps, and there is considerable forest in the inland. Agricultural activities have prospered in the vast plain land. The products include rice, maize, cassava, cashews, sugarcane, coconuts, citrus, cotton, and tea. Fishing is especially productive of shrimp, and gemstones are mined at several sites. Zambezi River has caused annual floods in rainy season recently.

(9) Nampula Province

The inland is mountainous terrain, costal area is flat plain. Nampula is the capital of the province, the second largest city with over 500,000 population and economic center in the northern provinces. There is Island of Mozambique as an only world’s cultural heritage site in Mozambique in the province. The region is a major producer of cotton, and is known as Cotton Belt of Nampula Also the products are cashews, tobacco, gems and other minerals. Many of the cotton and tobacco farms in the Province are state-owned.

(10) Cabo Delgado Province

The province is mostly hilly area and borders Tanzania to the north. The coastal area is flat plain. The region is an ethnic stronghold of the Makonde tribe. Macua and Mwani ethnic groups are also present. Pemba is the capital of the province.

(11) Niassa Province

The province is mostly hilly area, borders Tanzania to the north and front onto Nyasa (Malawi) lake that is the third largest lake in Africa. There is no coastal zone. A mountain range lies north and south along Nyasa lake in the west and formulate the east bank of Nyasa Rift Valley as a portion of the Great Rift Valley. Lichinga is the capital of the province and located in high land of 1300 m above sea level. It is the largest province in Mozambique. 75% of the province remains untouched by development and remains free of landmines. Considerable primary forest areas also remain in the province. There are a minimum estimated 450,000 Yao people living in Mozambique. They largely occupy the eastern and northern part of the Niassa province and form about 40% of the population of Lichinga.

10.2.7 Languages, Religion and People

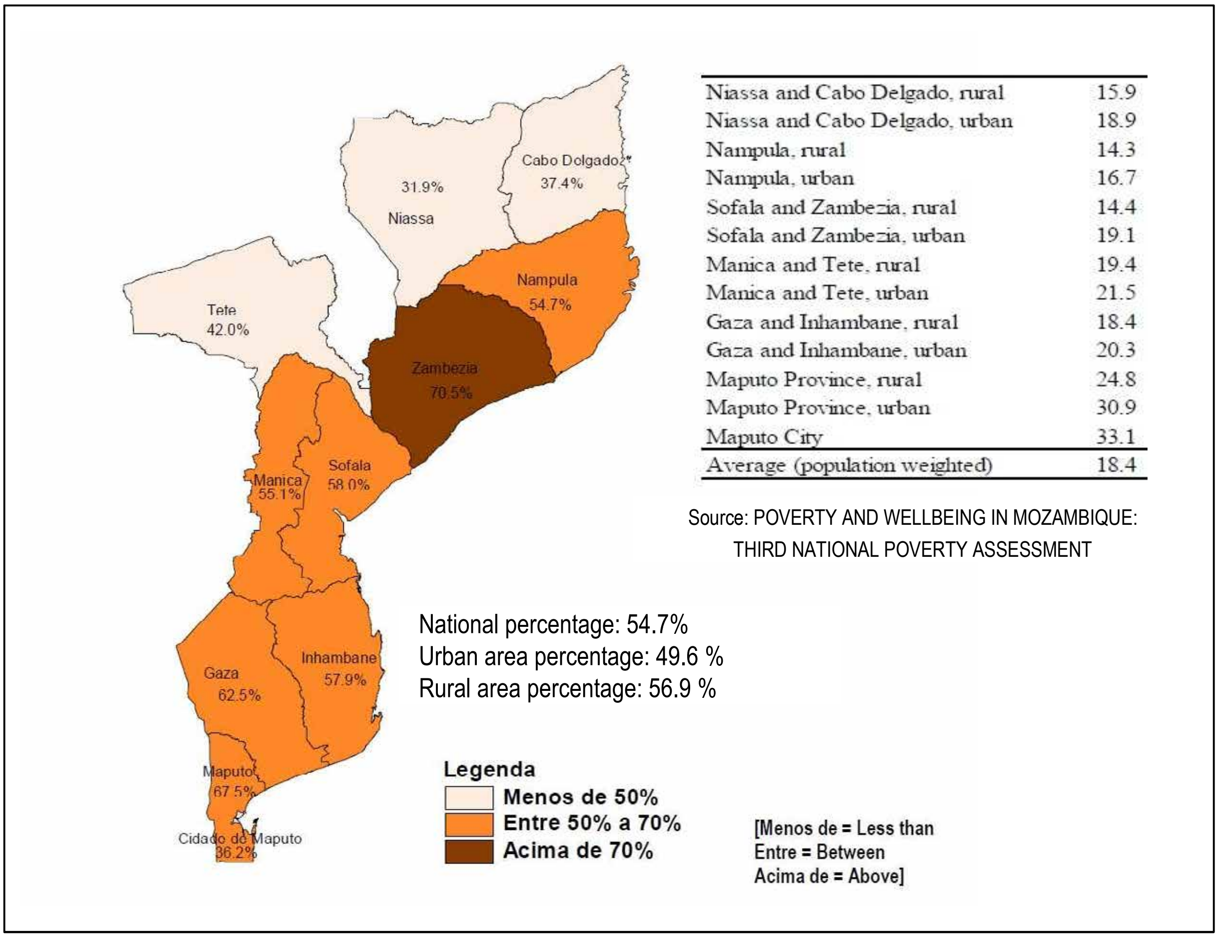
Portuguese is the official and most widely spoken language. Most of official documents are written by Portuguese. Other native languages are also spoken. In the northern part, Swahili is used too. English is available in limited locations such as hotels and air ports.

Christian religion (41%) is worshiped widely, mainly in the southern part. Islamic religion (18%) is also worshiped mainly in the northern part. Other traditional practices are still widespread.

43 tribal groups such as Emakhuwa-Lomwe (mainly in the northern part) and Tsonga (mainly in the southern part) live in Mozambique.

10.2.8 Poverty Situation

Poverty rates in northern three provinces are low. The rates in middle provinces are relatively high. The poverty rate has a tendency to improve. Improvement is more obvious in rural areas rather than urban areas. Provincially, provinces which are less dependent on agriculture, such as the Tete province and Inhambane province experienced a huge improvement. The Tete province has an active coal mining industry. The Inhambane province has a strong inflow of investment in its tourism industry. However, provinces that are highly dependent on agriculture - such as the Zambezia and Gaza provinces did not show improvement in the poverty rate. Unfavorable weather in 2008 negatively affected the Zambezia province.



Niassa and Cabo Delgado, rural	15.9
Niassa and Cabo Delgado, urban	18.9
Nampula, rural	14.3
Nampula, urban	16.7
Sofala and Zambezia, rural	14.4
Sofala and Zambezia, urban	19.1
Manica and Tete, rural	19.4
Manica and Tete, urban	21.5
Gaza and Inhambane, rural	18.4
Gaza and Inhambane, urban	20.3
Maputo Province, rural	24.8
Maputo Province, urban	30.9
Maputo City	33.1
Average (population weighted)	18.4

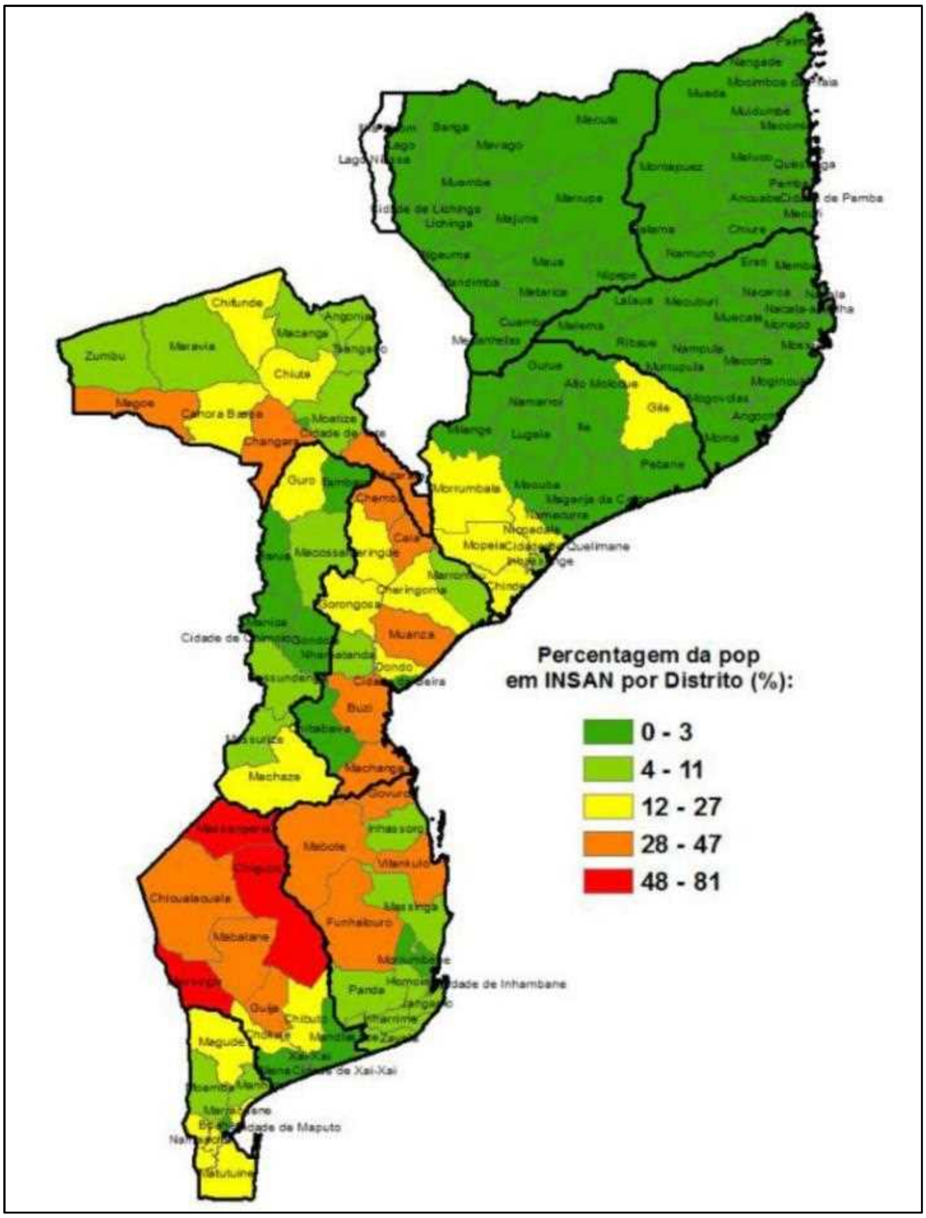
Source: Report on The Millennium Development Goals – Mozambique - 2010

Figure 10.2-6　Poverty Rate by Province in 2009

10.2.9　Drought

Shortages of rainfall, especially in the southern and parts of central regions of Mozambique, were recorded between October 2015 and January 2016. The country faced the worst drought in 30 years, especially in the southern provinces of Maputo, Gaza and Inhambane, and parts of central regions, notably in Tete and Sofala provinces as a result of El Niño in 2016.

The Technical Secretariat for Food Security and Nutrition's report released by UNICEF in March 2016 presents a serious food security and nutrition situation in the country. The report shifts the severity of the situation from the southern provinces of Maputo, Gaza, and Inhambane to the central provinces of Tete, Manica, Sofala and Zambezia where the situation is reported to be much worse by comparison. 1.5 million people were facing food insecurity and nutritional crisis in these seven provinces. 191,000 children are expected to be severe acutely malnourished in the next 12 months and Global Acute Malnutrition (GAM) rates for children under 5 are 15.3% and 15.5 % in Sofala and Tete provinces respectively.



Source: Technical Secretariat for Food Security and Nutrition, March 2016

Figure 10.2-7 Percentage of food insecure population per district

10.2.10 CO2 Emissions from Fuel Combustion

Total CO2 Emission of Mozambique is very low level. The CO2 Emission from electricity sector is also very low, because Cahora Bassa Hydroelectric Power Plant is a main power plant. CO2 emissions per population is also very low, one thirtieth of World Average or one seventh of African Average.

Table 10.2-2 CO2 Emissions from Fuel Combustion

Item	Unit	Mozambique		Africa		World	
Total CO2 emissions from fuel combustion in 2014	million tonnes of CO 2	3.9		1,105.3		32,381.0	
Electricity and heat production sector	million tonnes of CO 2	0.7	18%	468.7	42%	13,625.0	42%
Other energy sector	million tonnes of CO 2	0.0	0%	89.3	8%	1,683.1	5%
Manufacturing industries and construction sector	million tonnes of CO 2	0.6	16%	139.8	13%	6,230.1	19%
Transport sector	million tonnes of CO 2	2.2	58%	286.3	26%	7,547.3	23%
Other sectors	million tonnes of CO 2	0.3	8%	121.3	11%	3,295.5	10%
CO2 emissions / GDP in 2014 using exchange rates	kilograms CO 2 / US dollar using 2010 prices	0.29		0.50 (Average)		0.44 (Average)	
CO2 emissions / population in 2014	tonnes CO 2 / capita	0.14		0.96 (Average)		4.47 (Average)	

Source: CO2 EMISSIONS FROM FUEL COMBUSTION Highlights (2016 edition) by INTERNATIONAL ENERGY AGENCY

10.3 Strategic Environmental Assessment (SEA)

10.3.1 Background and Role of SEA

Environmental Impact Assessment (EIA) systems have been established and regulated for many kind of development projects in many counties and regions as a process of decision-making and perdition for implementation of the projects. The EIA has been an effective tool to identify environmental and social impacts in the project stage. However, because main project components have been fixed in the project stage, the mitigation measures against the identified serious negative impacts are limited in tactic level such as alternative analysis including without the project, which is known as a week point of EIA system.

In this regard, to assess projects including fundamental review, comprehensive and strategic assessment systems in prior stage of project preparation had been required.

Strategic Environmental Assessment (SEA) had been considered in this background. The SEA is a method to assess policies, plans and programs of national, regional and sector level, and implement the fundamental review in strategic and upper level. The SEA is an assessment system to reflect environmental and social considerations into policies, plans and programs.

10.3.2 Definition of SEA

At present, there is no fixed definition of SEA. According to OECD-DAC (2006), following description was proposed:

- SEA is a set of analytical and participatory approaches to strategic decision-making that aim to integrate environmental considerations into policies, plans and programs, and evaluate the inter linkages with economic and social considerations.

This description is followed by World Bank.

In JICA Guidelines for Environmental and Social Considerations (Amended April 2010), following definition and explanation are given:

- A "strategic environmental assessment" is an assessment that is implemented at the policy, planning, and program levels, but not a project-level EIA.
- JICA applies a Strategic Environmental Assessment (SEA) when conducting Master Plan Studies etc., and encourages project proponents etc. to ensure environmental and social considerations from an early stage to a monitoring stage.
- JICA makes efforts to avoid or minimize significant environmental and social impacts by applying a SEA when preparing a sectoral or regional cooperation program.
- JICA applies a SEA when the preparatory surveys include not only project-level but also upper-stream-level studies, which are called Master Plan Studies.

The SEA in the Master Plan is defined as environmental and social considerations, and environmental impact assessment in planning stage.

10.3.3 Role of SEA and Plans for Administrative Decision Level

As mentioned above SEA can also be applied to formulation of policies, plans and programs at a higher administrative level. Contents and evaluation factors for SEA are somewhat changed depending on the targeted levels of policies, plans and programs such as administrative, spatial and/or sectarian level. In view of SEA for necessary environmental and social considerations relation of policies and plans with environmental and social considerations are shown in Table 10.3-1.

Table 10.3-1 Development Plan and Strategic Environmental Assessment

Development Plan, Pograme and Project		SEA/EIA/ Initial Environmental Examinatio (IEE)	Environmental and Social considerations
Level	Policy, Plan, Program, Project etc.		
National Level	National Policy, Plan, Program etc.	SEA	National environmental policy, Environmental Law etc.
Regional Level	Regional development policy, master plan for several regions and cities	SEA	Regional environmental management policy and plan, Enviornmetal regurations, etc.
Sector Level	Master plan of nationwide and/or regional energy/electric power sector, etc.	SEA・EE	Sector level environmental policies, plans and programs, Environmental evaluation, Environmental regulations, etc.
Selection of Prioritized Plan or Multi-projects	Alternative energy/electric power plans and projects (energy/power plants, transmission line, distribution system etc.)	SEA・IEE・EIA	Environmental evaluation of plan and/or project, Alternatives analysis of development plans/projects for energy/power plants, transmission line, distribution system, etc Environmental regulations, etc.
Implementation of Project	Specific project (Feasibility Study) with pre-determined site and process etc.	IEE・EIA	EIA of projects (development of energy/power plant, transmission line, distribution system, etc. EIA regulation, etc.

Source: JICA Study Team

10.3.4 Relevant Strategy and Plan

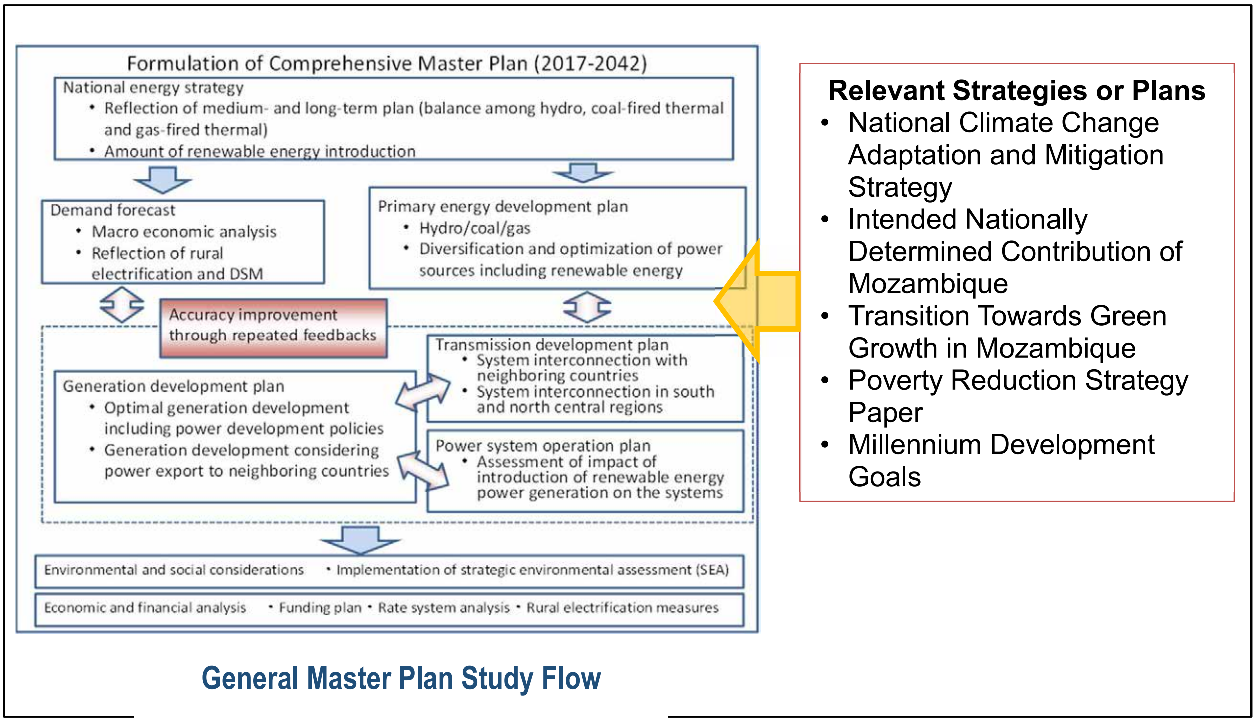
External assessment form wider and outer viewpoint of other sectors is required in the SEA. This SEA evaluates and considers the Master Plan by reference to the following descriptions on the electric sector in relevant national strategies and plans.

1. National Climate Change Adaptation and Mitigation Strategy 2012
   - ✓ Promoting the electrification of rural communities using renewable energy
   - ✓ Increase of energy efficiency
2. Intended Nationally Determined Contribution of Mozambique to the United Nations Framework Convention on Climate Change 2015
   - ✓ Increase of the access to renewable energy sources
   - ✓ Promoting the efficient use of the natural assets and clean technologies
3. Transition Towards Green Growth in Mozambique Policy Review and Recommendations for Action 2015 by African Development Bank
   - ✓ Promoting renewable energy and scaling up investments
   - ✓ Creating energy efficiency programmes
   - ✓ Integrated development of hydropower resources
4. Poverty Reduction Strategy Paper 2011-2014 by International Monetary Fund
   - ✓ Increase of renewable energy and new energy sources
   - ✓ Expansion of access to electrical energy
5. Report on the Millennium Development Goals 2010 by Ministry of Planning and Development, and UNDP
   - ✓ Promoting supply of electricity in some areas of the country

The following common key words are identified in the above five documents.

1. Renewable Energy and Energy Efficiency against Global Warming
2. Rural Electrification for Poverty Reduction

The assessment for the Master Plan puts much weight in these two key words.



Source: JICA Study Team

Figure 10.3-1 Mater Plan and Relevant Strategy or Plan

10.4 SEA and IEE of Generation Development Plan and Transmission Development Plan

10.4.1 Comparison of Alternatives in Terms of Environmental and Social Considerations

Possible alternatives to be examined in the Master Plan are the following.

1) Comparison of power development scenario

2) Zero-option scenario

The basic stance on the examination of the above two alternatives in the Master Plan is presented below.

1) Comparison of power development scenario

The comparison of power development scenario in the master plan study proposes three scenarios shown in the following. Sub-projects included in the respective scenarios are described in Chapter 5. The results of the alternative analysis are presented in "10.4.2 Evaluation of Generation Development Scenario".

Table 10.4-1 Outline of Power Development Scenario

Development Scenario	Case		
	Year of Integrated Power System	Domestic / Export	Solar and Wind Power
Base Scenario	2024	Domestic Oriented	10% of Domestic Peak Demand
Option 1: Export Scenario 1	2024	Export Oriented: 20% Domestic Peak Demand	10% of Domestic Peak Demand
Option 2: Solar and Wind Power	2024	Domestic Oriented	20% of Domestic Peak Demand

Source: JICA Study Team

2) Zero-option scenario

A zero-option scenario means a case without the power system development master plan. Even in the zero-option scenario, power system development is expected to be carried out to meet the increasing power demand. The development will not be conducted in a planned manner without the master plan, and as a result, serious impacts on peoples' lives and economic activities will be unavoidable such as frequent power cuts and increase in electricity tariff. In addition, the local economic impact and poverty reduction by the electrification will be less effective. The case where power development is conducted in a planned manner is deemed more desirable than the case where power development is unplanned in order to avoid or mitigate potential environmental and social impacts including cumulative impacts. The former case will enable project proponents and other stakeholders to predict potential impacts, and to prepare and take necessary measures. Moreover, because the power generation will be effectively conducted in former case, the CO2 emission volume is expedited to decrease and be controlled in the national level. Therefore, the former will cause less significant impacts than the latter. Based on the above considerations, an alternative pursuing the zero-option scenario is not considered in the master plan.

10.4.2 Evaluation of Generation Development Scenario

The evaluation item, reasons of selection and index are shown in Table 10.4-2. Information of the site locations is not included in this evaluation stage.

Table 10.4-2 Evaluation Item, Reasons of Selection and Index

Evaluation Item	Reasons of Selection	Evaluation Index
Total CO2 emission volume	CO2 emission from power plants is likely to have an impact on global warming..	- CO2 emission from power plants
Poverty reduction and economic effect in local areas	Poverty reduction and economic effect in local areas will be expected due to progress of electrification and generation development.	- Economic indicators - Poverty rate - Jobless rate
Ecosystem	Construction works, and existence and operation of power plants are likely to have negative impacts on terrestrial, aquatic and soil ecosystem.	- Conditions of protected areas - Decrease in habitat for wildlife - Loss of endangered species
Air pollution	Construction works, and operation of power plants and mines will generate are pollutants.	- Emission volume of air pollutants (Sulfur oxide, Nitrogen oxides and Particulate Matter) from power plants and mines - Air quality around power plants and mines
Water resources	Construction works, and existence and operation of power plants are likely to have negative impacts on water resources and use.	- Change of flow volume of main rives in up and down stream areas - Water contamination level around power plants and mines

Source: JICA Study Team

For the master plan, three alternatives of power development scenario were studied. Table 7.1.10 compares advantages and disadvantages of these alternatives.

Table 10.4-3 Comparison of Alternatives of Power Development Scenario

Evaluation Rank Very good or desirable: ◎ Good or desirable: ○ Middle: △ Bad or improper: ×

Evaluation Item	Base Scenario	Option 1: Export Scenario 1	Option 2: Solar and Wind Power
Total CO2 emission volume (see "10.4.3 CO2 Emissions by Development Scenarios")	○ 2024 : 2,620,220 2030 : 3,106,397 2035 : 4,012,038 2040 : 6,370,429 (Unit : kilo-Ton/Year)	△ 2024 : 3,020,480 2030 : 3,620,554 2035 : 5,346,164 2040 : 8,815,845 (Unit : kilo-Ton/Year)	◎ 2024 : 2,604,324 2030 : 3,056,600 2035 : 3,177,356 2040 :6,101,711 (Unit : kilo-Ton/Year)
Poverty reduction and economic effect in local areas	○ The electrification is expected to stimulate local economic activates and reduce poverty. Power plants, especially thermal plants, will create job opportunities for local people.	◎ The electrification is expected to stimulate local economic activates and reduce poverty. Because thermal plants will increase compered to Base Scenario or Option 2, these plants will create more job opportunities for local people. Utilization of local resources such as natural gas and coal will contribute to local economic activities and poverty reduction. Because power generation and transmission business will be well due to income of export, the electricity rate is likely to be cheaper than one of Base Scenario or Option 1.	○ The electrification is expected to stimulate local economic activities and reduce poverty. Power plants, especially thermal plants, will create job opportunities for local people. Because generation cost of solar and wind power is generally high, the electricity rate is likely to be higher than one of Base Scenario or Option 1
Ecosystem	△ Because the volume of power generation by hydro plants will increase, new hydro power plants will be required. Impacts on ecosystem in revers are likely to occur. Considerations of the site location can mitigate impact of construction of thermal, solar and wind Power plants on ecosystem.	△ Because the volume of power generation by hydro plants will increase, new hydro power plants will be required. Impacts on ecosystem in revers are likely to occur. Considerations of the site location can mitigate impact of construction of thermal, solar and wind Power plants on ecosystem.	△ Because the volume of power generation by hydro plants will increase, new hydro power plants will be required. Impacts on ecosystem in revers are likely to occur. Considerations of the site location can mitigate impact of construction of thermal, solar and wind Power plants on ecosystem.

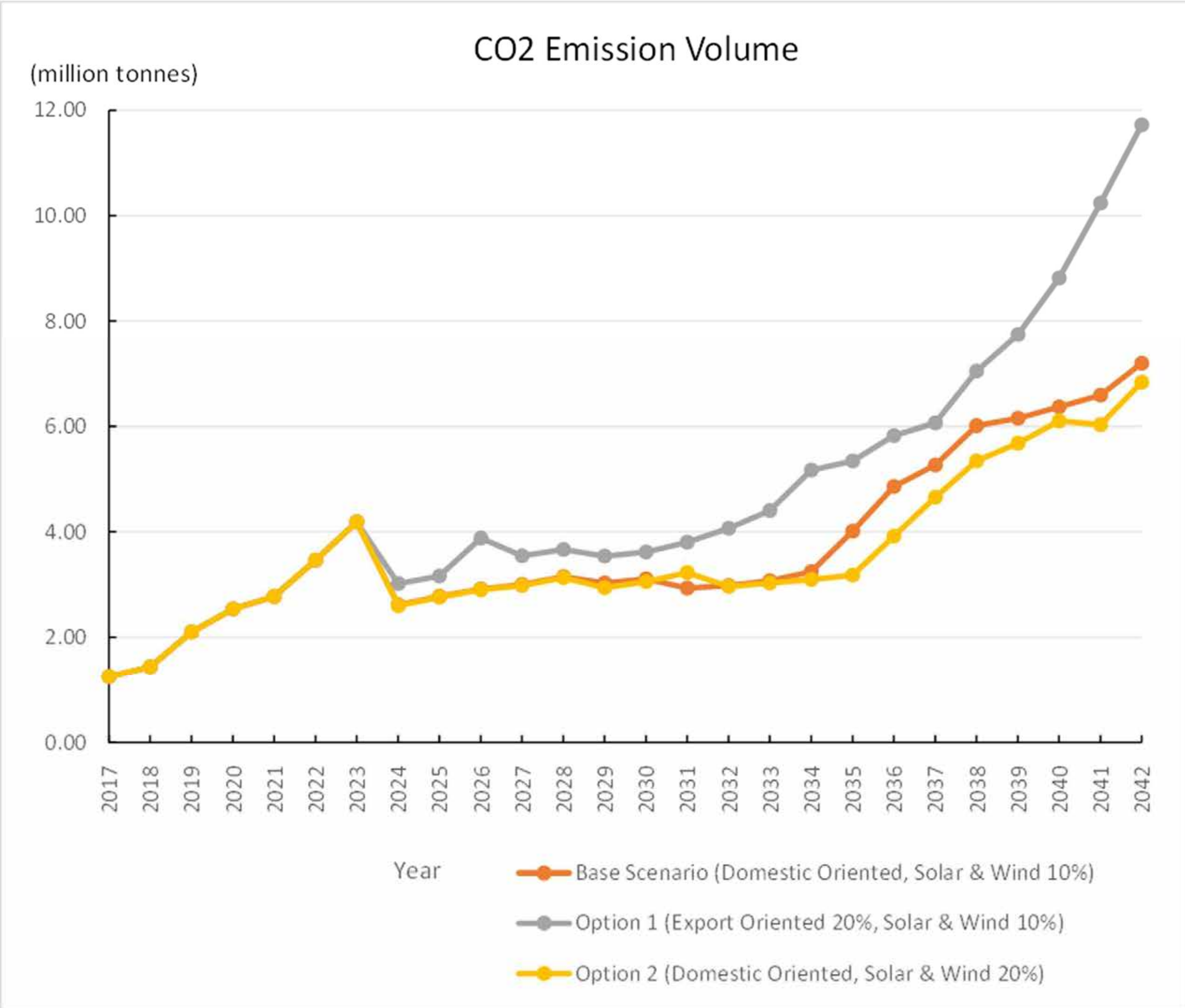
Air pollution	○ Thermal power plants using natural gas and coal generate air pollutants. However, considerations of the site location and installation of the proper treatment system can mitigate the impacts.	△ As the volume of power generation by thermal plants will increase compered to Base Scenario or Option 2, the total emission volume of pollutants will increase.	○ Thermal power plants using natural gas and coal generate air pollutants. However, considerations of the site location and installation of the proper treatment system can mitigate the impacts.
Water resources	△ Because the volume of power generation by hydro plants will increase, new hydro power plants will be required. Impacts on water resources and use are likely to occur.	△ Because the volume of power generation by hydro plants will increase, new hydro power plants will be required. Impacts on water resources and use are likely to occur.	△ Because the volume of power generation by hydro plants will increase, new hydro power plants will be required. Impacts on water resources and use are likely to occur.

Source: JICA Study Team

After discussions among relevant organizations including DEM and JICA Team, Option 1 was e adopted as the optimal power development scenario.

10.4.3 CO2 Emissions by Development Scenarios

Figure 10.4-1 shows the transition of CO2 emission volume by the development scenario. The CO2 emission volume from 2018 to 2023 is gradually increased due to the introduction of not only combined cycle gas turbine unit, coal fired unit but also engine-generator for Central & Northern System. On the other hand, the volume after 2024 is decreased and not increased so much because of the operation of large scale hydropower units. After that, the volume is increased again. The volume of Option 1 was estimated at 115% in 2024, 117% in 2030, 133% in 2035 and 138% in 2040 respectably compered to Base Scenario. The volume of Option 2 was estimated at 99% in 2024, 98% in 2030, 79% in 2035 and 96% in 2040 respectably compered to Base Scenario. Because hydro power will have been major into the future in Mozambique, reduction volume of CO2 emission due to installation of renewable energy plants is unlike to be great amount.

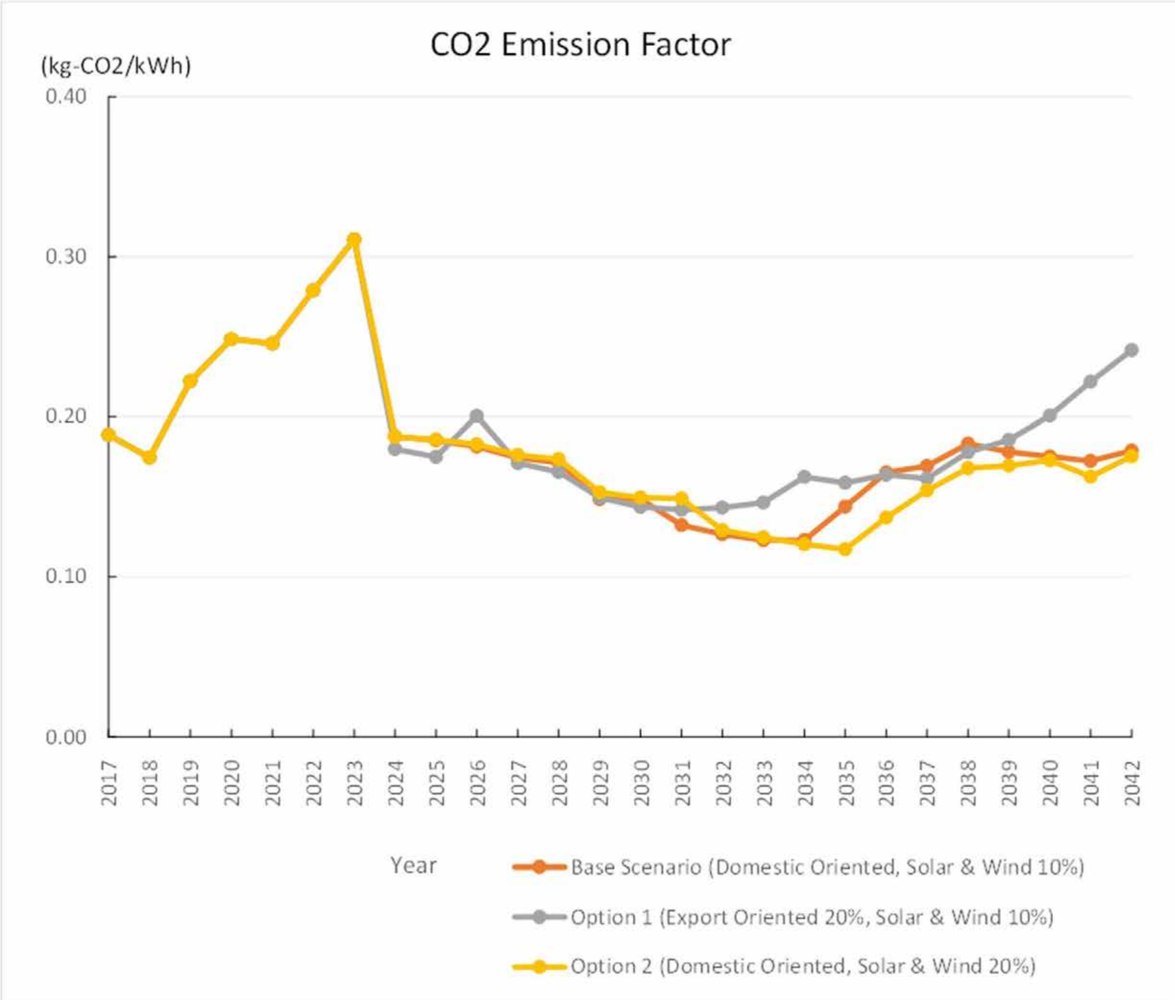


Source: JICA Study Team

Figure 10.4-1 Transition of CO2 Emission Volume by Development Scenario

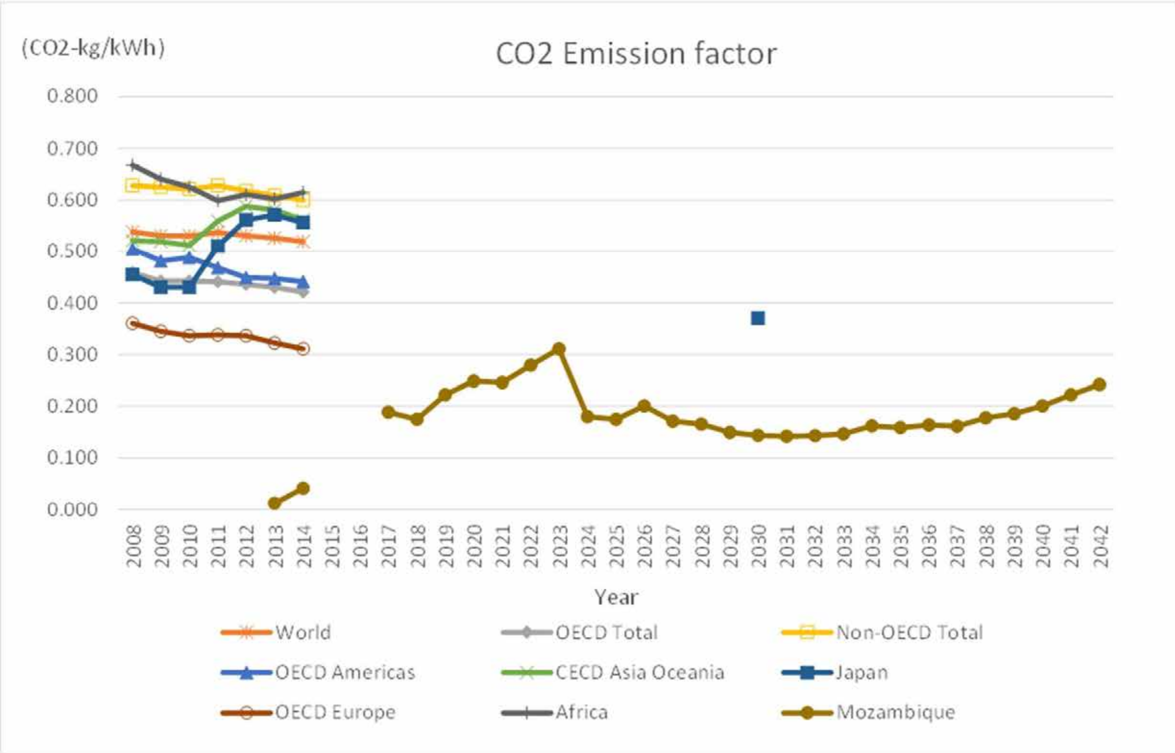
Figure 10.4-2 shows the transition of average CO2 emission factor by the development scenario. Average CO2 emission factor is the value of total amount of CO2 emission divided from total generated electricity in a year. The factor from 2018 to 2023 is gradually increased due to the introduction of not only combined cycle gas turbine unit, coal fired unit but also engine-generator for Central & Northern System. On the other hand, after 2024, the factor is decreased and not increased so much because of the operation of large scale hydropower units.

Figure 10.4-3 shows the transition of CO2 emission factor by main regions and the estimated values of the option 1 in Mozambique. The factor of Japan in 2014 was 0.554 kg-CO2/kWh. Japan has aimed to reduce the level by 0.37 kg-CO2/kWh by 2030. On the other hand, the factors of Mozambique are estimated at 0.14 kg-CO2/kWh in 2030 or 0.24 kg-CO2/kWh in 2042, respectably, in case of Option 1 that is the highest scenario. The low level of the factor is likely to continue in the future.



Source: JICA Study Team

Figure 10.4-2 Transition of CO2 Emission Factor by Development Scenario



Source: CO2 EMISSIONS FROM FUEL COMBUSTION (2016 edition) by INTERNATIONAL ENERGY AGENCY (IEA) and JICA Study Team

Figure 10.4-3 Transition of CO2 Emission Factor by Main Region and Mozambique

10.4.4 Initial Environmental Examination (IEE) of Generation Development Project

(1) Checklist

In JICA Environmental Checklist, the check items are (1) Permit and Explanation, (2) Pollution Control, (3) Natural Environment, (4) Social Environment and (5) Others. The checklist relevant to electric sector is shown in Table 10.4-4.

Table 10.4-4 JICA Environmental Checklist relevant to Electric Sector

	Development Plan	Thermal Power Station	Hydropower Stations, Dams and Reservoirs	Geothermal Power Station	Other Electric Generation	Power Transmission and Distribution Lines
Category	Environmental Item					
1 Permits and Explanation	(1) EIA and Environmental Permits	○	○	○	○	○
	(2) Explanation to the Local Stakeholders	○	○	○	○	○
	(3) Examination of Alternatives	○	○	○	○	○
2 Pollution Control	(1) Air Quality	○		○	○	
	(2) Water Quality	○	○	○	○	○
	(3) Wastes	○	○	○	○	
	(4) Soil Contamination				○	
	(5) Noise and Vibration	○		○	○	
	(6) Subsidence	○		○	○	
	(7) Odor	○		○	○	

	Development Plan	Thermal Power Station	Hydropower Stations, Dams and Reservoirs	Geothermal Power Station	Other Electric Generation	Power Transmission and Distribution Lines
	(8) Sediment					
3 Natural Environment	(1) Protected Areas	○	○	○	○	○
	(2) Ecosystem	○	○	○	○	○
	(3) Hydrology		○		○	
	(4) Topography and Geology		○	○	○	○
	(5) Management of Abandoned Sites					
4 Social Environment	(1) Resettlement	○	○	○	○	○
	(2) Living and Livelihood	○	○	○	○	○
	(3) Heritage	○	○	○	○	○
	(4) Landscape	○	○	○	○	○
	(5) Ethnic Minorities and Indigenous Peoples	○	○	○	○	○
	(6) Working Conditions	○	○	○	○	○
5 Others	(1) Impacts during Construction	○	○	○	○	○
	(2) Accident Prevention Measures	○	○	○		
	(3) Monitoring	○	○	○	○	○

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which the project is located.

Source: JICA Study Team

(2) Provisional Environmental Scoping

To identify whether the sub-projects proposed in the master plan are likely to have impacts that need to be assessed by conducting environmental and social considerations studies and choose potentially significant impact items, the provisional environmental scoping was conducted. Because in this master plan, the site location data are not included in the sub-projects, except for some priority sub-projects, generally potential impacts of each sub-project are considered. The impacts may vary from sub-project to sub-project, and thus, the sub-projects with more significant impacts are featured during the scoping of potential impacts. Table 10.4-5 shows the scoping result of the typical sub-projects in the master plan.

Table 10.4-5 Result of Provisional Environmental Scoping

Development Project	Hydro Power Generation		Gas Thermal Power Generation		Coal Thermal Power Generation		Solar Power Generation		Wind Power Generation		Transmission Line		Power Distribution	
Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase
Pollution														
Air pollution	B-	D	B-	B-	B-	A-~B-	B-	D	B-	D	B-	D	B-	D
Water pollution	B-	B-	B-	B-	B-	B-	B-	D	B-	D	B-	D	B-	D
Waste	B-	B-	B-	D-	B-	A-~B-	B-	B-	B-	D	B-	D	B-	B
Soil pollution	D	D	D	D	D	C~D	D	D	D	D	D	D	D	D
Noise and vibration	B-	D	B-	B-	B-	B-	B-	D	B-	B-	B-	D	B-	B
Ground subsidence	D	C~D	D	C~D	D	C~D	D	D	D	D	D	D	D	D
Offensive odors	D	D	D	D	D	C~D	D	D	D	D	D	D	D	D
Bottom sediment	D	B-	D	D	D	D	D	D	D	D	D	D	D	D
Natural Environment														
Protected areas	B-~C	B-~C	C~D	C~D	C~D	C~D	C~D	C~D	C~D	C~D	C~D	C~D	D	D
Ecosystem	A-	A-	C~D	C~D	C~D	C~D	C~D	C~D	C~D	B~C	C~D	B~C	D	D
Hydrology	A-	A-	D	D	D	D	D	D	D	D	D	D	D	D
Geographical features	A-	D	D	D	C~D	D	D	D	D	D	B-	D	D	D
Social Environment														
Resettlement/ Land Acquisition	A-	D	C~D	D	C~D	D	C~D	D	C~D	D	B~C	D	D	D
Poor people	B-	D	C~D	D	C~D	D	C~D	D	C~D	D	C~D	D	D	D
Ethnic minorities and indigenous peoples	B-	D	C~D	D	C~D	D	C~D	D	C~D	D	C~D	D	D	D

Development Project	Hydro Power Generation		Gas Thermal Power Generation		Coal Thermal Power Generation		Solar Power Generation		Wind Power Generation		Transmission Line		Power Distribution	
Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase
Local economies, such as employment, livelihood, etc.	B±	B±	B±	B±	B±	B±	B±	B±	B±	B±	B±	B±	D	B±
Land use and utilization of local resources	B-	B-	B-	B+	B-	B+	B-	D	B-	D	B-	D	D	D
Water usage	B-	B-	D	D	D	D	D	D	D	D	D	D	D	D
Existing social infrastructures and services	B-	B-	B-	D	B-	D	B-	D	B-	D	B-	D	D	D
Social institutions such as social infrastructure and local decision-making institutions	B-	D	D	D	D	D	D	D	D	D	D	D	D	D
Misdistribution of benefits and damages	B-	D	D	D	D	D	D	D	D	D	D	D	D	D
Local conflicts of interest	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Cultural heritage	B-	D	D	D	D	D	C~D	D	C~D	D	D	D	D	D
Landscape	A-	A-	D	D	D	D	D	B-	D	B-	D	B-	D	D
Gender	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Children's rights	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Infectious diseases such as HIV/AIDS	B-	B-	B-	D	B-	D	B-	D	B-	D	B-	D	D	D

Development Project	Hydro Power Generation		Gas Thermal Power Generation		Coal Thermal Power Generation		Solar Power Generation		Wind Power Generation		Transmission Line		Power Distribution	
Impact Item	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase	Pre-Construction Phase Construction Phase	Operation Phase
Working conditions (including occupational safety)	B-	B-	B-	B-	B-	B-	B-	D	B-	D	B-	B-	B-	B-
Other														
Accidents	B-	B-	B-	B-	B-	B-	B-	D	B-	B-	B-	B-	B-	B-
Trans-boundary impacts or climate change	B-	D	B-	B-	B-	B-	B-	D	B-	D	B-	D	B-	D

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected

* Impact Items refer to “JICA Guidelines for Environmental and Social Considerations April 2010”

Source: JICA Study Team

The potential impacts of each items in the scoping on the basis of the environmental and social conditions in Mozambique are as follows:

Air pollution:

[Hydro Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Air pollutants in exhaust gas will be emitted from heavy machinery and construction vehicles during the construction phase. However, the impact will be temporary and in limited areas.

[Gas Thermal Power, Coal Thermal Power] Air pollutants in exhaust gas will be emitted from heavy machinery and construction vehicles during the construction phase. However, the impact will be temporary and in limited areas. Combustion of fossil fuel for power generation will emit some amount of air pollutants such as sulfur dioxide (SOx), nitrogen dioxide (NOx) and particulate matter (PM) in operation phase.

Water pollution:

[Hydro Power] Construction works will cause the inflow of turbid water into rivers and the reservoir newly developed, which likely to deteriorate the water quality of the rivers and reservoir. Occurrence or nonoccurrence of water pollution is unclear at present since it depends heavily on the components of individual projects and the locations of related facilities. In operation phase, eutrophication and poor oxygen water mass in the deeper layer may occur in the reservoir.

[Gas Thermal Power, Coal Thermal Power] Coolant water discharged from a thermal power plant may affect the water quality of a nearby water body depending on its quality and temperature. If chemicals are used to prevent water creatures from adherence to the inside of coolant pipes, such chemicals may cause water pollution. Occurrence or nonoccurrence of water pollution is unclear at present since it depends heavily on the components of individual projects and the locations of related facilities.

[Solar Power, Wind Power, Transmission Line, Power Distribution] Construction works will cause the inflow of turbid water into rivers and the reservoir newly developed, which likely to deteriorate the water quality of the rivers and reservoir. Occurrence or nonoccurrence of water pollution is unclear at present since it depends heavily on the components of individual projects and the locations of related facilities.

Waste:

[Hydro Power] The construction of hydropower facilities will generate waste soil and construction wastes. The operation and maintenance works of hydro power plants will also generate wastes including flood wood and garbage flowing in the reservoir.

[Gas Thermal Power, Wind Power, Transmission Line] The construction of power plant facilities and transmission line will generate waste soil and construction wastes.

[Coal Thermal Power] The construction of power plant facilities will generate waste soil and construction wastes. Coal ash and fly ash will be continuously generated during the operation of coal thermal power plants. Coal ash and fly ash are strong alkaline materials and may contain heavy metals depending on the quality of coal fuels.

[Solar Power, Wind Power, Power Distribution] The construction of power plant facilities and substation will generate waste soil and construction wastes. The replacement of old batteries and transformers will generate waste including sulfuric acid and transformer oils contaminated by Polychlorinated Biphenyl (PCB).

Soil pollution:

[Hydro Power, Gas Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Soil pollution to need considerations is unlikely to occur.

[Coal Thermal Power] Coal ash and fly ash will be continuously generated during the operation of coal thermal power plants. Coal ash and fly ash are strong alkaline materials and may contain heavy metals depending on the quality of coal fuels, thus, if improperly disposed of, they may cause soil pollution.

Noise and vibration:

[Hydro Power, Solar Power, Transmission Line] The construction works will cause a certain level of noise and vibration. In particular, if there are villages in the vicinity of construction sites, an impact of the noise on local residents' livelihoods is likely to occur.

[Gas Thermal Power, Coal Thermal Power, Wind Power, Power Distribution] The construction works will cause a certain level of noise and vibration. In particular, if there are villages in the vicinity of construction sites, an impact of the noise on local residents' livelihoods is likely to occur. Operation of a thermal plant will cause a certain level of noise. Operation of a wind power plant will cause low-frequency noise. Transformers with high capacity will also discharge low-frequency noise that can reach tens of meters. Whether a project causes noise impacts on neighboring communities is unclear since it relies heavily on the layout plans of individual projects.

Ground subsidence:

[Hydro Power] Ground subsidence may occur depending on the ground stability of the construction sites for the dam.

[Gas Thermal Power, Coal Thermal Power] If coolant water is taken from groundwater, operation of thermal power stations might cause ground subsidence. Occurrence or nonoccurrence of ground subsidence is unclear at present since it depends on individual project plans.

[Solar Power, Wind Power, Transmission Line, Power Distribution] Ground subsidence to need considerations is unlikely to occur.

Offensive odors:

[Hydro Power, Gas Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Offensive odors to need considerations is unlikely to occur.

[Coal Thermal Power] Offensive odors caused by emission gas might occur. Occurrence or nonoccurrence of offensive odors is unclear at present.

Bottom sediment:

[Hydro Power] Organic matter not to be decomposed due to eutrophication and poor oxygen water mass may accumulate as sludge on bottom of the reservoir.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution]

Impacts on bottom sediment to need considerations are unlikely to occur.

Protected areas:

[Hydro Power] If the project site is located in and around protected areas, impacts on the protected areas will occur. Indirect impacts on protected areas existing in the downstream areas are likely to occur.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line] If the project site is located in and around protected areas, impacts on the protected areas will occur.

[Power Distribution] Because the affected area is very limited, impacts on protected areas are unlikely to occur.

Ecosystem:

[Hydro Power] Loss of habitat for wildlife by reservoir creation, impacts on fish and other aquatic life caused by changes in river flow and clearance of trees for land formation are likely to occur.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line] Some impacts such as clearance of trees or loss habitat for wildlife are likely to occur depending on the project location. Wind turbine and transmission lines may have impacts on migration of birds such as Vulture.

[Power Distribution] Because the affected area is very limited, impacts on ecosystem are unlikely to occur.

Hydrology:

[Hydro Power] Water intake from rivers and the creation of reservoirs or low-water section will affect the hydrology of the rivers to be developed. Such impacts on local hydrology will also affect the distribution and amount of nearby groundwater.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Impacts on hydrology to need considerations is unlikely to occur.

Geographical features:

[Hydro Power] Submersion of land caused by the creation of reservoirs and land formation for the construction of power facilities may cause loss or damage of valuable topography and geological features.

[Coal Thermal Power] Coal mine development may cause loss or damage of valuable topography and geological features.

[Transmission Line] Alteration of topographic features caused by the construction of transmission lines may cause loss or damage of valuable topography and geological features.

[Gas Thermal Power, Solar Power, Wind Power, Power Distribution] Impacts on geographical features to need considerations is unlikely to occur.

Resettlement/Land Acquisition:

[Hydro Power] If villages exist in the vicinity of a proposed dam site, large-scale involuntary resettlement will occur. Because the dam site will be selected depending on natural conditions such as geography, geology and river flow, the resettlement will be avoidable.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line] If some residences exist in the vicinity of the planned construction site, small-scale involuntary resettlement may be required.

Occurrence or nonoccurrence of resettlement is unclear at present since it depends on individual project plans. In general, these facilities will be constructed in remote areas from villages.

[Power Distribution] Because the affected area is very limited, resettlement is unlikely to occur.

Poor people:

[Hydro Power, Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] If the project affected persons include socially vulnerable groups such as poverty group, the livelihood of these groups may get worse.

Ethnic minorities and indigenous peoples:

[Hydro Power] If villages of ethnic minorities or indigenous peoples exist in the vicinity of a proposed dam site, their independent culture may disappear.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] If the project affected persons include ethnic minorities or indigenous peoples, impacts on their independent culture may occur.

Local economies, such as employment, livelihood, etc.:

[Hydro Power, Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line,] In pre-construction phase, the land acquisition and resettlement may cause livelihood degradation of the project affected persons. The construction works will create job opportunities to local people as unskilled labor. In operation phase, beneficial impacts such as promotion of goods and persons movement, improvement of living conditions and creation of employment opportunity due to new power generation on local economy are expected.

[Power Distribution] In operation phase, beneficial impacts such as promotion of goods and persons movement, improvement of living conditions and creation of employment opportunity due to new power generation on local economy are expected.

Land use and utilization of local resources:

[Hydro Power] The construction of a hydropower station with a reservoir will cause changes in land use pattern due to the submersion of agricultural and forestry land, and other types of land. Agricultural and forest resources are likely to decrease as a result. In operation phase, change of local hydrology may have impacts on water and fishery resources.

[Gas Thermal Power, Coal Thermal Power] Land acquisition for the construction will cause changes in land use pattern. Agricultural and forest resources are likely to decrease as a result. In operation phase, local natural resources such as natural gas and coal will be used effectively.

[Solar Power, Wind Power, Transmission Line] Land acquisition for the construction will cause changes in land use pattern. Agricultural and forest resources are likely to decrease as a result.

[Power Distribution] Impacts on land use and local resources to need considerations is unlikely to occur.

Water usage:

[Hydro Power] Water resources of rivers to be developed for hydropower generation are already developed for other uses than power generation, such as irrigation. Water intake for power generation may cause conflicts with water intake for irrigation and other usage.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Impacts on water usage to need considerations is unlikely to occur.

Existing social infrastructures and services:

[Hydro Power] Relocation or protection of existing utilities such as water pipe and optical fiber cable will be required. Temporary traffic congestion in and around construction site will occur during the construction works. The new reservoir is likely to disturb crossing the river.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line] Relocation or protection of existing utilities such as water pipe and optical fiber cable will be required. Temporary traffic congestion in and around construction site will occur during the construction works.

[Power Distribution] Impacts on existing infrastructures to need considerations is unlikely to occur.

Social institutions such as social infrastructure and local decision-making institutions:

[Hydro Power] If the whole or considerable part of villages is submerged as a result of the construction of hydropower stations, some impacts such as loss or malfunction of local institutions may be predicted. Reservoirs to be constructed may cause separation in local society due to the creation of barriers for passage.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Impacts on social institutions to need considerations is unlikely to occur.

Misdistribution of benefits and damages:

[Hydro Power] In case of large scale resettlement, misdistribution of benefit among the project affected persons may occur.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Misdistribution of benefits to need considerations is unlikely to occur.

Local conflicts of interest:

[Hydro Power, Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Local conflicts to need considerations is unlikely to occur.

Cultural heritage:

[Hydro Power] If the whole or part of cultural heritages is submerged as a result of hydropower development, the loss of the heritages is inevitable.

[Solar Power, Wind Power] If the whole or part of cultural heritages is located in the construction site, the loss of the heritage is likely to occur.

[Gas Thermal Power, Coal Thermal Power, Transmission Line, Power Distribution] Because the affected area is very limited and locations of facilities can be selected flexibly, impacts on cultural heritage are unlikely to be avoided.

Landscape:

[Hydro Power] Local landscape may be significantly changed due to the construction of hydropower stations and creation of reservoir.

[Solar Power, Wind Power, Transmission Line] Appearance of new enormous artificial structure may affect local landscape depending on the location.

[Gas Thermal Power, Coal Thermal Power, Power Distribution] Impacts on landscape to need considerations is unlikely to occur.

Gender:

[Hydro Power, Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Impacts on gender to need considerations is unlikely to occur.

Children's rights:

[Hydro Power, Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Impacts on children's right to need considerations is unlikely to occur.

Infectious diseases such as HIV/AIDS:

[Hydro Power] HIV/ AIDS could spread as a result of the long-term inflow of construction workers into construction sites. Risk of malaria, schistosomiasis and other water-borne diseases may increase as a result of the creation of reservoirs.

[Gas Thermal Power, Coal Thermal Power, Solar Power, Wind Power, Transmission Line] HIV/ AIDS could spread as a result of the long-term inflow of construction workers into construction sites.

[Power Distribution] Impacts on infectious diseases to need considerations is unlikely to occur. If a project causes large scale involuntary resettlement, problems of sanitation and infectious disease may be caused in relocation destinations.

Working conditions (including occupational safety):

[Hydro Power, Gas Thermal Power, Coal Thermal Power, Transmission Line, Power Distribution] Dust and emission gas caused by construction works may affect workers health. Because construction will include high-place works, labor accident including tumble accident may occur. Electric shock accidents or health hazards caused by emission gas may occur.

[Solar Power, Wind Power]

Dust and emission gas caused by construction works may affect workers health. Because construction will include high-place works, labor accident including tumble accident may occur.

Accidents:

[Hydro Power, Gas Thermal Power, Coal Thermal Power, Wind Power, Transmission Line, Power Distribution] Labor accidents may occur in construction site. Traffic accidents may occur surrounding of construction site. In operation phase, ground leakage, burst and dropping by damage may occur.

[Solar Power] Traffic accidents may occur surrounding of construction site.

Trans-boundary impacts or climate change:

[Hydro Power, Solar Power, Wind Power, Transmission Line, Power Distribution] Impacts on climate change to need considerations is unlikely to occur.

[Gas Thermal Power, Coal Thermal Power] Fossil fuel combustion will cause considerable volume of CO2 emission.

(3) Mitigation Measures

Because actual site and components of each project do not take on a concrete form in this master plan stage, except for some priority projects, environmental mitigation measures for formulating projects are presented in the master plan. The concrete and detailed mitigation measures against each environmental and social impact should be prepared in the next stage such as a feasibility study or EIA.

1. Hydro Power Generation:

a Because the dam site will be selected depending on natural conditions such as geography, geology and river flow, the candidate sites are limited. Multiple alternatives including dam height and discharge volume besides site location should be compared and considered. Baseline data for the consideration such as distribution of residential areas, social and economical conditions, ecosystem and water environment should be collected and surveyed for sufficient duration in wider areas than the directly affected areas. The collected baseline data are utilized for not only selection of the optimal plan also the environmental mitigation and monitoring plan prepared in the EIA.

b In case resettlement is required, proper compensation according to the World Bank and JICA Guidelines shall be prepared for the project affected persons. The project cost should include all of the expense for the resettlement.

c Development projects in Zambezi river system should take into account of the cumulative impacts.

d Water rights and regulations should be confirmed. These pieces of information should be considered in the planning stage.

2. Thermal Power Generation (Gas and Coal):

a Selection of the site of thermal power plants need the following considerations.

- ✓ To ensure that the quantities of water used will not disrupt local hydrological conditions
- ✓ To avoid locations where cooling waters will be released close to or affecting areas of high ecological and biodiversity value or sensitivity: especially areas such as mangroves and coral reefs that are extremely sensitive to water temperature changes.
- ✓ To avoid locations near residence areas
- ✓ To avoid locations in and around protected areas

b It is necessary to assess the cumulative effects of cooling water of several power plants located near each other.

c Some amounts fly ash and other wastes will be recycled into useful products, such as briquettes, cement and building materials, while the rest should be disposed in an appropriate area. The proper disposal sites should be surveyed in advance.

d Abatement technologies for air emissions are to be considered such as flue gas desulfurization (FGD) for SOx, low NOx burners, a selective catalytic reduction (SCR) system, a selective noncatalytic reduction (SNCR) system, fabric filters and electrostatic precipitators (ESPs) for particulate matter, where necessary to meet the emission limits. The project cost should include all of the expense for these measures for pollution control.

4. Solar Power Generation and Wind Power Generation

a Selection of the site of solar or wind power plants need the following considerations.

- ✓ To identify and take into account of rural development plans through meetings with local government and people
- ✓ To avoid resettlement
- ✓ To avoid or minimize forest clearing
- ✓ To avoid locations in and around protected areas

3. Transmission Line and Power Distribution

a Selection of the route of transmission line need the following considerations.

- ✓ To identify and take into account of rural development plans through meetings with local government and people
- ✓ To avoid resettlement
- ✓ To avoid or minimize forest clearing
- ✓ To avoid locations in and around protected areas as much as possible

b The project cost should include all of the expense for proper compensation of the land acquisition and resettlement.

c Areas with concentrations of vulnerable bird species should be surveyed in advance. In case the routes cross their areas, counter measures to prevent bird from electric shock should be prepared in the early stage.

(4) Environmental Management and Monitoring

The objective of environmental management and monitoring is to ensure that the mitigation measures are implemented appropriately and to collect information on the changes of the environmental quality on a regular basis to identify any impacts on the environment caused by sub-projects. The monitoring should be implemented by EDM Environmental and Social Department or sub-project owners collaboratively with other sub-project owners and related institutions. The project owners should take charge of the monitoring of each project in accordance with the project EIA and Environmental Management Plan (EMP). Table 10.4-6 shows key monitoring items. The concrete and detailed EMP and environmental monitoring plan (EMoP) should be prepared in the next stage such as a feasibility study or EIA.

Table 10.4-6 Potential Key Item for Monitoring

Impact Item	Key Monitoring Item	Hydro Power Generation	Thermal Power Generation (Gas and Coal)	Solar and Wind Power Generation	Transmission Line and Power Distribution
Air pollution	- Emission of SOx, NOx and particulate matter - Ambient air quality		○		
Water pollution	- Water quality of dam reservoir - Water quality of discharged water from dam reservoir - Temperature of discharged cooling water from thermal power plants - Temperature of ambient water (river, lake, coastal area)	○	○		
Waste	- Amount of coal ash waste generated (ton/year)	○	○		
Ecosystem	- Impact on wildlife habitats - Impacts on ecosystems and sensitive areas including national parks, nature reserves, wetlands, wildlife habitat, forest area - Vegetation clearance - Impact of operation and existence of generation and transmission facilities on wildlife	○	○	○	○
Resettlement	- Implementation of resettlement action plan	○	○	○	○
Water usage	- Acquisition of water use permit - Water withdrawal of thermal power plants - Conflicts on water use	○	○		
Local economy	- Impact on livelihood activities of local people	○	○	○	○
Climate change	- Emission of CO2 (ton-CO2eq/year)		○		
Project Effects	- Rate of access to electricity - Electricity consumption (kWh/capita)	○	○	○	○

Source: JICA Study Team

EDM Environmental and Social Department or sub-project owners reports to t Ministry of Land Environment and Rural Development (MITADER) on the status of environmental and social consideration in implementing the projects and changes in environmental quality referring to the relevant regulations and environmental standards in Mozambique.

10.5 Stakeholder Meeting

It is important and inevitable to collect comments and opinions of various stakeholders from earlier stage, and reflect them formulation of the master plan. In general, information disclosure and stakeholder participation should be with wider and various levels. However, procedures of formulating the master plan of energy and electricity, which are important and crucial to national policies and plans, it is also necessary to proper consideration to dissemination and participation of stakeholders. Because the main subjects for discussion in the meetings were political and strategic matters in this master plan, the government related organizations including local governments, electric power generation and supply companies, academic institutes, foreign donors and NGO, etc. were invited to the meetings.

Seminars to explain the survey contents and outputs of this master plan were held three times in Maputo inviting wide-ranging stakeholders concerned. The stakeholder meetings were included in the seminars. The seminars and meetings were open to mass media.

In this master plan study, Project Affected Persons (PAPs) of the sub-projects cannot be identified in the meeting stage since the master plan will not specify the exact locations of individual sub-project. Therefore, specific PAPs did not attend the meetings.

The main participating organizations are as follows:

- Government:
  - Ministry of Natural Resource and Energy (MIREME)
  - Ministry of Land, Environment and Rural Development (MITADER)
  - Ministry of Economies and Finance (MEF)
  - Ministry of Agriculture and Food Security (MASA)
  - Provencal government
  - Municipal government
- Agency and Company in power sector:
  - Electriciade de Moçambique (EDM)
  - Hidroeléctrica de Cahora Bassa (HCB)
  - Energy Regulatory Authority (ARENE)
  - Fundo de Energia (FUNAE)
  - Empresa Moçabicana de Explorazao Mineira (EMEM)
  - Empresa Nacional de Hidrocarbonectos de Moçambique (ENH)
  - Implementation unit of on going project
- Institute and University:
  - Instituto Nacional de Petroreo (INP)
  - Eduardo Mondlane University (UEM)
- Donor:
  - Japan International Cooperation Agency (JICA)

World Bank

African Development Bank (AfDB or BAD)

Agence Française de Developpement (AFD)

Kreditanstalt für Wiederaufbau (KfW)

Others:

Confederation of Economic Associations of Mozambique (CTA)

Center for Public Integrity (CIP)

The summaries of the seminars and meetings are as follows:

Title	1st Seminar
Date and Time	Tuesday, 11th April, 2017, 9:00 ~ 13:30
Venue	Montebelo Indy Maputo Congress Hotel
Attendance	Approximately 90

The 1st Seminar was held with approximately 90 attendances including Chairman & CEO of EDM, members of Joint Coordinating Committee (JCC) (9), members of Joint Study Team (JST) (17), World Bank, Embassy of Norway and AFD.

Opening remarks were made by Chairman & CEO of EDM and deputy chief representative in JICA Mozambique office. Keynote speech was made by Permanent Secretary of MIREME, on behalf of Minster of MIREME. The JICA team leader and planning director of EDM, explained outline of the Study. The JST members explained the progress of the study.

- 9:00 ~ 9:20 Address by Chairman & CEO of EDM
- 9:20 ~ 9:30 Opening Session by Permanent Secretary of MIREME
- 9:30 ~ 11:45 Explanation of Outline of Study by JICA team and JST (Including Coffee Break)
- 11:45 ~ 13:30 Question and Answer

The 13 participants had questions in the question and answer session. The main questions and answers are as follows:

<u>Demand Forecast</u>

Q: Local population forecast had better make use of a demographer.

A: The estimation of the provincial demand uses INE population increase data. The INE data include analysis of demographers.

Q: Was each local economic development considered?

A: Each provincial GDP growth was evaluated on the basis of each past actual provincial GDP and the local characteristics.

Q: The contract of Cahora Bassa with Eskom will expire in 2029. If the electric power enter into EDM, how do impacts on the demand occur?

A: The supply volume of the electric power is not associated with the demand.

Q: A paper factory is a consumer of electricity. If the factory installs its own generator in the future, the factory will consume its electric power. How to evaluate the private power generation? Some companies may sell their own electricity to EDM. How do impacts on the demand occur?

A: Specific information such as capacities and actual generated electricity can be considered in the demand. Please let me know the information.

Q: The electricity tariff will increase and be an important indicator. Can the tariff be considered in the demand?

A: The electricity tariff that be used in the study has remained politically in the recent decade. Because the tariff has been steady, the relation can not be evaluated. Consequently, the tariff can not be used as an indicator.

Q: Export of electricity changes depending on demand in neighboring counties. Was the demand in

neighboring counties considered?
A: Domestic demand was assumed. Evaluation of export of electricity to neighboring counties is considered in Export Oriented Scenario of the generation development plan.
Q: Why was the Special Customer reduced to 20%?
A: Because the project feasibility, actual demand less than contract quantity and connection control due to shortage of EDM system capacity were assessed.

Generation Development Plan
Q: Mphanda Nkuwa Project is likely to increase from 1,500MW to 2,600MW. Is this increase reflected in the master plan?
A: According to EDM, Mphanda Nkuwa Project is 1,500MW. We will confirm the increased 2,600MW.
Q: Do you consider installation of renewable energy?
A: We will consider the renewable energy in the next stage.
Q: Why were hydropower plants introduced before combined cycle plants in the analysis result?
A: Hydropower plants have the high construction cost and low maintenance cost. On the other hand, combined cycle plants have the low construction cost and low maintenance cost. According to a minimum cost simulation, hydropower plants will be totally cheaper than combined cycle plants despite the high construction cost in the long term.

Rural Electrification
Q: How do you think the criteria of off-grid?
A: The study team should not set up the criteria, because on-grid and off grid have drawback and advantage and should be judged politically. The demand in the master plan will include the demand of off-grid. The study team is interested in the increase of number of on-grid houses and present a springboard for discussion.
Q: FUNAE regulates that areas with 5 km and more away from transmission lines are installed electricity. Is 5 km too short? The electrification areas were selected on the basis of electrification plans for 5 year. From what is the standard?
A: These are based on the information from FUNAE and only concepts, not standards. We will continue to discuss FUNAE.

Distribution Development Plan
Q: Does the master plan focus on the technical loss?
A: The loss has technical and non-technical loss. The master plan focus on the reduction of the technical loss from technical viewpoints. However, Japanese electric power companies have experiences to reduce the non-technical loss. So we will propose the improvement measures also.

Title	2nd Seminar
Date and Time	Tuesday, 19th June, 2017, 9:15 ~ 14:00
Venue	Montebelo Indy Maputo Congress Hotel
Attendance	Approximately 120

The 2nd seminar was held with approximately 120 attendances including Chairman & CEO of EDM, staffs of EDM (68), relevant members of MIREME (10), World Bank, AFD, KfW, Embassy of Norway and Embassy of Sweden. Local mass media also attended the seminar.

Opening remarks were made by Chairman & CEO of EDM and representative in JICA Mozambique office. Keynote speech was made by of Minster of MIREME. The JICA team explained the study results of 1. Demand Forecast (Final), 2. Generation Development Plan (Progress), 3. System Operation Plan (Progress) and 4. Economic and Financial Analysis (Progress).

- 9:15～9:30 Address by Chairman & CEO of EDM and JICA Representative in Mozambique Office
- 9:30～9:40 Opening Session by Minister of MIREME
- 9:40～9:45 Explanation of Outline of Master Plan by DEM Counterpart
- 9:45～11:50 Explanation of Outline of Study by JICA team and JST (Including Coffee Break)
- 11:45～14:00 Question and Answer

The 12 participants had questions in the question and answer session. The main questions and answers are as follows:

Demand Forecast

Q: Was electrification rate used as an indicator for the demand forecast?

A: The electrification rate hardly have any impact on the result of demand forecast. The result without the rate as an indicator was more precise. So the rate was not used.

Q: Projects managed by CPI (Centro de Promoção de Investimentos) have been implemented only about 30%. Was this fact considered?

A: All project as well as CPI projects for special customers were considered regarding their feasibility and shortage of system and power generation. 30% on energy base were estimated as new loads to connect systems.

Q: Were urban and tourism development plan of Palma, Macze and Pemba in Cabo Delgado considered in the master plan?

A: Considered as much as possible.

Generation Development Plan

Q: Were hydro, solar and wind power considered as maximum utilization? Give us comments on effective operation of hydro power plants for water shortage in the future.

A: Solar and wind power have limits in the operation. The optimal introduction of solar and wind power was considered. Potential of water resources can not be estimated. The total development costs can be reduced by shifting partially electricity from base to peak to constrict the peak electric source.

Q: Does the generation development plan link to the demand forecast and system plan?

A: Yes, the generation development plan was prepared on the basis of the demand estimated by JST. The generation development plan sets up the development volume of each power plant and locations, which prepares the system plan.

Q: Is an import scenario prepared in the generation development plan?

A: Self-sufficiency is a basic premise. Scenarios depending on import are not considered.

Q: Will Japan develop nuclear power generation in large by 2030.

A: Japanese electric power companies aim to gain the approval form the government and resume the operations by 2030.

System Operation & Transmission Development Plan

Q: According to the master plan, control areas should be set up in Mozambique. How to operate?

A: It is important that Mozambique should adjust and control the electric-generating capacity by itself in the future. EDM recognizes this situation and plans a dispatching center

Q: Some mines with poor electricity conditions use private generators. Are the generation and system plans considered local counter measures for these demands?

A: Large scale customers include these mins in the demand forecast. The system plan should assure the electric quality on the basis of the demand.

Distribution Development Plan

Q: The proposed multi-transformer system is available in urban areas. How about rural areas where the demand is not high?

A: The availability depends on the progress of electrification, demand density and scale. Considering increase in the demand in the future, the multi-transformer system have the potential to introduce in rural areas.

Q: Could you propose reduction measures of non-technical loss to us?

A: SIGEM project by World bank contend with the reduction measures of non-technical loss. Moral improvement is one of the reduction measures in Japanese experience.

Economic and Financial Analysis

Q: Could you present the financial forecast by 2042.

A: The financial forecast is under considering regarding the conditions including the investment cost, foreign exchange rate and borrowing cost. After the analysis of these data with EDM, the draft results will be shared in the next meeting.

Q: Introduction of renewable energy would be promoted and developed by financial resources of donors. How do you think the renewable energy?

A: The supply forecast of renewable energy is based on the installation volume and unit tariff of EDM. The supply volume depends on government policy, movement of investors and limitation of distribution system. The unit tariff depends on the borrowing cost of investors, subsidy from government and expected interest. Using donor's resources will contribute to the development of renewable energy. The renewable energy will be considered in the financial analysis.

【News by Mass Media】

The seminar was reported by STV channel on the next day morning. The following comments of Chairman & CEO of EDM were informed.

"Mozambique aim to competitive and sufficient energy supply for domestic industry. The power generation will increase 8 times of present 900 MW in 2042. This power generation will dramatically change the national condition. 20 ~ 40 % of the generation can be exported."

A English news (Club of Mozambique Facebook) reported the following statements of Minister of MIREME

- Require EDM to enhance power generation and export to SADC
- The master plan will be confer a benefit on the citizens through wide-range energy developments.
- Mozambique aim to become worldwide power bases besides for south African nations.
- The master plan will contribute to the national economic balance and domestic industries.
- The master plan should suggest the project priority, conditions of private electric power companies and feasibility.
- The master plan should consider development of human resources.

Title	3rd Seminar
Date and Time	Monday, 4th December, 2017, 8:30 ~ 13:15
Venue	VIP Grand Maputo Hotel Pungue Room
Attendance	122

The 3rd seminar was held with 122 attendances including Minster of MIREME, Vice Minster of MIREME, Chairman & CEO of EDM, Ambassador of Japanese Embassy, staffs of EDM (86), relevant members of MIREME (18), World Bank, KfW. Local mass media also attended the seminar.

Opening remarks were made by Chairman & CEO of EDM and representative in JICA Mozambique office. Keynote speech was made by of Minster of MIREME. The study team explained the study results of 1. Demand Forecast, 2. Generation Development Plan, 3. System Operation & Transmission Development Plan, 4. Distribution Development Plan, 5. Economic and Financial Analysis and 5. Environmental and Social Consideration.

・8:30 ~ 8:50　Address by Chairman & CEO of EDM and JICA Representative in Mozambique Office
・8:50 ~ 9:00　Opening Session by Minister of MIREME
・9:00 ~ 9:10　Explanation of Outline of Master Plan by JICA Team Leader
・9:10 ~ 11:40　Explanation of Outline of Study Results by JICA team and JST (Including Coffee Break)
・11:40 ~ 13:15　Question and Answer

The 10 participants had questions in the question and answer session. The main questions and answers are as follows:

<u>Generation Development Plan</u>

Q: Were future plant locations considered gas pipelines proposed the gas master plan?

A: The gas master plan did not mention the concrete locations. The generation development plan did not fix the concrete plant location. After the pipelines concretize, the locations of plants will be revised.

Q: Are there any organizations such as ENH in the generation development plan?

A: To achieve the generation development plan on schedule, appropriate allocation of gas will be required.

Q: How much is coal generation in stage 1 and 2? The coal generation in stage 2 is less than one in stage 1, isn't it?

A: The coal generation will be 650MW in stage 1 and 1,300MW (900+400) in stage 2.

System Operation & Transmission Development Plan

Q: International system operation (Malawi and Tanzania) wasn't referred in the plan, was it?

A: The system figure after 2022 in the plan includes Malawi line in 2021, Tanzania line in 2026 and Caia-Nacala line in 2022.

Q: Does the transmission planning include substation development plans?

A: The transmission planning includes substation development plans and their costs to satisfy increasing demand and N-1 standard.

Q: O&M of distribution facilities isn't referred in this study, is it?

A: This study does not include the O&M.

Distribution Development Plan

Q: Why did the distribution plan include transmission substations described as SE1 and SE2?

A: The distribution sector collects information of the demand at first and considers the load switching between substations. If the load switching is insufficient to avoid over operating rate, the distribution plan cooperates with the transmission plan for concrete substations. It is important that the distribution sector formulates the basic substation development plan.

Q: Should other provinces be prepared in addition to Maputo city, Maputo province and Nampula province

A: The 3 areas were prepared according to the TOR. However, because JICA team and the counterparts prepared these plans, the counterparts can prepare plans of other areas using same methods by themselves.

Q: Request considerations for reduction of distribution losses.

A: Under consideration. We proposed multi-transformer systems in the last seminar to reduce the losses. Decentral transformers can shorten length of low voltage lines and reduce the losses. Please refer to our repot for the details.

Economic and Financial Analysis

Q: Hoe many years is the assumed return of investment?

A: Hydro power projects are 40 years. Thermal power projects are 25 years. Transmission line projects are 30 years. Distribution projects are 25 years.

Q: Will the development plans implement on schedule? How about possibility of investment?

A: Some development plans of EDM leave something to be desired. More detailed studies on the implementation permission, financing and procurement should be required. Investment environment for private sectors should be enhanced. That is a future task. The possibility of each project will be considered in future years.

Q: To realize, are business models needed?

A: This master plan is to overview the long-term ideals during 25 years, not for the feasibility of each investment project. Each project abounds in tasks to be considered in planning. Considerations and formulation of implementation plans are important. The business models should be prepared in the considerations.

Environmental and Social Consideration

Q: What standard does the emission factor refer to?

A: Referring to Several data including INTERNATIONAL ENERGY AGENCY, a standard of Japanese study result was adopted.

Q: How to be recovered impacts of coal thermal plants on agriculture?

A: Specific impacts and mitigation measures of each project will be considered in the feasibility study and environmental impact assessment.

Chapter 11 Technical transfer through Master Plan Study

11.1 Technical transfer by On-the-job training to counterparts

11.1.1 Demand forecast

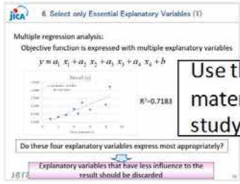
On-the-job training was conducted through the cooperative work focusing on processes so that counterparts of EDM and MIREME will be able to conduct demand forecast by themselves after this master plan study is over. Figure 11.1-1 shows the flow. Furthermore, technical transfer was conducted with manual which was created during this study. It is expected that they will forecast demand continuously with the manual and know-how they got during this study.

Explanation of procedure and outline of demand forecast

↓ Make them have image to create by themselves

Explanation of the importance of the necessary data

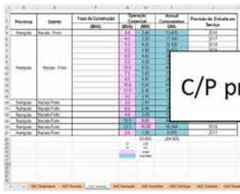
↓ C/P can collect proper information by themselves thanks to the well understanding



Use the dedicated material for the study

Data collection (Cooperate work however C/P has initiative)

↓ C/P can easily update from next year because they could collect mainly.



C/P prepared

Data analysis and Demand forecast
JICA Study Team has initiative and progress is confirmed frequently

↓ Much more proper demand forecast is prepared

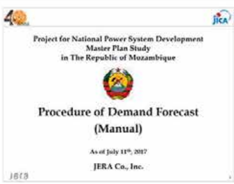
Cooperate presentation in the seminars

↓ Independence of mind emerges.

Team leader , Mr. Iazalde Jose

Establishment of Demand forecast knowledge
(Retry using manual by C/P)

Technical transfer
(Training)



Source: JICA Study Team

Figure 11.1-1 Technical Transfer through Cooperate Work (Demand forecast)

11.1.2 Generation Development Plan

Technical transfer for generation development plan was conducted regarding concept of Least Cost Method, consideration about introduction amount of PV and Wind power, and simulation tool “WASP”. The details are mentioned below contents.

(1) Generation development planning with Least Cost Method

For the planning with Least Cost Method, following contents should be studied by the planner.

- Future demand (Daily load curve and load duration curve)
- Specifications of generators (output, efficiency, operational life, major maintenance period, fuel consumption, etc.)
- Future fuel procurement (potential primary energy and fuel cost)
- Characteristics of the cost of each generator (Construction, O&M cost and annual production cost)
- Influence of the output solar & wind power to power system (daily span, short span and needed operating reserve to absorb fluctuation of solar and wind power)
- Calculation method of total generation cost (basic knowledge such as interest during construction and capital recovery factor, evaluation using screening analysis, etc.)
- Potential for the development of each generator and development area

In the technical transfer, necessity for collecting the operation data and how to collect the data are explained.

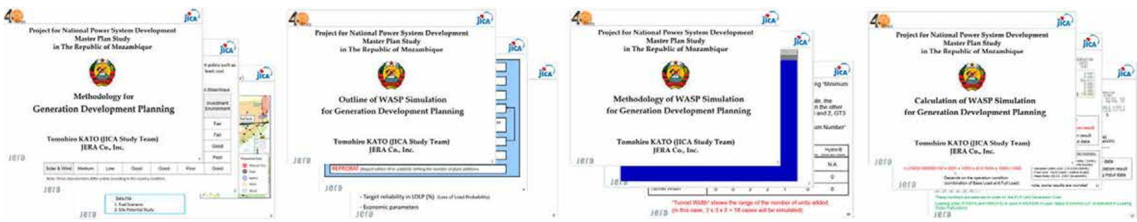
(2) Explanation about the data for the planning

Necessity data for generation development planning including for WASP simulation are calculated and marshaled with Excel sheet. calculation method and calculated results in each content shown above (1) are explained with the sheet.

(3) Simulation of generation development with WASP simulation tool

Technical transfer with WASP simulation by JST members are conducted. For the simulation, not only official manual but also original manuals are proposed. In the transfer, how to use the tool and calculation method in WASP simulation are explained.

For the master of general simulation tool, it is very important not only to understand how to use the tool but also to evaluate the simulation result by himself. It will be also hopeful for a planner to learn the simulation tool by trial and error, and become the master enough to estimate a result before simulation with the tool.



Source: JICA Study Team

Figure 11.1-2 Technical transfer documents for generation development plan

11.1.3 Power system plan

Technical transfer about power system plan was conducted as follows;

(1) Demand estimates method for distribution substation utilizing result of demand forecast

Substation demand until 2042 was calculated based on maximum demand of existing substations. Each substaion demand was typified by zoning characteristic using growth rate of province demand calculated by Demand Forecast JST, and it was adjasted that sum of each substation demand was equal to total demand of Mozambique. In addition, power system plan was made considering development of new/additional substation in case existing substation capacity was overload, and new/additional substation was basically set up two tranformer which capacity is 40MVA. Thus, power system plan was made to meet N-1 citeria in 2022. Power system plan was also made considering tranformer lifetime which was set 30 years and was to be rplaced in case transformer operation period exceeded 30 years.

(2) Future power plant location considering primary energy potential

Location of power plant which is not identified in the generation development plan was fixed for concretization of project which is necessary to create considering generaiton development plan, Locaation of power plant was discussed and selected with Generation Development JST and System Planning JST considering potential and possibility of energy source such as natural gas, coal, hydro, solar, and wind, and also considering location of existing and future transmission line.

(3) System planning considering profress of demand forecast, generation development plan, and system expansion plan

Power system plan until 2042 was reflected considering demand forecast and generation development plan including above two contents, and latest progress of system expansion plan which was confirmed by System Planning JST and project managers.

11.1.4 Distiburtion development plan

Technical transfer for distribution development plan was conducted regarding loss reduction measure, loss calculation method, and expansion planning method for distribution substation. Study Team and counterparts collaorated on presentations at JCC and Seminar for promoting understanding and fostering counterparts' initiative.

(1) Reduction measures of distribution loss and calculation method of distribution loss

Multi-transformer system was inducted one of the distribution loss reduction method focusing on low voltage line was laid long distance beyond the norm for EDM (500m).

It is necessary for calculation of distribution loss to obtain the data such as length and width of line, number of customer, and capacity of customer. Therefore, it was promoted to understand the calculation method with practicing calculation of distribution loss using Excel sheet. It was also explained that data of length and width of line, number of customer, and capacity of customer were needed to be properly managed in the future.

(2) Expansion planning method for distribution substation

It is necessary to make expansion plan for distribution substaion, such as new substaion plan, expansion of transforemer, mobile transformer, and so on, whcih is considered distiburion line extension and supply reliability. Distirbution development plan until 2022 was jointly made by idnetifiable manner at a time which is able to confirm each year's demand, availablitiy of each transforemer, and necessity of countermeasure. It was explained that detailed expansion plan was able to make comparnng between annual actual maximum load and demand which was used for expansion plan.

Source: JICA Study Team

Figure 11.1-3 Technical transfer through cooperate work (Distribution development plan)

11.2 Training in Japan

Training in Japan was conducted from May 14 to May 27, 2017. In the training, trainees visited sites to see the actual state of operation of electric power facilities with advanced technologies and learn about ecperience and knowhow for facility maintenance and operation accumulated by an electric supplier as well as knowledge of electric power business management and human resource development that contributes to the management of EDM. Explanation about advanced technologies and superiorities, and opinion exchange about formulation of electric power and energy planning were also conducted. Training schedule is shown in Table 11.2-1. Examples of training in Japan are shown in Figure 11.2-1.

Table 11.2-1 Training schedule

Date	Type	Time	Content
May 14 (Mon)			Arrive at Tokyo
May 15 (Tue)	Lecture & Site Visit	Morning	Orientation Lecture: Electrification in Japan
		PM(1)	Discussion about Electricity in Mozambique and Japan
		PM(2)	Site Visit: Organization for cross-regional coordination of transmission operators (OCCTO)
May 16 (Wed)	Lecture & Site Visit	PM(1)	Site Visit: Futtsu thermal power plant (TEPCO)
		PM(2)	Lecture: Thermal power technology and enveironmental measures
May 17 (Thu)	Lecture	All day	Technology fair by Japanese manufacturers
May 18 (Fri)	Lecture & Site Visit	AM	Lecture: Outline of JERA Construction and maintenance of substation
		PM	Site Visit: Central load dispatching center (TEPCO)
May 19 (Sat)	Day-off		Day-off
May 20 (Sun)	Day-off		In the evening move to Nagoya
May 21 (Mon)	Lecture & Site Visit	AM	Lecture: Transmission network planning
		PM	Site Visit: Higashi Nagoya Substation (CEPCO)
May 22 (Tue)	Lecture & Site Visit	All day	Site Visit: Human resource development center (CEPCO)
May 23 (Wed)	Lecture & Site Visit	AM	Site Visit: Nishidaira hydro power plant (CEPCO)
		PN	Site Visit: Tokuyama hydro power plant (CEPCO)
May 24 (Thu)	Lecture	All day	Action plan presentation Evaluation meeting
May 25 (Fri)			Leave for Mozambique

Source: JICA Study Team

(a) Lecture: Electrification in Japan

(b) Site tour: Futtsu thermal power plant

(c) Site tour: Central load dispatching center

(d) Site tour: Higashi-Nagoya Substation

(e) Lecture: Construction and maintenance of substation

(f) Site tour: Human resources development center

Source: JICA Study Team

Figure 11.2-1　Training in Japan

Chapter 12 Technical assistance in order to realize the electric power master plan

12.1 Background

Following technical assistant are proposed in order to revise the Master plan study periodically by EDM.

12.2 Proposed assistance

12.2.1 Technical support to formulate the Electric Power Master Plan.

Technical support will be provided in the form of a) long term JICA expert assigned to EDM as an in-house consultant or b) Additional JICA study team assignment to follow up this master plan study.

a) Electric power planning and policy advisor (JICA long term expert)

A long term JICA expert in the field of power planning and power policy will be assigned to EDM as an in-house consultant and give advice on electric power planning and policy making. Electric power Master plan should be revised periodically by using the latest information such as demand forecast, power development policy, power interchange with neighbor countries, investment climate, etc.. The expert will help EDM in revising the Master Plan technically and politically.

The expert will be in charge of coordination work between EDM and related agencies such as MIREME, FUNAE, Finance Ministry and donor agencies.

The expert will be assigned to EDM for two (2) years. Short term expert(s) in the specified fields will be assigned for around one month, if necessary.

b) Additional JICA study team assignment

An additional JICA Study team will support EDM in revising the Master Plan periodically by using the latest data and information of demand forecast, power development policy, power interchange with neighbor countries, investment climate, etc,. The team will be in charge of coordination work between EDM and related agencies such as MIREME, FUNAE, Finance Ministry and donor agencies.

The team will consist of five (5) experts of team leader/power development, power generation expansion plan, transmission plan, rural electrification and economic/financial analysis. The project term will be 2 or 3 years and needs 20M/M.

12.3 Rural electrification Master Plan

Rural electrification is one of the most important national policies. Although a target of universal access is set up, there are no practical access to achieve the target. Basic data and information is necessary to establish rural electrification planning. The master plan will include ① study of rural electrification status, ② rural electrification policy, ③rural electrification planning, ④development organization and institution, ⑤financial arrangement, ⑥donor agencies, etc..

The project term will be 2 years and needs 80M/M including local consultant.

12.4 Investigation of measures of distribution loss reduction

Following technical services are proposed;

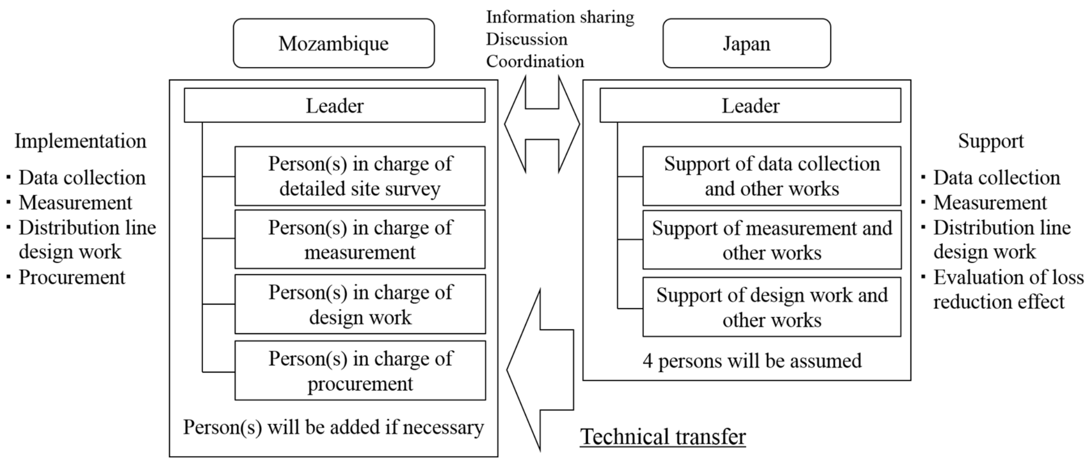
・Selection of pilot area (urban and rural area)

・Technical transfer of skills and know-how regarding measurement methodology of distribution line data (voltage and current etc.), distribution design work and so on.

・Evaluation of loss reduction effect

In case of nationwide expansion of multi-transformer system, Japanese financial assistance(ODA Loan) can be used. EDM will be in charge of site survey, data collection, distribution line design work and so on, so that EDM can accelerate loss reduction measures by themselves in the future. JICA study team supports their work as advisor which is shown in Figure 12.4-1.

This project term will be 2 years and needs 20M/M.



Source: JICA Study Team

Figure 12.4-1 Project implementation structure

12.5 Study of Energy Efficiency and DSM

To secure the energy security, increasing power station is not only the countermeasure but also the measure at the demand side. The latter one is to deal with existing facilities therefore its effect appears immediately and cost-effectiveness is high because electricity tariff is expected to increase from now on. In addition, there are other effects, which are installation cost reduction because of effective utilization of existing facilities, effective usage of energy and so on.

Following technical services are proposed;

① Idea of DSM established firmly (Thinking, Approach)

② Investigation of DSM activities in other countries (Developed counties including Japan, Newly Industrialized Countries, Developing countries)

③ Investigation of EDM activities

④ Investigation of legal system requested for DSM installation (ToU, Negawatt transaction platform, and so on)

⑤ DSM installation study and evaluation of its quantitative effect

Besides that, training in Japan will be held and participants are expected to learn effective DSM activities in Japan (Electric power company's activities, Legal system, Energy efficient facilities, Energy management and so on) and enhance their understanding. This project term will be about 2 years and needs about 20M/M.

12.6 Technical cooperation for power system operation

Currently NCC, National Control Center, operates her power system without formalized code(s), such as system operating guideline in EDM. To prepare and tackle the operation for future system where will expand nationwide, it is necessary to establish formal rules and specific instructions. It helps not only EDM's system operators to improve their working duties but also EDM to upgrade her enterprise governance.

This project terms will be about 1.5-year and needs 15MMs.