Ministry of Energy (MoE)
Tanzania Electric Supply Company Ltd. (TANESCO)
The United Republic of Tanzania

DATA COLLECTION SURVEY ON DODOMA TRANSMISSION AND DISTRIBUTION SYSTEM IN THE UNITED REPUBLIC OF TANZANIA

FINAL REPORT

MARCH 2020

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

YACHIYO ENGINEERING CO., LTD.
WEST JAPAN ENGINEERING CONSULTANTS, INC.

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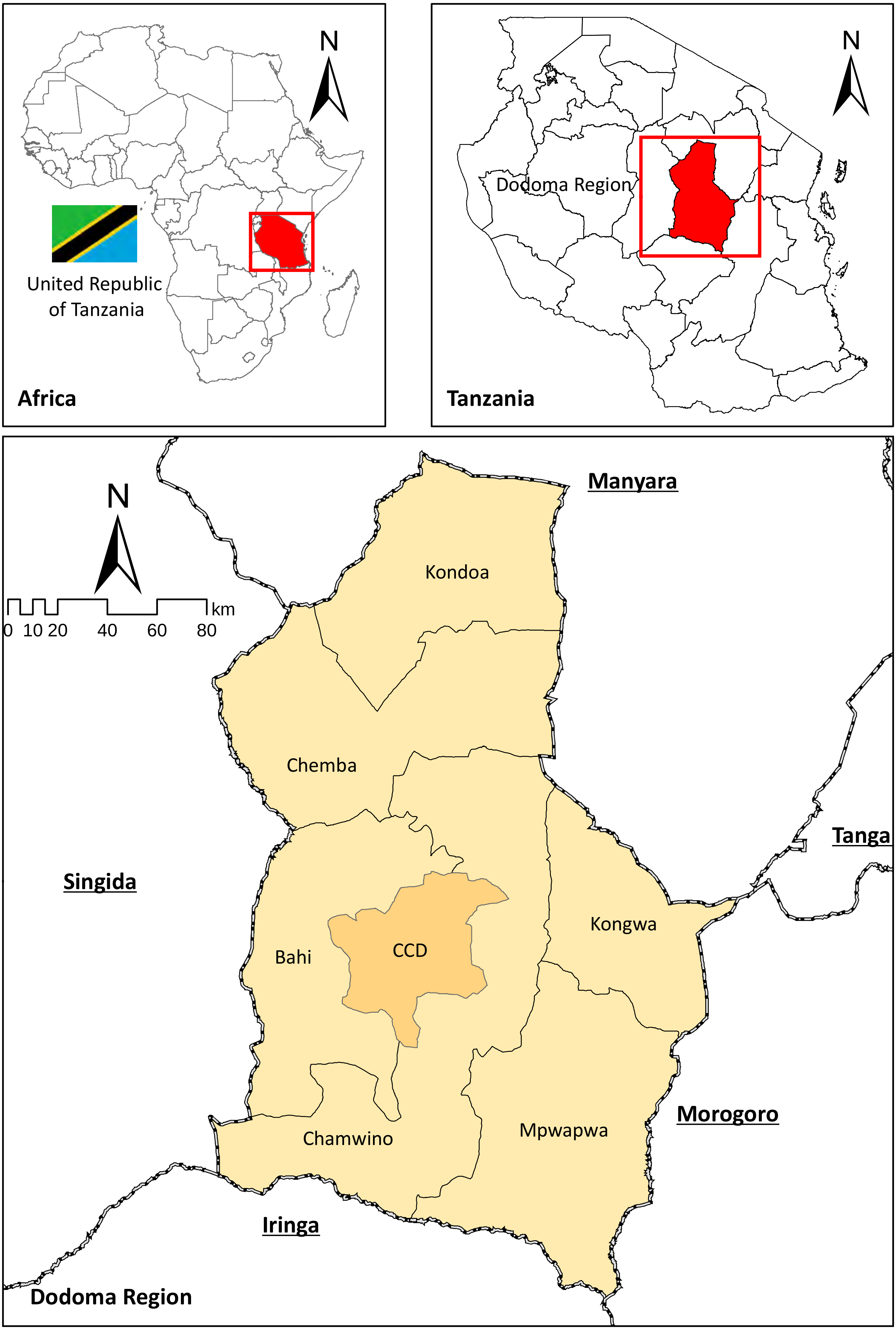


Location Map (Dodoma Capital City District(CCD))

Photo of the current situation in the survey area (1 of 3)

220/33kV Zuzu Substation (Switchgear)

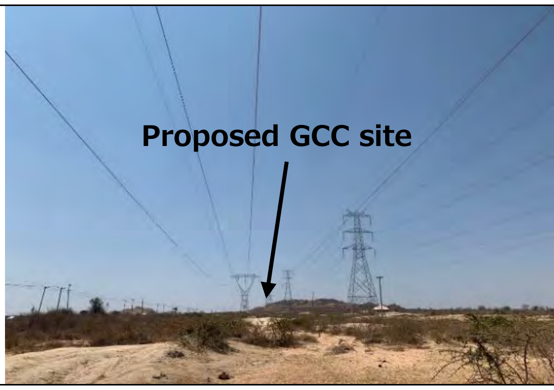
An existing core substation owned by TANESCO. Located about 6km west of Dodoma city center. 400kV transmission line has been completed as an international interconnection line, but it is operated at 220kV. 400 / 220kV substation has been constructed and will be in operation in 2020.

220/33kV Zuzu Substation (Control Room)

The control room of the existing core substation owned by TANESCO. 220kV control system and substation Automation (SAS) are Chinese manufacturer's equipment. When 220kV switchgear is added, it is necessary to ask the manufacturer for modification adjustment.

Transmission Lines around 220/33kV Zuzu Substation

Since the 400kV transmission line is arranged to surround the east side of the substation, it is necessary to pay attention to the transmission line route when constructing a new transmission line.



New GCC Construction Site

TANESCO will build a GCC in Dodoma and a backup GCC in Dar es Salaam. The proposed site is the location where a small hill intersects the transmission line from Zuzu Substation to Mtera and Iringa. A planned area of 300m x 900m has been prepared.

33/11kV Dodoma Town Substation (Switchgear)

A distribution substation adjacent to TANESCO's Dodoma regional office. Two 5MVA transformers (made in 1990) are installed to supply power to the center of Dodoma.

33/11kV Dodoma Town Substation (Control Room)

A control room of the adjacent to TANESCO's Dodoma regional office. The protection panels are old and outdated.

Photo of the current situation in the survey area (2 of 3)

33/11kV Mnadani Substation

A distribution substation located about 8km north of the center of Dodoma. It was built around 2012 with the assistance of MCA-T (USA). One 15MVA transformer (made in 2011) are installed. There has been a fire incident in the control room in the past, and some equipment remains burned.

33/11kV Mzakwe Substation

A distribution substation located about 25km north of the center of Dodoma. It was built around 2012 with the assistance of MCA-T (USA). An important substation with one 10MVA (made in 2011) to supply power to pump stations in the Mzakwe region.

Planned Construction Site
for New 220/33kV Ihumwa Substation

A substation planned to be built approximately 20km northeast of the center of Dodoma. Power supply to the Government City area is assumed.

Planned Construction Site
for New 220/33kV Kikombo Substation

A substation planned to be built approximately 30km east of the center of Dodoma. It was planned to supply power from the Kikombo substation to the Government City area.

Temporary Building of the Ministry of Energy

It is a temporary building of the Ministry of Energy, about 20km east of the center of Dodoma.

The Office for the Dodoma Capital City Master Plan

The building is owned by the Dodoma City Council and it was the office for the Dodoma Capital City Master Plan task force.

Photo of the current situation in the survey area (3 of 3)

Confirmation of Information at TANESCO's Ubungo Office

Before the interview at Dodoma, the level of TANESCO staff and JICA Study team confirmed the information required for the survey.

Presentation for TANESCO in the First Field Survey

Prior to the Technical Memorandum discussion, the study team made three presentations and explained the results of the study in Dodoma. After that the Technical Memorandum was signed between TANESCO and the study team.

Presentation for TANESCO in the Second Field Survey

The study team made several presentations and explained an overview of Draft Final Report and transmission development scenarios in Dodoma. After that the Technical Memorandum was signed between TANESCO and the study team.

Presentation for MoE in the First Field Survey

The study team made several presentations and explained an overview of Draft Final Report and transmission development scenarios in Dodoma.

List of Figures & Tables

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Abbreviations

AAAC	All Aluminum Alloy Conductor
ACSR	Aluminum Cable Steel Reinforced
ACSR/AC	Alumninum-Cable Steel Reinforced
ADSS	All Dielectric Self-supporting Cable
AFD	Agence françise de développement
AfDB	African Development Bank
AIS	Air Insulated Switchgear
AU	African Union
CCD	City Council Dodoma
CDA	Capital Development Authority
EPZ	Export Processing Zones
E/N	Exchange of Notes
F/S	Feasibility Study
GCC	Grid Control Center
GDP	Gross Domestic Product
GNI	Gross National Income
GRDP	Gross Regional Domestic Product
GIS	Gas Insulated Switchgear
GIS	Geographic Information System
H-GIS	Hybrid Gas Insulated Switchgear
IMF	International Monetary Fund
IPP	Independent Power Producer
JICA	Japan International Cooperation Agency
JPY	Japanese Yen
MOE	Ministry of Energy
MOFP	Ministry of Finance and Planning
MLHHSD	Ministry of Lands, Housing and Human Settlements Development

MWTC	Ministry of Works, Transport and Communications
ODA	Official Development Assistance
OPGW	Optical fiber composite overhead ground wire
PMO	Prime Minister's Office
PSMP	Power System Master Plan
R/D	Record of Discussions
SCADA	Supervisory Control And Data Acquisition
SGR	Standard Gauge Railway
TA	Technical Assistance
TANESCO	Tanzania Electric Supply Company Limited
TANROADS	Tanzania National Roads Agency
TARURA	Tanzania Rural and Urban Road Agency
T/M	Technical Memorandum
TOR	Terms of Reference
TRC	Tanzania Railways Corporation
USAID	United States Agency for International Development
USD	United States Dollars
VAT	Value-added tax
WB	World Bank

Chapter 1 Outline of the Survey

Chapter 1 Outline of the Survey

1-1 Background of the Survey

In Tanzania, economic development has progressed since independence with Dar es Salaam as its capital. However, relocation of the capital to Dodoma was decided in 1973. In 1996, the capital was officially relocated to Dodoma, although Dar es Salaam still remains as the center of social and economic activities at present, with strong economic growth still maintained.

The Dodoma National Capital City Master Plan was formulated in 1976 and approved by the Tanzanian government. However, the government reviewed the master plan in 1988 and 2010 but did not officially approve the review results. Under such circumstances, the first draft of the 20-year master plan from 2019 to 2039 was formulated in December 2018. According to the Proposed Land Use agreement for Dodoma Urban shown in Figure A-3 at the beginning of the document, outer, middle and inner ring roads are planned to surround the center of the urban area. In addition, international airport, industrial zone, government offices, etc. are planned.

President Magufuli, who was elected in November 2015, considers the transfer of government functions to the capital Dodoma as one of the most important policies. He is aiming for a complete transfer of government functions by the year 2020. Therefore, the final review of the previous master plan, government approval, and investment promotion for the realization of the master plan is highly expected.

The second draft report of the Dodoma National Capital City Master Plan study (2019-2039) produced in April 2019 reports Dodoma's actual power demand at 31.0MW recorded in March, 2019.

The Tanzania Electric Supply Company Limited (TANESCO) predicts the electricity demand for 30 years from 2018 to 2047. According to this demand forecast, the demand in 2047 is estimated at 307.1MW (about 10 times of the recorded actual power demand) due to transfer of capital functions.

Currently, all ministries have completed the transfer of their headquarters to Dodoma, as the size of the Dodoma city continues to expand rapidly. In the master plan, it is reported that it will be necessary to supply power to essential loads such as the newly built presidential palace, government offices and new airport. In order to ensure the quality and reliability of electric power supply, a transmission and distribution network expansion plan in the Dodoma urban area is investigated by TANESCO.

1-2 Outline of the Survey

1-2-1 Objectives of the Survey

The Survey has the following objectives:

(1) To confirm the details of the Dodoma National Capital City Master Plan, the status of existing facilities, and related donor trends,

(2) To analyze and investigate the current and future power demand and the applicability of Quality Infrastructure,

(3) To consider JICA's cooperation policy for Dodoma's transmission and distribution network expansion based on the result of the survey and discussion results with TANESCO.

1-2-2 Survey Site

The aim of this survey is to develop the power system of the Dodoma Capital City District (CCD), a target location for the complete transfer of government functions. However, since the survey includes information sharing with other donors and relevant authorities in Dar es Salaam, the Team conducted the survey in Dar es Salaam in addition to Dodoma.

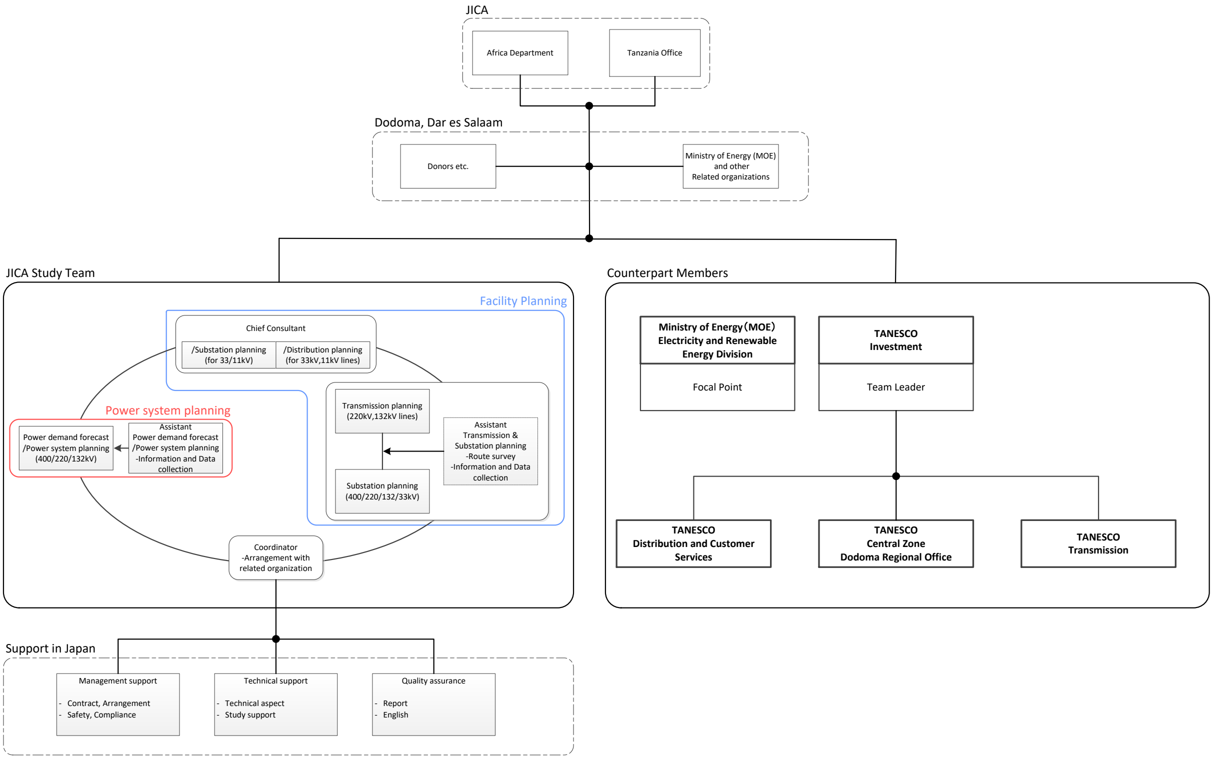
1-3 Structure and Work Plan of the Survey

1-3-1 Structure of the Survey

In order to conduct a proper survey, the Study team explained the background, purpose, and flow of the survey and requested nomination of counterpart members. The Study team requested TANESCO and the Ministry of Energy to nominate the counterpart and accompany the survey at the start of the survey. The Tanzanian side provided the convenience requested by the Study Team.

Since the scope of this survey covers the wide spectrum of power demand forecast to system planning and equipment planning, TANESCO formed a counterpart team, led by the Investment Department as the team leader, with Distribution and Customer Services department and Transmission department as team members. The survey was carried out with a great deal of support from the Counterpart team and the Dodoma regional office.

The actual structure of this survey is shown in Figure 1-3.1.



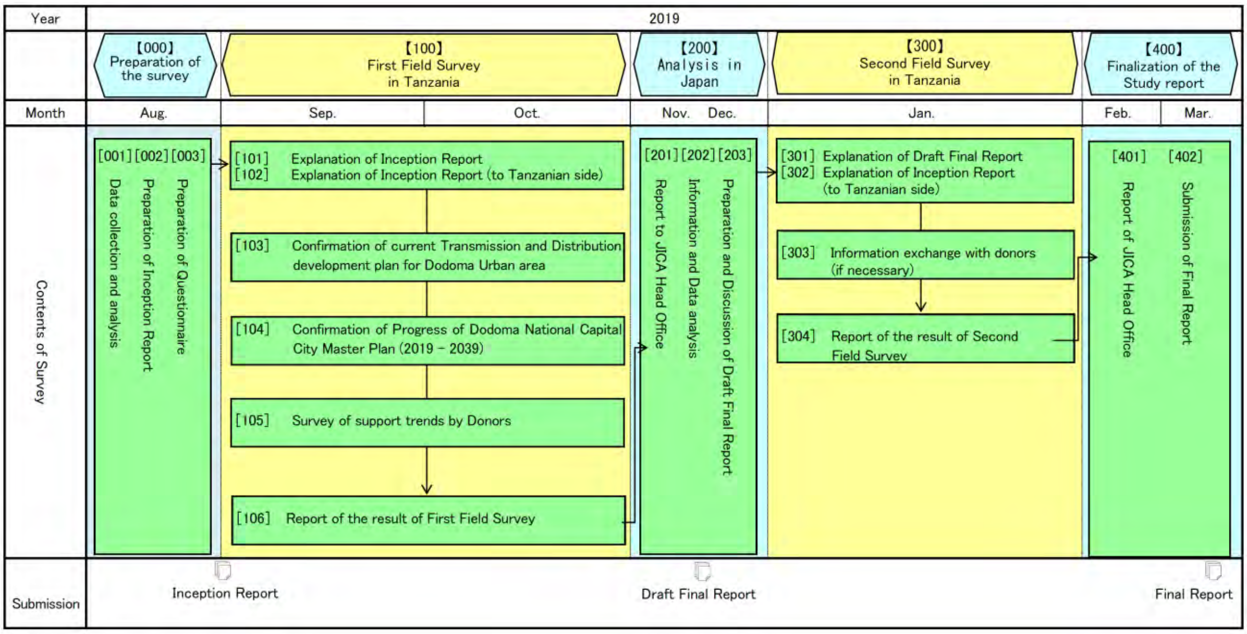
[Source] JICA Study Team

Figure 1-3.1 Structure of the Survey

1-3-2 Overall Work Flow

In addition to the survey analysis work in Japan, the Field Work was conducted twice in total. In the first field work in Dodoma and Dar es Salaam, interview with stakeholders was carried out including information gathering, field surveys, discussions with the Tanzania side, presentations from the Study Team, etc., and discussions on draft final report in the second field work. After that, the report was explained, discussed and finalized in Japan.

Figure 1-3.2 shows the overall work flow with schedule for the entire survey, including the work performed at each stage of the survey.

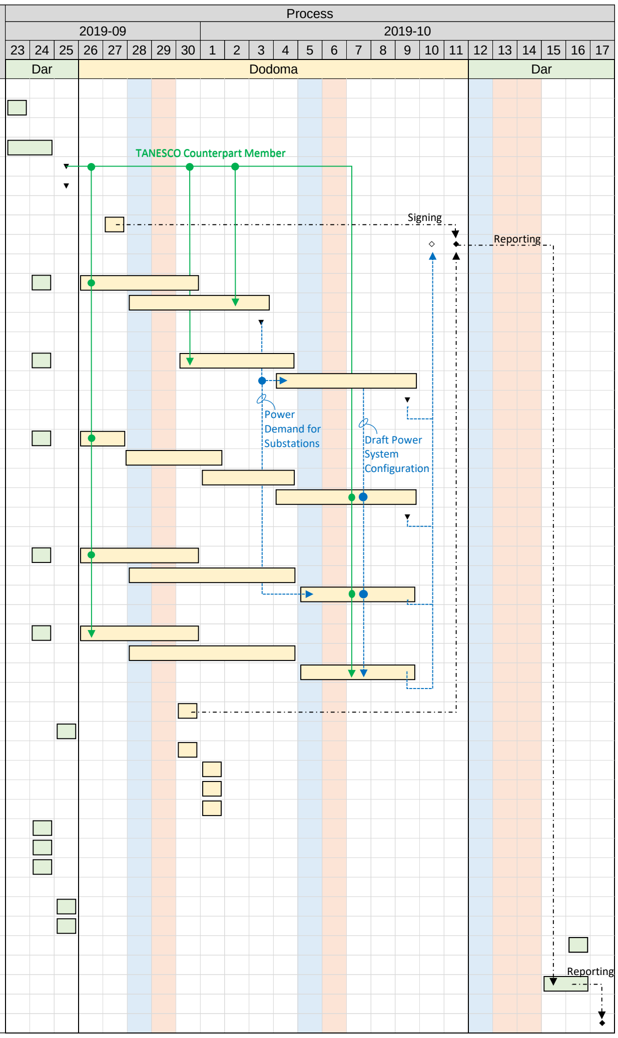


[Source] JICA Study Team

Figure 1-3.2 Overall Work Flow of the Survey

In addition, Figure 1-3.3 and Figure 1-3.4 show the detailed process of the work performed in the First Field Work and Second Field Work.

No.	Task	Objective
1	■ JICA Tanzania Office	
1-1	Inception Report, Schedule	To be discussed
2	■ Discussion withTANESCO(Ubungo)	
2-1	Inception Report, Schedule	To be agreed
2-2	Nomination of Counterpart members	To be nominated
2-3	Answers to the Questionnaire	To be submitted
3	■ Discussion withTANESCO(Dodoma)	
3-1	Inception Report, Schedule	To be agreed
3-2	Technical Memorandum	To be signed
4	□ Power Demand Forecast	
4-1	Technical Discussion with TANESCO	Provision of updated information
4-2	Power Demand Forecast for the Survey	To be agreed
4-3	Allocation of the Demand to Substations	To be proposed
5	□ Power System Planning	
5-1	Technical Discussion with TANESCO	Provision of updated information
5-2	Draft Power System Plan	To be discussed
5-3	System Configuration and Alternative	To be proposed
6	□ Transmission Plannign	
6-1	Technical Discussion with TANESCO	Provision of updated information
6-2	Pre-confirmation of the Line Route	Confirmation of conditions, etc.
6-3	Pre-consideration of the Line Route	Route study
6-4	Route Survey	Site Survey
6-5	Draft Line Route and alternatives if any	To be proposed
7	□ Substation Planning	
7-1	Technical Discussion with TANESCO	Provision of updated information
7-2	Survey for the existing substations	Site Survey
7-3	Review and Study for the existing plan	Review & Study
8	□ Distribution Plan	
8-1	Technical Discussion with TANESCO	Provision of updated information
8-2	Survey for the existing substations	Site Survey
8-3	Review and Study for the existing plan	Review & Study
9	■ Visit to Government, Authority, etc.	
9-1	Ministry of Energy	Explanation of the Survey
9-2	Ministry of Lands, Housing and Human Settlements Developments	Progress of Dodoma MP
9-3	Ministry of Finance and Planning (MFP)	Explanation of the Survey
9-4	Prime Minister's Office (PMO)	Progress of Dodoma MP
9-5	Dodoma Region	Progress of Dodoma MP
9-6	Dodoma District	Progress of Dodoma MP
9-7	Tanzania Railway Corporation	Progress of SGR
9-8	TANROADS	Progress of Road development
9-9	TTCA	Information exchange
10	■ Visit to Donors	
10-1	African Development Bank (AfDB)	Information exchange
10-2	World Bank (WB)	Information exchange
10-3	Agence française de développement (AFD)	Information exchange
11	■ Discussion withTANESCO(Ubungo)	
11-1	Progress of the Survey	Report & Discussion
12	■ JICA Tanzania Office	
12-1	Progress of the Survey	Report & Discussion



[Source] JICA Study Team

Figure 1-3.3 Work Process for the First Field Work

	Task	Objective	Process										
			2020-01						2020-02				
			26	27	28	29	30	31	1	2	3	4	5
			Dar		Dodoma				Dar				
1	■ JICA Tanzania Office												
1-1	Draft Final Report, Schedule	To be discussed		□									
2	■Discussion withTANESCO(Dodoma)												
2-1	Draft Final Report, Schedule	To be discussed			□	□	□						
2-2	Site Survey	Confirmation					□						
2-3	Technical Memorandum	To be signed						◆					
3	■ Visit to Government, Authority, etc.												
3-1	Ministry of Energy	To be discussed			□								
3-2	Ministry of Finance and Planning (MFP)	To be discussed				□							
4	■ Visit to Donors												
4-1	African Development Bank (AfDB)	Information exchange										□	
4-2	World Bank (WB)	Information exchange											□
4-3	Agence française de développement (AFD)	Information exchange											□
5	■ Discussion withTANESCO(Ubungo)												
5-1	Draft Final Report	To be discussed									□		
6	■ JICA Tanzania Office												
6-1	Progress of the Survey	Report & Discussion											□

[Source] JICA Study Team

Figure 1-3.4 Work Process for the Second Field Work

Chapter 2 Overview of Tanzania and Dodoma City

Chapter 2 Overview of Tanzania and Dodoma City

2-1 Social and Economic Overview

2-1-1 Politics

In October 2015, John Joseph Magufuli of the Tanzania Revolutionary Party (Chama Cha Mapinduzi, CCM) was elected as President, after the Presidential Election of the United Republic of Tanzania, with a five-year term mandate. After being elected as a Diet member in 1995, President Magufuli has served in various positions such as Deputy Minister of Works, Minister of Works (first), Minister of Lands, House and Human Settlement, Minister of Works (second). President Magufuli has made the transfer of government functions to Dodoma one of the most important policies, and it is expected to be completed in 2020. He also prioritizes Tanzania's industrialization, employment expansion and economic development.

After independence, the Government of Tanzania placed the support for the independence and liberation movements of neighboring countries at the center of the country's foreign policy, but after the independence of African countries and apartheid in South Africa, he has promoted economic diplomacy and strived to build wide relationships with foreign countries. In particular, with the aim of regional peace and stability, he is making efforts to promote stability in the Great Lakes region such as the Democratic Republic of the Congo and Burundi, dispatch PKO to Sudan, and counter piracy. He also plays a role in promoting the economic integration of the East African Community (EAC) and the activities of the Southern African Development Community (SADC).

In 1996, the legal capital was set to Dodoma, but the substantial capital function was in Dar es Salaam. Although the government office was also in Dar es Salaam at that time, the government office was then moved to Dodoma by October 13 the same year due to the recent trend of capital function transfer to Dodoma.

2-1-2 Social and Economic Overview

Tanzania is the largest country in East Africa, located in the eastern part of the African continent. It is an allied nation formed by the union of mainland Tanganyika and the island of Zanzibar in 1964, just after independence in 1961. Basic data for Tanzania is shown in Table 2-1.1. The population of Dodoma State is 2,083,588, from the 2012 census, and 2,492,989 in 2018 as estimated from the 2012 census.

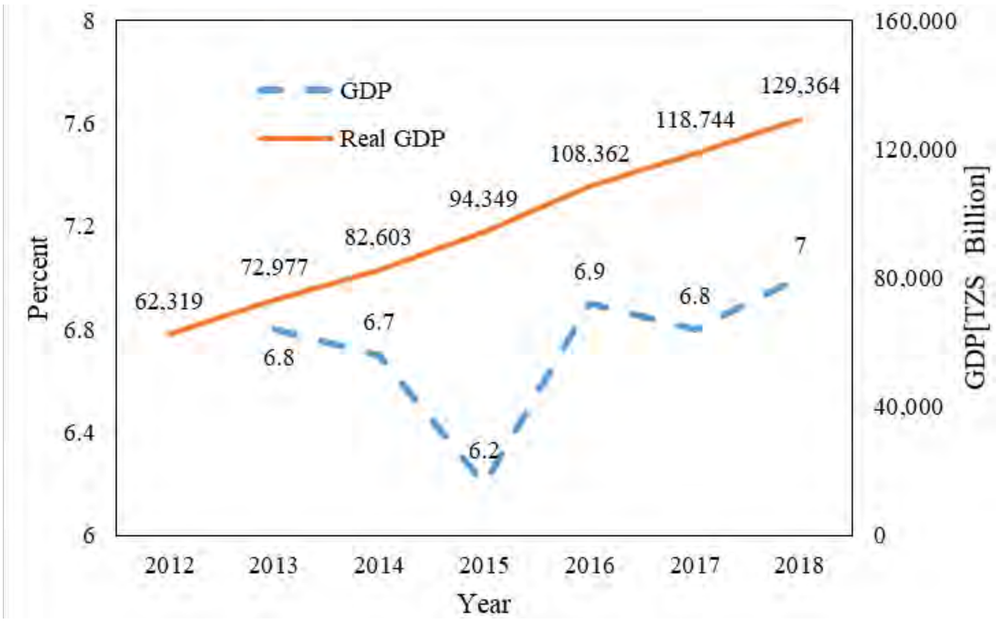
Table 2-1.1 Basic Data

Land Area	945,000 square kilometer (About 2.5 times of Japan)
Population	56,320,000 (2018, World Bank)
Capital	Dodoma
Ethnic Groups	Sukuma, Nyakyusa, Haya, Chaga, Zaramo etc. (About 130)
Language	Swahili (National Language), English (Common Language)
Religion	Islam (About 40%), Christianity (About 40%), Indigenous Religion (About 20%)
Currency	Tanzanian Shilling (TSH)
Exchange Rate	1 USD = About 2,295 TSH (January 2018)
Major Industries	Agriculture, Forestry and Fisheries: About 30% of GDP (Tanzania National Bureau of Statistics 2017) Mining / Manufacturing / Construction : About 26% of GDP Service: About 37% of GDP
Gross Domestic Product (GDP)	574 Billion USD (2018, World Bank)

GNI per capita		1,020 USD (2018, World Bank)
Economic Growth Rate		5.2% (2018, World Bank)
Price Increase Rate		4.0% (2018, World Bank)
Unemployment Rate		1.9% (2018, World Bank)
Trade Value (2018: Bank of Tanzania)	Export	5,146 Million USD
	Import	8,463Million USD
Major Trading Items (2018: Bank of Tanzania)	Export	Gold, Cashew Nut, Tobacco, Sisal Hemp, Coffee etc.
	Import	Petroleum, Machinery, Transportation Equipment, Building Materials etc.
Major Trading Partners (2017, World Bank)	Export	India, South Africa, Vietnam, Kenya, Switzerland
	Import	China, India, United Arab Emirates, Saudi Arabia, South Africa, Japan
Military Power		Budget: 528 Million USD Force of Arms: Total 27,000 (Army 23,000, Navy 1,000, Air Force 3,000) (Military Balance 2018)

[Source] Ministry of Foreign Affairs (https://www.mofa.go.jp/mofaj/area/tanzania/data.html#section1)

In terms of economics, socialist economic policies was promoted immediately after independence, but since 1986, with the support of the World Bank and the IMF, market economy and economic reforms had begun. Figure 2-1.1 shows the real GDP from 2012 to 2018 and the GDP growth rate from 2013 to 2018 in mainland Tanzania. The GDP growth rate is at an increasing level of 6-7%. In 2018, the GDP by industry is 30.7% for the primary industry, 29.1% for the secondary industry and 40.2% for the tertiary industry, with the tertiary industry tending to be slightly higher.



[Source] Tanzania in Figures 2018 (National Bureau of Statistics)

Figure 2-1.1 GDP Growth Rate

2-2 Geography and Climate

2-2-1 Geography

Tanzania is located in the eastern part of the African continent and faces the Indian Ocean as shown in Figure 2-2.1. The land area is 940,000 square kilometers, of which Dodoma occupies about 40,000 square kilometers. Tanzania borders Kenya, Uganda, Rwanda, Burundi, Zambia, Malawi and Mozambique, and the Democratic Republic of Congo that is on the other side of Lake Tanganyika. Seven sites such as Ngorongoro

Conservation Area, Serengeti National Park and Mount Kilimanjaro are recognized as World Heritage Sites.

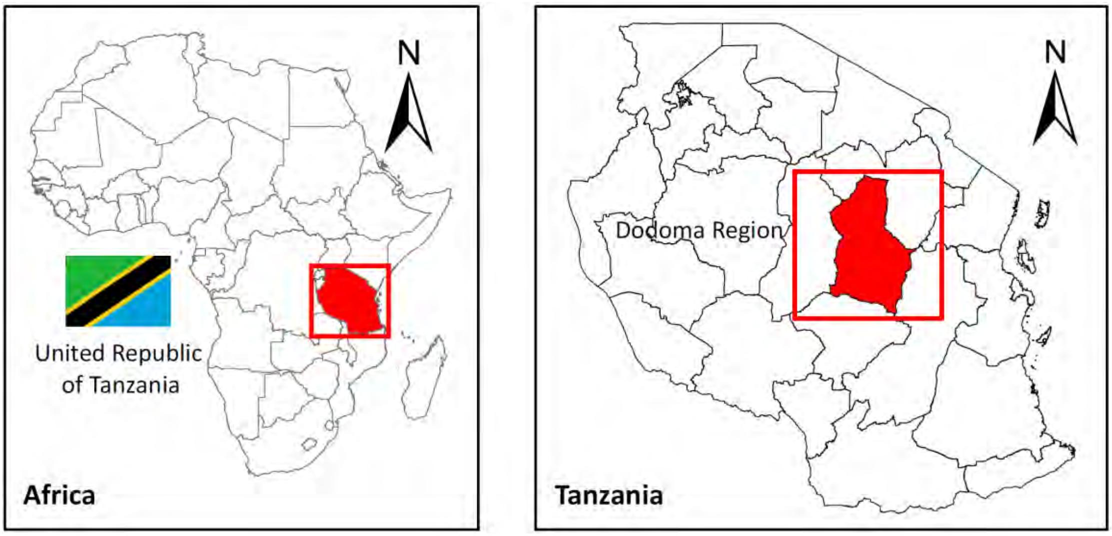
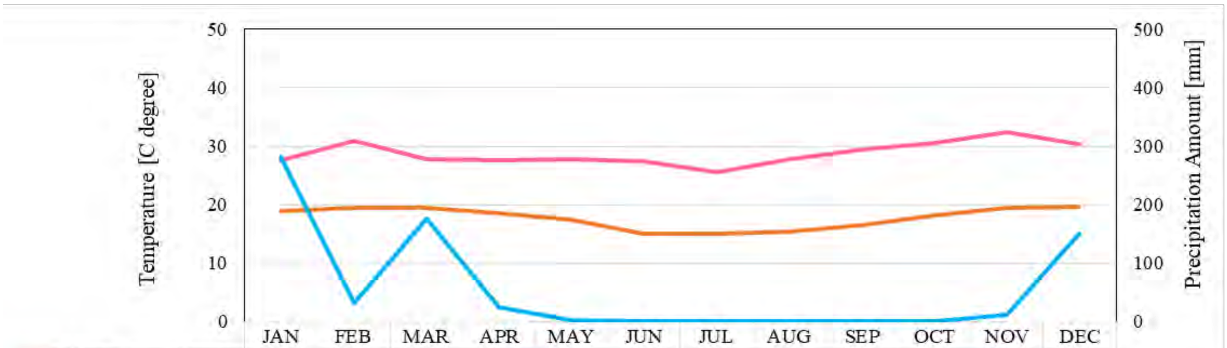


Figure 2-2.1 Map of Africa and Tanzania

2-2-2 Climate

Tanzania is located just below the equator, the coastal lowland has a hot and humid tropical climate, the central plain has a savanna climate, and most of the country is a plateau of 1,000 to 2,000 meters. December to March is the rainy season, while other season is the dry season.

Monthly change in Dodoma's meteorological data for 2018 is shown in Figure 2-2.2. The average maximum temperature is around 30 degrees Celsius, while the average minimum temperature is around 18 degrees Celsius. The temperature does not change much throughout the year. On the other hand, with regard to precipitation, the difference between the rainy season and the dry season tends to be large.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max. Temperature	27.7	30.9	27.8	27.7	27.8	27.4	25.6	27.8	29.5	30.6	32.5	30.3
Min. Temperature	19	19.5	19.4	18.6	17.4	15.1	15.1	15.4	16.6	18.1	19.5	19.7
Precipitation Amount	282.3	32.6	176.2	24.2	2.9	0	0	0	0	0	11.3	149.8

[Source]Tanzania Meteorological Agency

Figure 2-2.2 Monthly trend of Dodoma weather data (2018)

2-3 Current Status and Challenge on Government Function Transfer and Capital Development to Dodoma

2-3-1 Progress of Transferring the Government Functions

Although Dodoma was enacted as the Capital City of Tanzania in 1973 by the President, Julius Nyerere with Presidential Declaration No.320, due to various difficulties, the substantial capital functions were not transferred from Dar es Salaam.

President Magufuli who assumed office in 2015, declared in 2016 that the transfer of government functions to the Capital Dodoma was one of the most important policies, and that the capital functions would be transferred to Dodoma by 2020. Following the declaration, the Prime Minister’s Office was officially relocated in September 2016, the Vice President Office was officially relocated in December 2017, all ministries were transferred to temporary offices in Dodoma by April 2019 and the President’s Office was finally relocated to Dodoma in October 2019. In the future, related agencies and government corporations will also be relocated.

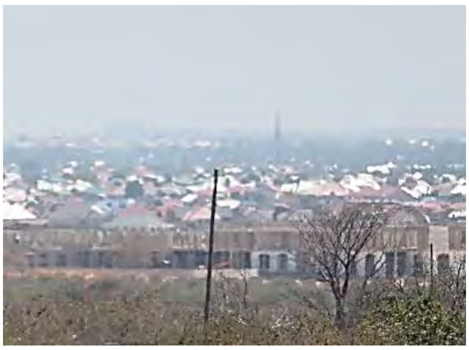
2-3-2 Expansion of Urban area and Infrastructure Development

As a result of discussions with the Dodoma municipality development department, the development plan of large-scale facilities was clarified. The development plan is shown in Table 2-3.1.

Table 2-3.1 Planned large scale facilities and target year

Development area	Planes large scale facilities	Target year
North area	Msalato international airport	2019-2024
	Msalato EPZ	—
Western area	Nala industrial area	—
Central area	National stadium	2019-2024
	Dala Dala bus terminal	—
	Nane Nane market	2019-2024
	Intercity bus terminal	2019-2024
	TPDF Quarters	—
Eastern area	Government city	2019-2029
	Marshaling yard	With regards SGR Development
	Presidential Place	2019-2029
	Dry Port	

[Source] Dodoma municipality

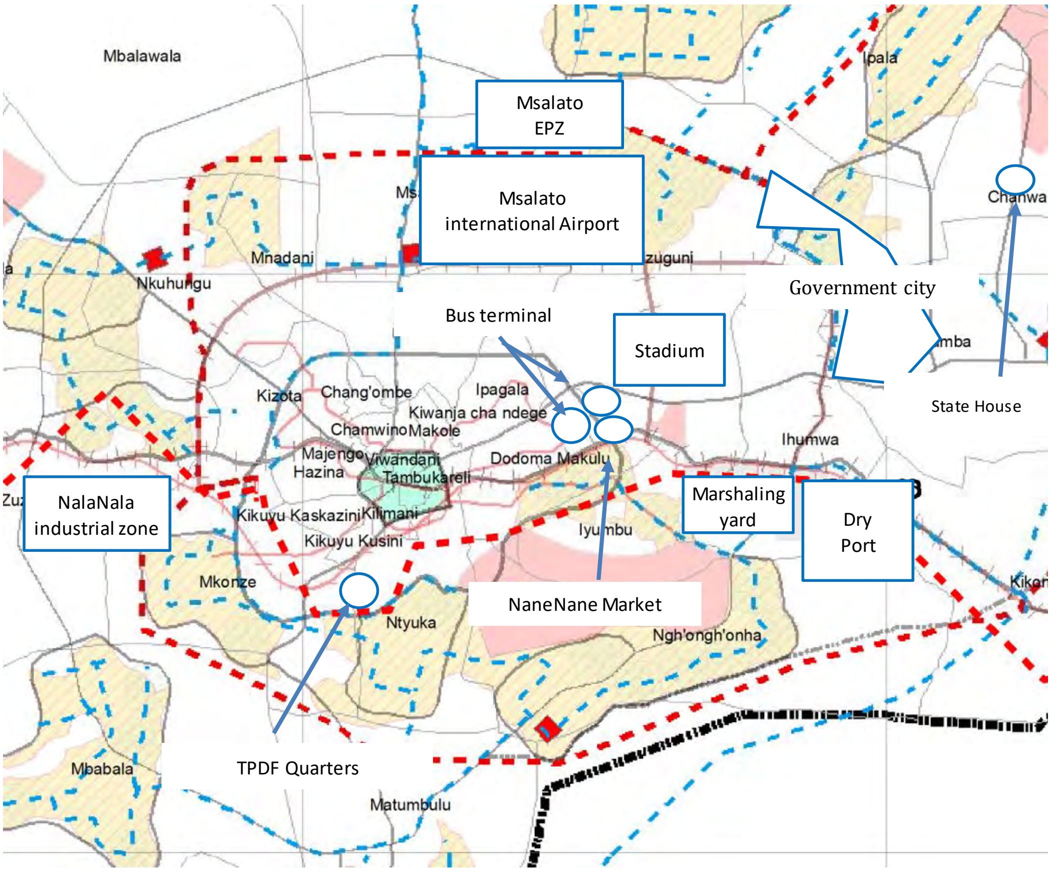


Intercity bus terminal (under construction)

Ministry of Energy(Ihumwa area)

	
Government city(Ihumwa area)	Msalato international airport(Planned area)

[Source] JICA Study Team



[Source] Dodoma municipality

Figure 2-3.1 Planned large scale facilities

2-4 Overview of Dodoma National Capital City Master Plan (2019 – 2039)

2-4-1 Overall plan for Dodoma Capital City Master Plan

Originally, Dodoma Master Plan was formulated in 1976, and leading the comprehensive National Capital City Master Plan for 20 years from 2019 to 2039 is a review of past master plans by a government led by task force team. The first draft was created in December 2018. The task force team then completed an updated second draft by April 2019.

The JICA Study Team conducted interviews with the director of the Ministry of Lands, Housing and Human Settlements Developments, the working-level of Dodoma City Council, and the task force team working on the formulation of master plan to obtain the contents of the master plan. .

Public hearing is being conducted based on the second draft mentioned above during the interview (as of October 2019). Even though, by the end of November, the master plan would be revised to reflect the results of public hearing and approved by the government of Tanzania, final confirmation from the Tanzania side has not been done yet.

The Dodoma National Capital City Master Plan is composed of 10 technical supplements (TSs) in addition to the main body, and development plans for each field are proposed.

TS-1 : Demography, Housing and Residential Characteristics
TS-2 : Earthquakes and its Implication on Built Environment
TS-3 : Infrastructure and Public Utilities
TS-4 : Transportation Infrastructure and Services
TS-5 : Landscape Improvement Plan
TS-6 : Capital Business District Redevelopment Plan
TS-7 : Government City Planning
TS-8 : Impact Region Study
TS-9 : Strategic Environmental Assessment (SEA)
TS-10 : Implementation Arrangement and Strategies

Regarding the transmission and distribution development plan, TS-3 outlines the load demand forecast, transmission, substation and distribution plans as well.

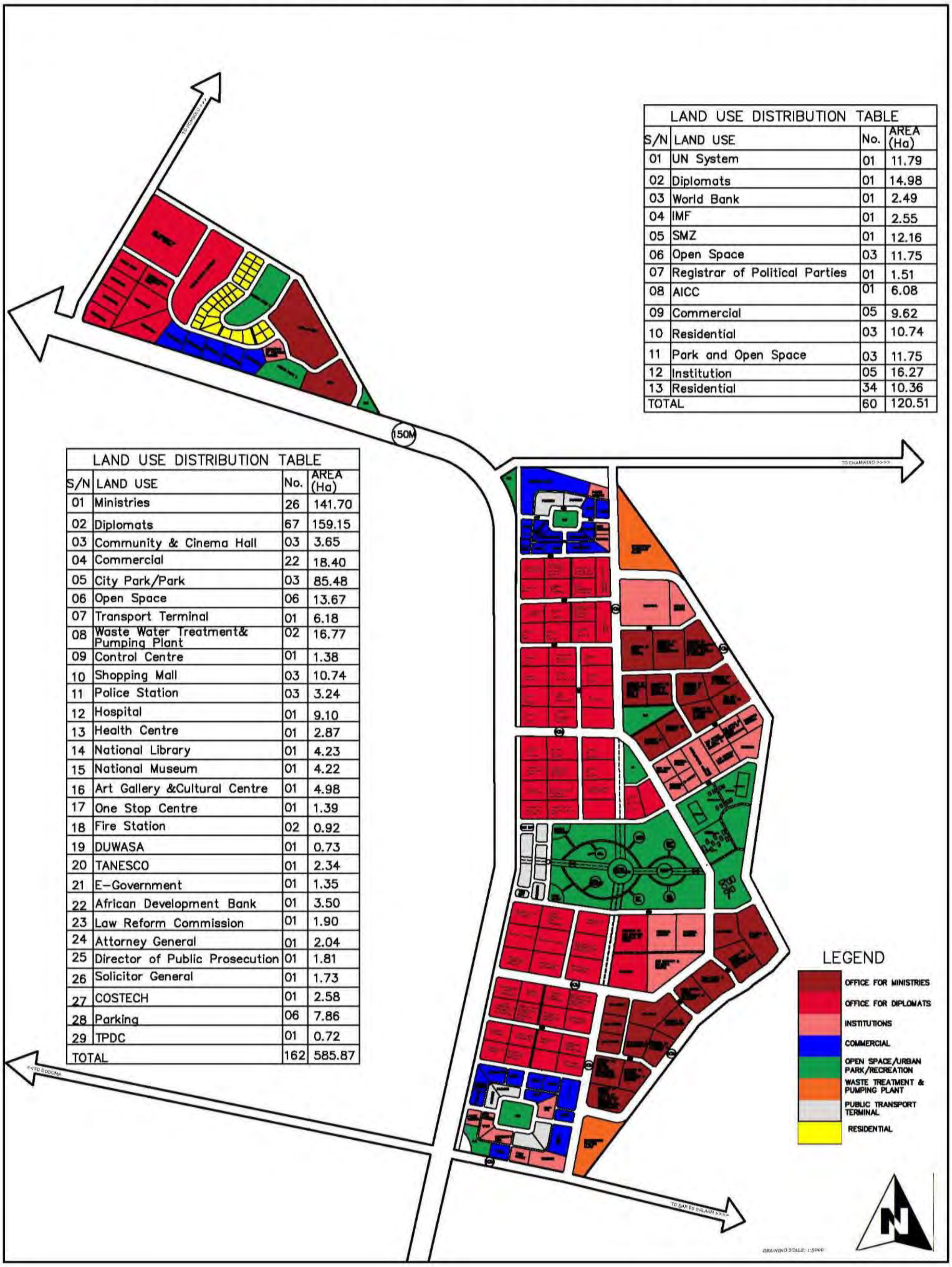
Regarding the government city plan, TS-7. Table 2.4-1 shows the overall of the development plan and Figure 2-4.1 shows the layout plan.

Table 2-4.1 Government City Plan (Overview)

SN	Major land use	No of plots	Area covered (Ha)	Percent
1.	Government Ministries	24	84.22	15.72
2.	Government Offices	16	47.22	8.81
3.	Diplomatic Missions/Embassies	67	167.88	31.34
4.	International Organizations	5	22.35	4.17
5.	Public Government Offices/Institutions	13	32.68	6.10
6.	Commercial	21	45.89	8.57
7.	City Park	1	74.70	13.97
8.	Parking Facilities	2	14.08	2.63
9.	Waste Water Treatment	2	16.77	3.13
10.	Open Spaces	9	23.08	4.31
11.	Government quarters	34	10.36	1.93
12.	Road Network		1.68	0.31
	TOTAL		**540.90**	**100.99**

DODOMA NATIONAL CAPITAL CITY MASTER PLAN

GOVERNMENT CITY: PROPOSED LAND USES



LAND USE DISTRIBUTION TABLE

S/N	LAND USE	No.	AREA (Ha)
01	UN System	01	11.79
02	Diplomats	01	14.98
03	World Bank	01	2.49
04	IMF	01	2.55
05	SMZ	01	12.16
06	Open Space	03	11.75
07	Registrar of Political Parties	01	1.51
08	AICC	01	6.08
09	Commercial	05	9.62
10	Residential	03	10.74
11	Park and Open Space	03	11.75
12	Institution	05	16.27
13	Residential	34	10.36
TOTAL		60	120.51

LAND USE DISTRIBUTION TABLE

S/N	LAND USE	No.	AREA (Ha)
01	Ministries	26	141.70
02	Diplomats	67	159.15
03	Community & Cinema Hall	03	3.65
04	Commercial	22	18.40
05	City Park/Park	03	85.48
06	Open Space	06	13.67
07	Transport Terminal	01	6.18
08	Waste Water Treatment& Pumping Plant	02	16.77
09	Control Centre	01	1.38
10	Shopping Mall	03	10.74
11	Police Station	03	3.24
12	Hospital	01	9.10
13	Health Centre	01	2.87
14	National Library	01	4.23
15	National Museum	01	4.22
16	Art Gallery &Cultural Centre	01	4.98
17	One Stop Centre	01	1.39
18	Fire Station	02	0.92
19	DUWASA	01	0.73
20	TANESCO	01	2.34
21	E-Government	01	1.35
22	African Development Bank	01	3.50
23	Law Reform Commission	01	1.90
24	Attorney General	01	2.04
25	Director of Public Prosecution	01	1.81
26	Solicitor General	01	1.73
27	COSTECH	01	2.58
28	Parking	06	7.86
29	TPDC	01	0.72
TOTAL		162	585.87

Figure 2-4.1 Land Use Plan（Government City）

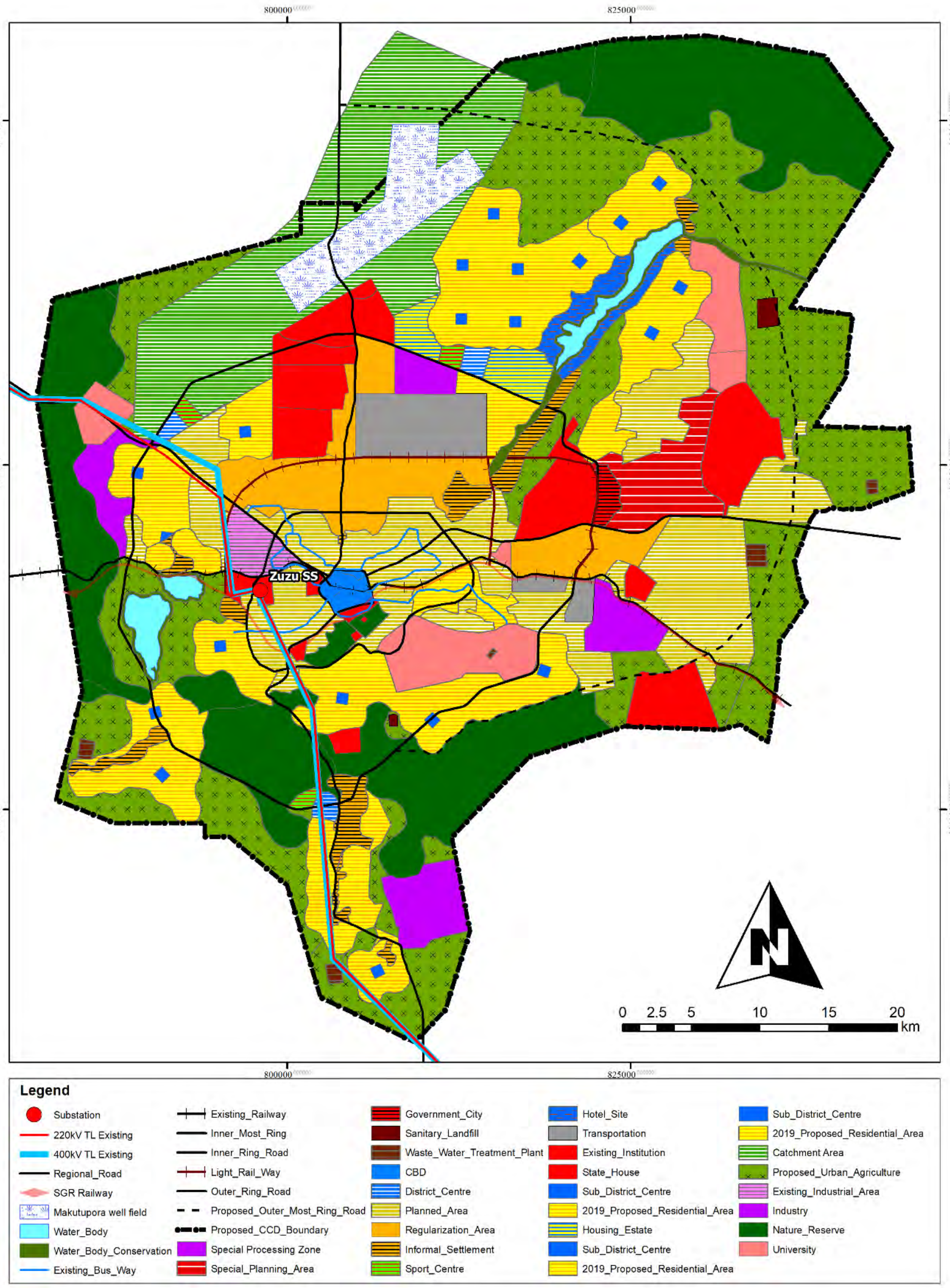
2-4-2 Implementation plan for Dodoma Capital City Master Plan

The Dodoma Capital Master Plan has a development plan that divides the capital development area into four phases: I, II, III, and IV.

Figure 2-4.2Figure 2-4.2 shows the land use plan from 2019 to 2039, and Figure 2-4.3 to Figure 2-4.6 show the target areas for the development plan of each phase.

Phase I will develop the Dodoma city center, in addition to government related facilities for five years from 2019 to 2024. From 2029 to 2034, community development in the southwestern and northeastern metropolitan areas is planned as Phase III.

The 15-year period from 2024 to 2039 is the period for Phase IA, and development is planned as needed while promoting land acquisition in the Peri-urban area of the Dodoma Capital City District (CCD).



[Source] Based on the Land Use Plan, Dodoma National Capital City Master Plan (2019 – 2039), existing power system has been added by the JICA Study Team

Figure 2-4.2 Land Use Plan (2019 - 2039)

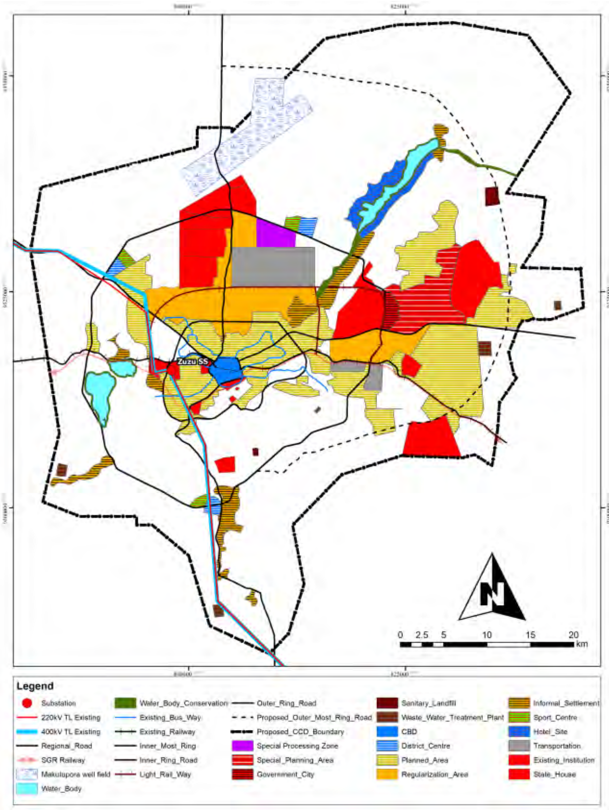


Figure 2-4.3 Development area (Phase-I)

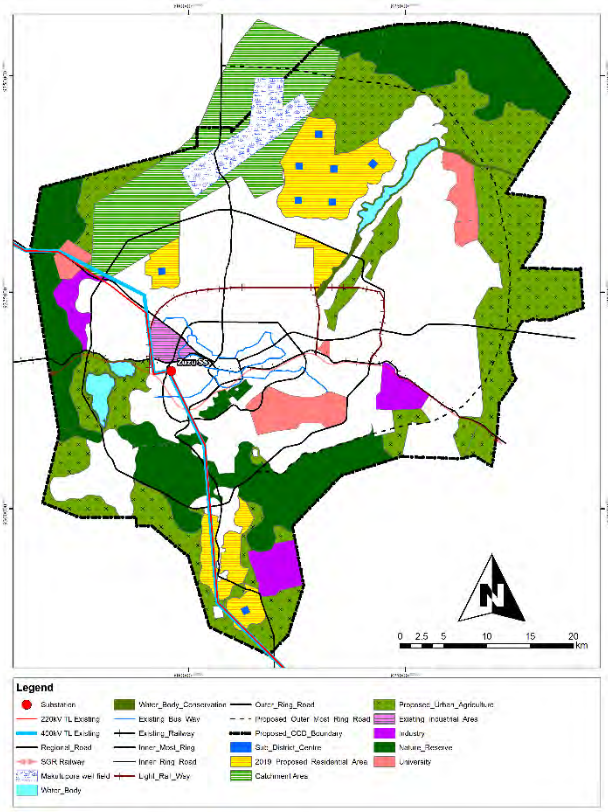


Figure 2-4.4 Development area (Phase-II)

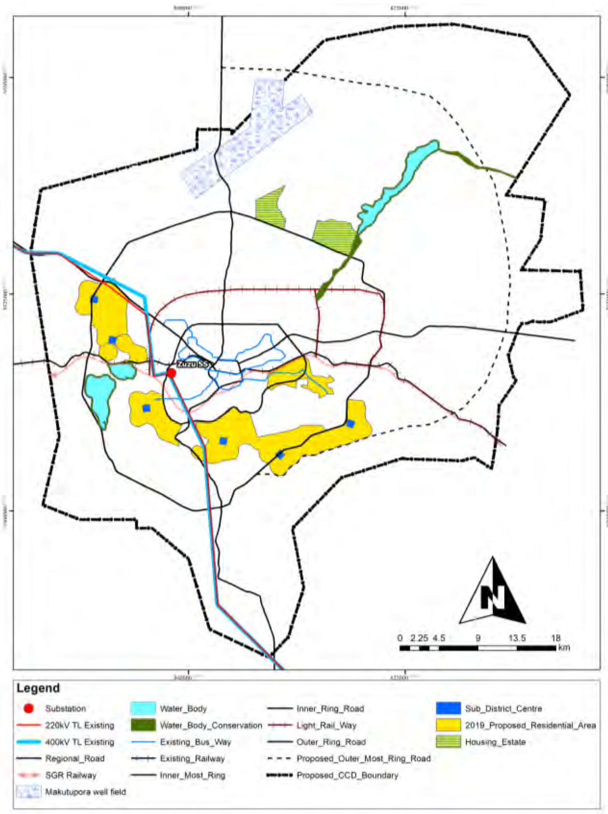


Figure 2-4.5 Development area (Phase-III)

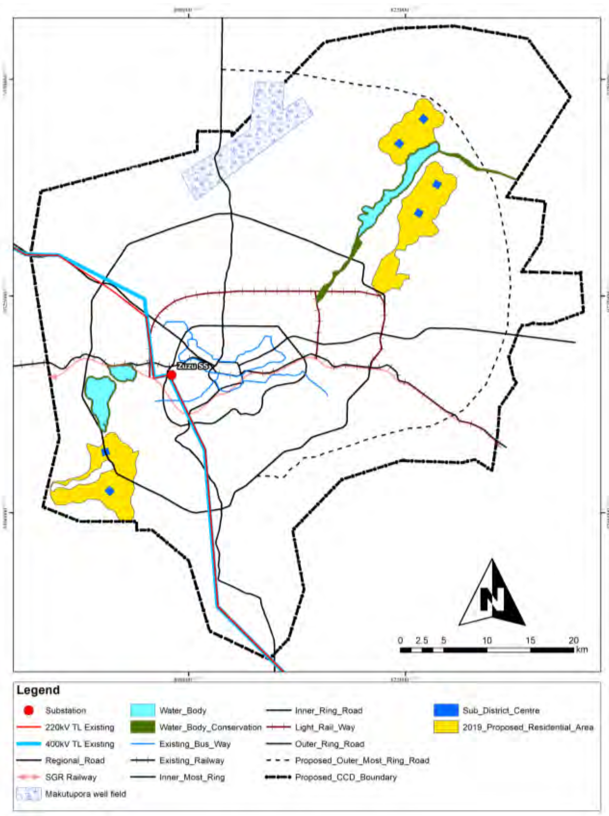


Figure 2-4.6 Development area (Phase-IV)

In the Dodoma National Capital City Master Plan, an implementation plan has been formulated in which the four phases divided into five years are developed step by step. Table 2-4.2 shows Master Plan implementation plan and the approximate project cost. In particular, the emphasis is placed on five years of development from 2019 to 2024, which is the first phase, and an approximate project cost equivalent to three times that of the other three phases has been calculated.

Table 2-4.2 Master Plan Implementation Plan (Overview)

Phase	Period	SN	Outline of the Development Plan	Cost (Million USD)
I	2019-2024	A.4	Completion and opening of road network improvements, sewerage system and ICT network construction in 11 planned communities of Nkuhungu, Chinangali, Miganga, Chidachi, Mkonze, Kikuyu, Kilimani, Ipagala, Kisasa, Mwangaza and Ilazo areas-Dodoma Capital City.	1,315
		A.5	Construction of ring roads (Outer Most, Outer, Inner, Inner Most)	
		A.11	Construction and servicing of the Government City (Road, Water Supply)	
		A.13,18	Construction of phase I of Msalato Airport (LOT 1). Construction for this phase include: 3,600 m x 60m runway, 2 Nos passenger apron taxiway, Passenger terminal apron, AGL and Navaids, 5.1 dual carriage way access road, 500 lots parking area, Presidential pavilion apron and taxi way, 1.5 million passenger terminal building, Fire station category 9, Control tower, MTO Building, Power Station, Drainage structures. Start construction of (Farkwa Dam)	
		A.23	Construction of community facilities in 12 new communities: 48 primary and nursery schools, 12 Secondary schools and police posts, 48 dispensaries, 48 markets, 12 health centres, 12 vocational training schools, 3 hospitals, 3 colleges and 12 service industries	
II	2024-2029	B.7	Completion of construction of the Government offices in the government city (Public buildings, Diplomats Offices, Hospital, Health Centre, Government Quarters, City park and Open spaces)	427
		B.11	Construction of light rail and tram lines networks in Dodoma.	
		B.17	Completion of Redevelopment of present CBD	
		B.20	Development of Mtumba Special Planning Area: Government institutions, Universities and Colleges; Hospitals; Commercial facilities, International Schools; Real Estates; Land Bank; District centre; Religious facilities; Cemeteries and Residential areas.	
		B.9	Construction of community facilities in 20 new communities: 80 primary and nursery schools and police posts, 80 dispensaries, 80 markets, 20 health centres, 20 vocational training schools, 5 hospitals, 5 colleges and 20 service industries.	
III	2029-2034	C.7	Construction of light rail and tram lines networks in Dodoma	230
		C.11	Redevelopment of the present CBD	
		C.13	Continued construction projects in Mtumba special planning area	
		C.5	Construction of community facilities in 16 new communities: 64 nursery schools, 64 primary schools, 16 Secondary schools and police posts, 64 dispensaries, 64 markets, 16 health centres, 16 vocational training schools, 4 hospitals, 4 colleges and 16 services	
IV	2034-2039	D.8	Completion of construction of light rail and tram lines networks in Dodoma	426
		D.9	Redevelopment of the present CBD	
		D.11	Completion of construction projects in Mtumba special planning area	
		D4	Construction of community facilities in 21 new communities: 82 nursery schools, 82 primary schools, 21 Secondary schools and police posts, 82 dispensaries, 82markets, 21 health centres, 21 vocational training schools, 5 hospitals, 5 colleges and 21 services	

[Source] Dodoma National Capital City Master Plan (2019 – 2039)

[Remarks] Development Plan does not cover all but indicated main development with serial number (SN) extracted from entire implementation for each phase

Chapter 3 Overview and challenges of the power sector in Dodoma Capital

Chapter 3 Overview and challenges of the power sector in Dodoma Capital

3-1 Current Status of the Electricity Business

3-1-1 Energy and Electricity Policy

Dodoma Capital MP was formulated in 1976 and approved by the government of Tanzania. In recent years, a revised version of the 20-year master plan from 2019 to 2039 was created in April 2019. Dodoma's energy and power measures and power system development are based on the Dodoma Capital City Master Plan. With the transfer of capital functions to Dodoma, power demand is expected to increase rapidly, so the construction of power generation facilities and transmission / distribution facilities is planned. On the other hand, in Dodoma, energy is supplied by various methods such as electricity, oil, gas, solar power, charcoal, wood, and wind energy. Energy has been consumed in homes by the use of lighting and electrical appliances. In Dodoma State, about 80% of charcoal is used for cooking purposes. In the future, the transmission and distribution network will be improved to meet the increasing demand for electric power, and electrification will be enhanced through the development of the transmission and distribution network.
The Government of Tanzania (Ministry of Energy) acknowledges that securing adequate and reliable power supply facilities in response to the development of Dodoma National Capital City Master Plan is an urgent issue, and considers development of Gas-fired power plant and Renewable Energy in Dodoma.

3-1-2 Power supply Structure

The state-owned company TANESCO supplies electricity in Tanzania, except for the supply of electricity to the island by Zanzibar's private company Zanzibar Electric Power Company (ZECO), and the supply of power to the regions where TANESCO's distribution network is not established by the REA (Rural Energy Agency).

TANESCO is responsible for power supply in Dodoma. According to interviews with TANESCO, there are no special licenses/permissions required during the planning and construction stages of transmission and distribution development in the Dodoma metropolitan area other than general items necessary for project implementation, such as land ownership and construction permit from the City Council, environmental impact assessment, etc.

3-1-3 Power Supply System

TANESCO supplies electricity by means of hydroelectric power generation, thermal power generation / diesel power generation connected to transmission network, with power supply by thermal power generation / diesel power generation being the largest. Thermal and diesel power plants have a capacity of about 57.02%, and hydropower plants have a capacity of about 36.64%. Table 3-1.1 shows the capacity of hydroelectric power stations and Table 3-1.2 shows the capacity of thermal power stations. It can be confirmed that the hydropower generation capacity is about 562MW, whilst the thermal power / diesel power generation capacity is about 769MW. The power generation capacity of diesel power generation not connected to transmission network is about 53MW. Figure 3-1.1 shows Transmission network in Tanzania. The transmission network in Tanzania is composed of voltage class ranging from 66kV to 400kV transmission lines, with 50 substations connected to the transmission network. As of May 2017, the transmission lines are 400kV: 670km, 220kV: 2,940.7km, 132kV: 1,697.47km, 66kV: 543km, totaling 5,851.17km. As shown in Figure 3-1.1, the power generated by the thermal power station on the east coast and the hydroelectric power station around Iringa is supplied from Dar es Salaam to the northern region of Tanzania via the Iringa and Zuzu substations. In addition, the transmission line designed for 400kV in Tanzania is currently operated as a 220kV, but will be operated at 400kV after the planned 400kV substation is completed.

An enlarged view of the transmission network around Dodoma State is shown in Figure 3-1.2.

The Dodoma Region consists of seven areas: the CCD (Capital City District) area including Dodoma City, Kondoa, Chemba, Bahi, Chamwino, Mpwapwa and Kongwa. Dodoma's only 220kV / 33kV substation is Zuzu substation, and power to the CCD, Bahi, Chamwino and Mpwapwa areas is supplied from Zuzu substation. On the other hand, the power in Kondoa and Chemba areas located in the northern part of Dodoma State is supplied from Babati substation via Singida substation from the Zuzu substation. The maximum power supply to the distribution network from Zuzu substation was 30.6MW, recorded in November 2018, supplied to each region through 11kV and 33kV distribution networks. Zuzu Substation has a surplus supply capacity of about 18MW, but the Dodoma Capital MP estimates that the demand for electricity in Dodoma City will increase rapidly due to the transfer of capital functions. Therefore, there is an urgent need to plan for expansion of the power infrastructure.

Table 3-1.1 Existing hydropower plant in Tanzania (February 2020)

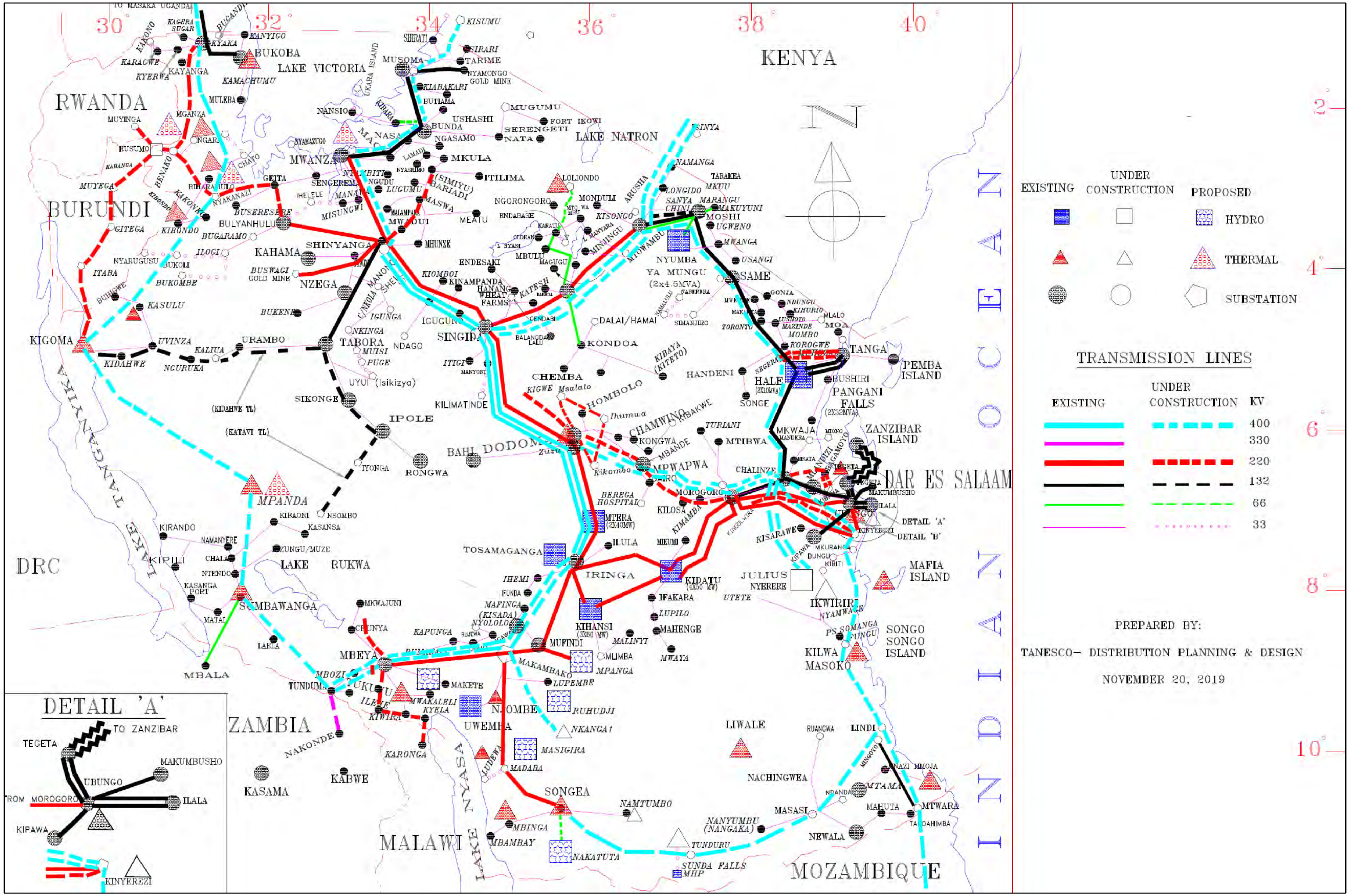
Name of Power station	Capacity [MW]
Kidatu	204.00
Kihansi	180.00
Mtera	80.00
New Pangani	68.00
Hale	21.00
Uwemba	0.84
Nyumba ya Mungu	8.00
MWENGA	4.00
YOVI	0.95
MATEMBWE	0.59
DARAKUTA	0.32
ANDOYA	1.00
TULILA	5.00
Total	**573.70**

[Source] TANESCO

Table 3-1.2 Existing thermal power plant in Tanzania (February 2020)

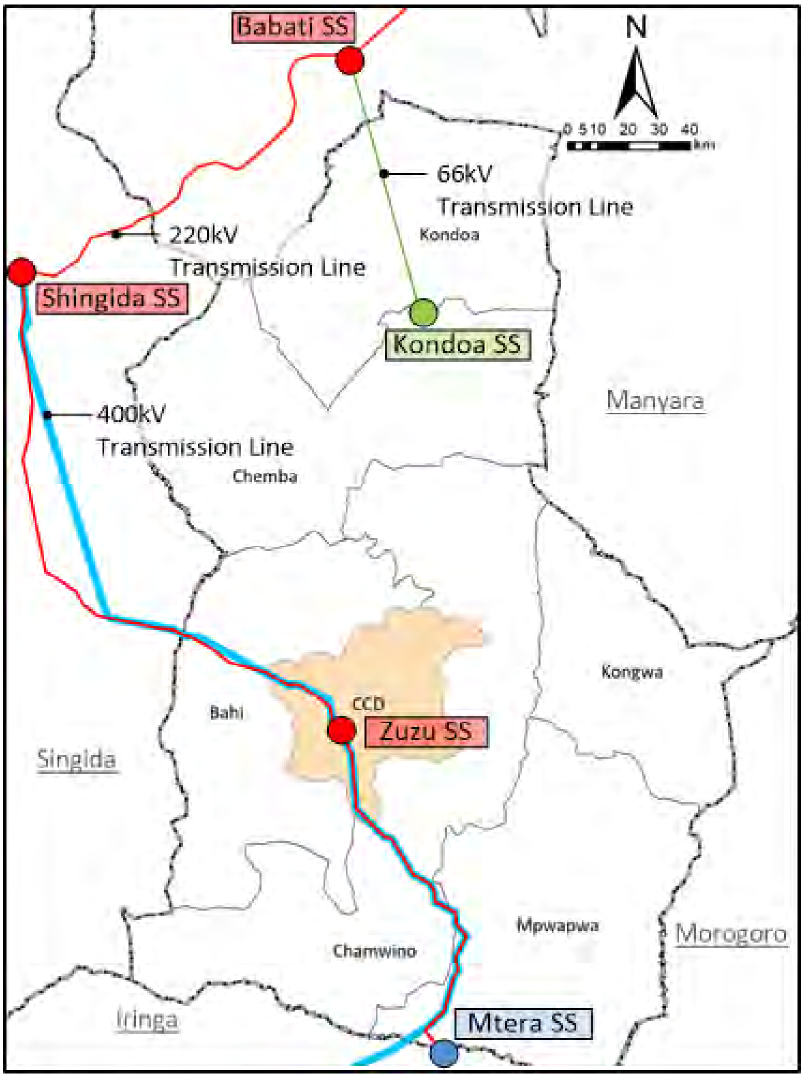
Name of Power station	Capacity [MW]
Kinyerezi I Gas Plant	150.00
Kinyerezi II Gas Plant	248.22
Ubungo I Gas Plant	102.00
Ubungo II Gas Plant	129.00
Tegeta Gas Plant	45.00
Somanga Gas Plant	7.50
Mtwara Gas Plant	22.00
Import from Songas	189.00
Total	**892.72**

[Source] TANESCO



[Source] From TANESCO

Figure 3-1.1 Transmission network in Tanzania



[Source] Created by JICA Study Team

Figure 3-1.2 Enlarged view of the transmission network around Dodoma State (66kV-400kV)

3-1-4 Power Development Plan for Power Supply to Dodoma

The power plant expansion plans listed in PSMP2016 are shown in Table 3-1.4. The power plant expansion plan in Tanzania is basically proceeding according to the plan shown in Table 3-1.4. The latest power development plan obtained from TANESCO is as follows.

- Mtwara 300MW Combined Cycle Gas Turbine (CCGT) power Plant.
  Status: Feasibility Study in progress.

- Somanga Fungu 330MW Combined Cycle Gas Turbine (CCGT) power Plant.
  Status: Feasibility Study is completed and is under review.

- Ruhudji 358MW hydropower Plant
  Status: Procurement to update the feasibility study is in progress

- 87MW Kakono hydropower plant

Status: Feasibility Study is finalized in October 2019.

- 45MW Malagarasi hydropower plant
  Status: Basic design of the project is finalized.

- 222MW Rumakali
  Status: Procurement to update the feasibility study is in progress.

3-1-5 Power Loss

In 2010, the transmission and distribution loss was estimated at 25.0%, of which transmission loss was 5.3% and distribution loss was 19.7%. According to the Cost of Service Study (COSS 2010), the goal is to reduce transmission loss by 0.2% per year, by 2035, and the target for transmission and distribution loss reduction is 15.8% by 2035. The breakdown is as follows: Transmission loss: 4.8%, Distribution loss: 11%. As of January 2019, the transmission and distribution losses were: 5.89% for transmission loss and 15.0% for distribution loss.

Table 3-1.3 Transmission loss in Tanzania

Year	Power Loss [%]
2012	6.12
2013	6.20
2014	6.13
2015	6.21
2016	6.15
Average	6.16

[Source] Created by JICA Study Team base on TANESCO web site

Table 3-1.4 Power Station Expansion Plan

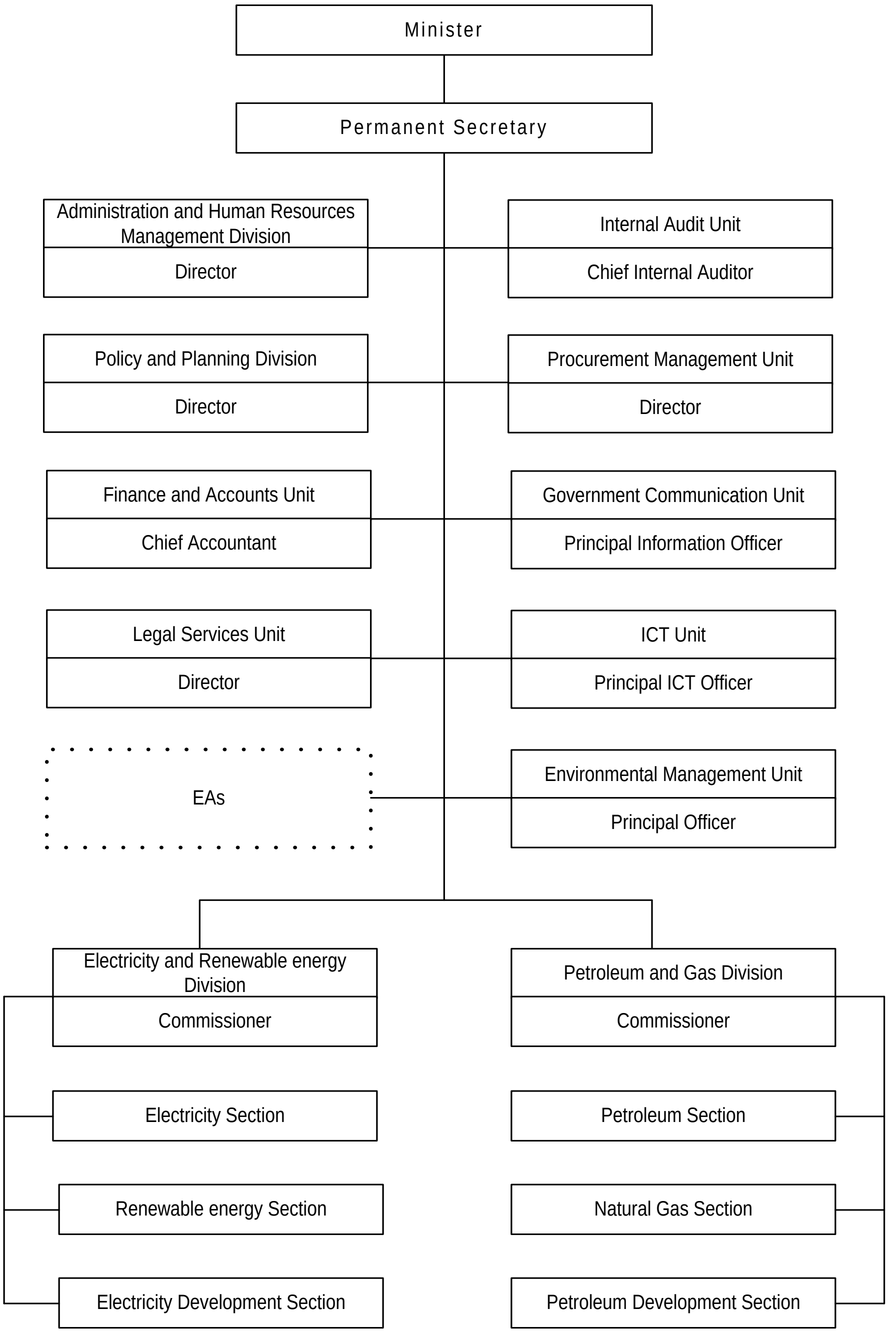
Status	Name of plant	Owner	Year of operation	Type	Installed Capacity(MW)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Peak demand at generator end (MW)						1,072	1,350	1,557	1,796	2,045	4,007	4,250	4,516	4,808	5,134	5,498	5,875	6,288	6,734	7,227	7,765	8,356	9,000	9,708	10,481	11,325	12,183	13,116	14,130	15,231	16,426
Power supply capacity (MW)						1,455	1,343	1,811	3,074	4,091	5,536	5,586	5,983	6,583	6,886	6,866	7,314	7,487	8,529	9,065	10,212	11,327	11,803	12,902	13,929	15,767	17,695	18,150	19,220	20,400	21,960
Generation capacity without solar,wind and import (MW)						1,455	1,343	1,761	2,749	3,616	4,736	4,736	4,933	5,533	5,836	5,816	6,264	6,437	7,479	8,015	9,162	10,277	10,753	11,852	12,879	14,717	16,645	17,100	18,170	19,350	20,910
Addition of generation capacity in each year (MW)							-112	418	988	867	1,120	0	197	600	303	- 20	448	173	1,042	536	1,147	1,115	476	1,099	1,027	1,838	1,928	455	1,070	1,180	1,560
Existing Thermal	Ubungo 1	TANESCO	2007	GasEngine	102	102	102	102	102	102	102	102	102	102	102	102	102	Retire													
	Tegeta	TANESCO	2009	GasEngine	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	Retire											
	Ubungo 2	TANESCO	2012	GT	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	Retire									
	Zuzu Diesel	TANESCO	1980	DG	7	7	7				Retire																				
	Songas 1	IPP	2004	GT	42	42	42	42	42	42	42	42	42	42	Retire																
	Songas 2	IPP	2005	GT	120	120	120	120	120	120	120	120	120	120	120	Retire															
	Songas 3	IPP	2006	GT	40	40	40	40	40	40	40	40	40	40	40	40	Retire														
	Tegeta IPTL	IPP	2002	DG	103	103	103	103	103	103	103	103	Retire																		
	Symbion Ubungo	IPP	2011	GasEngine	112	112	Retire																								
	Nyakato (Mwanza)	TANESCO	2013	DG	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	Retire							
	Mtwara	TANESCO	2007/10	GT	18	Isolated operation			18	18	18	18	18	18	18	18	18	6	Retire												
	Kinyerezi I	TANESCO	2015	Gas-GT	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	Retire					
Ongoing	Kinyerezi I Extension	TANESCO	2017	Gas-GT	185			185	185	185	185	185	185	185	185	185	185	185	185	185	185	185	185	185	185	185	185	Retire			
	Kinyerezi II	PPP	2017	Gas-C/C	240			240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	Retire			
Variable Thermal Candidates	Somanga Fungu (Kilwa E)	IPP	2018	Gas-GT	210				210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210	210
	Somanga Fungu (Kilwa E)	IPP	2019	ST add-on	110					110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
	Kinyerezi III(Ph1) 1-3	PPP	2018	Gas-GT	300				300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Kinyerezi III(Ph2) 1-2	PPP	2018	Gas-C/C	300				300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Kinyerezi IV 1-2	PPP	2020	Gas-C/C	330						330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
	Mtwara (TANESCO)	TANESCO	2019	Gas-C/C	300					300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Somanga (PPP)	PPP	2022	Gas-C/C	300								300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Somanga (TANESCO)	TANESCO	2020	Gas-C/C	240						240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240
	Bagamoyo(Zinga)	IPP	2027	Gas-C/C	200													200	200	200	200	200	200	200	200	200	200	200	200	200	200
	Future CGT1(1-3)			Gas-CGT1	110 *																						110	220	220	330	330
	Future CGT3(1-10)			Gas-CGT3	470 *																940	1,880	1,880	2,820	2,820	3,760	4,230	4,700	5,170	5,640	7,050
	Subtotal Gas					**716**	**604**	**1,029**	**1,857**	**2,267**	**2,837**	**2,837**	**3,137**	**3,137**	**3,095**	**2,975**	**2,935**	**3,021**	**3,015**	**2,970**	**3,910**	**4,745**	**4,745**	**5,685**	**5,685**	**6,475**	**7,055**	**7,210**	**7,680**	**8,260**	**9,670**
	Mchuchuma-1			SBCL	150 *				150	450	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
	Ngaka 1-2+3			SBCL	200 *									600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
	Ngaka (Exp)1-7			ASUB	300 *																				600	600	600	600	600	1,200	1,350
	Kiwira 1-2			SBCL	200 *						400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
	Kiwira (Exp)1-2			ASUB	300 *														600	600	600	600	600	600	600	600	600	600	600	600	600
	Mchuchuma(Exp)1-6			ASUB	300 *												300	300	600	600	600	600	600	600	600	600	900	1,200	1,200	1,200	1,200
	Rukwa 1+Exp			ASUB	300 *										300	300	300	300	300	600	600	600	600	600	600	600	600	600	1,200	1,200	1,200
	Subtotal Coal					**0**	**0**	**0**	**150**	**450**	**1,000**	**1,000**	**1,000**	**1,600**	**1,900**	**1,900**	**2,200**	**2,200**	**3,100**	**3,400**	**3,400**	**3,400**	**3,400**	**3,400**	**4,000**	**4,000**	**4,300**	**4,600**	**5,200**	**5,800**	**5,950**
Thermal generation capacity subtotal (MW)						**889**	**777**	**1,195**	**2,173**	**2,883**	**4,003**	**4,003**	**4,200**	**4,800**	**5,058**	**4,938**	**5,198**	**5,284**	**6,178**	**6,433**	**7,373**	**8,208**	**8,208**	**9,085**	**9,685**	**10,475**	**11,355**	**11,810**	**12,880**	**14,060**	**15,620**
	Geothermal	TGDC		Geo	50 *											**100**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Renewable	Singida Wind			Wind	50			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	Singida Wind			Wind	75				75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Njombe Wind			Wind	100					100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Dodoma solar			Solar	50					50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	Singida Wind			Wind	75						75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Singida Wind			Wind	100						100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Shinyanga/Simiyu Solar			Solar	150						150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
	Singida Wind			Wind	50							50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Renewable (Wind and Solar) subtotal (MW)								**50**	**125**	**275**	**600**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**	**650**
	Power Import from Ethiopia				Max. 400				**200**	**200**	**200**	**200**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**
Existing hydro	Hale	TANESCO	1967	Dam	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	Nyumba Ya Mungu	TANESCO	1968	Dam	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
	Kidatu	TANESCO	1975	Dam	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204
	Mtera	TANESCO	1988	Dam	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
	Uwemba	TANESCO	1991	Dam	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843	0.843
	New Pangani Falls	TANESCO	1995	Dam	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
	Kihansi	TANESCO	2000	Dam	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
	Mwenga SPP	SPP	2012	Run of river	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
Planned hydro	Rusumo	TANESCO	2019	Dam	27					27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
	Lower Kihansi Extension	TANESCO	2019	Dam	120					120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
	EA Power SPP	SPP	2019	Run of river	10					10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Darakuta SPP	SPP	2015	Run of river	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
	Mapembasi SPP	SPP	2019	Run of river	10				10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Variable Hydro Candidates	Malagarasi Stage-III	TANESCO	2024	Dam	44.7										44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7
	Mpanga		2031	Dam	160																	160	160	160	160	160	160	160	160	160	160
	Iringa-Nginayo		2026	Dam	52												52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
	Iringa-Ibosa		2026	Dam	36												36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
	Mnyera Ruaha		2028	Dam	60.3														60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3	60.3
	Mnyera-Pumbwe		2030	Dam	122.9																122.9	122.9	122.9	122.9	122.9	122.9	122.9	122.9	122.9	122.9	122.9
	Mnyera-Kwanini		2029	Dam	143.9															143.9	143.9	143.9	143.9	143.9	143.9	143.9	143.9	143.9	143.9	143.9	143.9
	Mnyera-Kisingo		2031	Dam	119.8																	119.8	119.8	119.8	119.8	119.8	119.8	119.8	119.8	119.8	119.8
	Mnyera-Taveta		2030	Dam	83.9																83.9	83.9	83.9	83.9	83.9	83.9	83.9	83.9	83.9	83.9	83.9
	Mnyera-Mnyera		2029	Dam	137.4															137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4
	Songwe Manolo		2028	Dam	88.1														88.1	88.1	88.1	88.1	88.1	88.1	88.1	88.1	88.1	88.1	88.1	88.1	88.1
	Kakono		2027	Dam	87													87	87	87	87	87	87	87	87	87	87	87	87	87	87
	Songwe Sofre		2034	Dam	79.5																				79.5	79.5	79.5	79.5	79.5	79.5	79.5
	Masigira		2032	Dam	118																		118	118	118	118	118	118	118	118	118
	Ruhudji		2032	Dam	358																		358	358	358	358	358	358	358	358	358
	Rumakali	TANESCO	2033	Dam	222																			222	222	222	222	222	222	222	222
	Kikonge		2034	Dam	300																				300	300	300	300	300	300	300
	Stieglers Gorge Ph-1		2035	Dam	1048																					1048	1048	1048	1048	1048	1048
	Stieglers Gorge Ph-2		2037	Dam	1048																						1048	1048	1048	1048	1048
	Upper Kihansi		2034	Dam	47																				47	47	47	47	47	47	47
Hydro subtotal						**566**	**566**	**566**	**576**	**733**	**733**	**733**	**733**	**733**	**778**	**778**	**866**	**953**	**1,101**	**1,382**	**1,589**	**1,869**	**2,345**	**2,567**	**2,994**	**4,042**	**5,090**	**5,090**	**5,090**	**5,090**	**5,090**
Total generation capacity (MW)						**1,455**	**1,343**	**1,811**	**3,074**	**4,091**	**5,536**	**5,586**	**5,983**	**6,583**	**6,886**	**6,866**	**7,314**	**7,487**	**8,529**	**9,065**	**10,212**	**11,327**	**11,803**	**12,902**	**13,929**	**15,767**	**17,695**	**18,150**	**19,220**	**20,400**	**21,960**
Reserve capacity (with rated hydro capacity)						383	-7	254	1,278	2,046	1,529	1,336	1,468	1,775	1,752	1,368	1,438	1,199	1,795	1,839	2,447	2,971	2,803	3,194	3,448	4,442	5,512	5,033	5,089	5,169	5,533
Reserve margin (with rated hydro capacity)						35.8%	-1%	16.3%	71.1%	100.0%	38.2%	31.4%	32.5%	36.9%	34.1%	24.9%	24.5%	19.1%	26.7%	25.4%	31.5%	35.6%	31.1%	32.9%	32.9%	39.2%	45.2%	38.4%	36.0%	33.9%	33.7%

Note: * means installed capacity per unit

[Source] PSMP2016

3-1-6 Ministry of Energy (MoE)

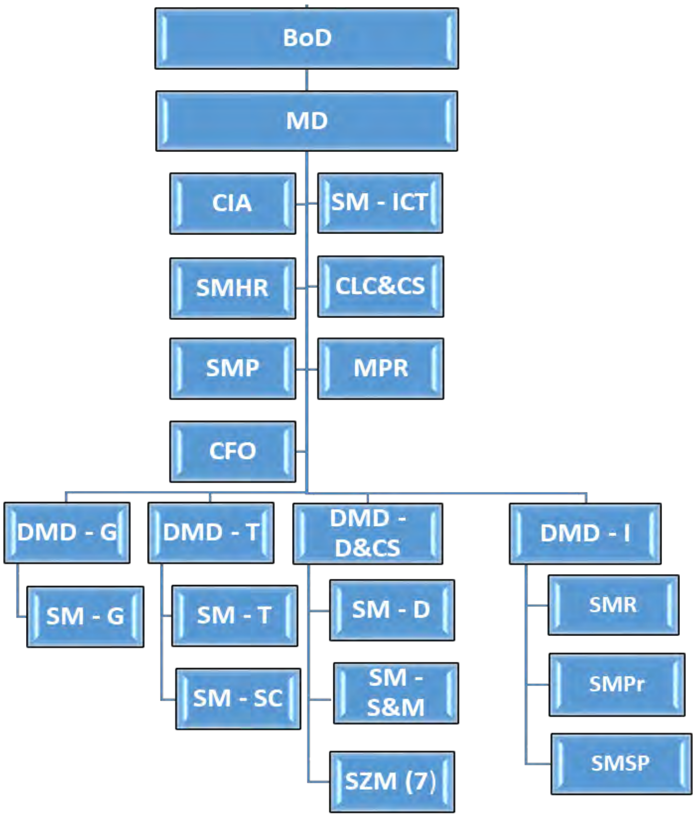
The Ministry of Energy consists of departments in charge of policy / strategy and general affairs, Electricity and Renewable energy Division, and Petroleum and Gas Division. The Electricity and Renewable energy Division has Electricity section, Renewable energy section, and Electricity Development section under the commissioner. The Petroleum and Gas Division has Petroleum Section, Natural Gas Section, and Petroleum Development Section under the commissioner. Figure 3-1.3 shows the organization chart of the Ministry of Energy.



[Source] Created by JICA Study Team based on the information from Ministry of Energy

Figure 3-1.3 Organizational chart of Ministry of Energy

3-1-7 TANESCO



BoD: BOARD OF DIRECTORS
MD: MANAGING DIRECTOR
CIA: CHIEF INTERNAL AUDITOR
SMHR: SENIOR MANAGER HUMAN RESOURCES
SMP: SENIOR MANAGER PROCUREMENT
SMICT: SENIOR MANAGER - INFORMATION AND COMMUNICATION TECHNOLOGY
CLC&CS: CHIEF LEGAL COUNSEL AND COMPANY SECRETARY
MPR: MANAGER PUBLIC RELATIONS
DMD - G: DEPUTY MANAGING DIRECTOR - GENERATION
DMD - T: DEPUTY MANAGING DIRECTOR - TRANSMISSION
DMD - D & CS: DEPUTY MANAGING DIRECTOR - DISTRIBUTION AND CUSTOMER SERVICE
DMD - I: DEPUTY MANAGING DIRECTOR - INVESTMENT
SM - G: SENIOR MANAGER - GENERATION
SM - T: SENIOR MANAGER - TRANSMISSION
SM - SC: SENIOR MANAGER - SYSTEM CONTROL
SM - S&M: SENIOR MANAGER - SALES AND MARKETING
SM - D: SENIOR MANAGER - DISTRIBUTION
SM - SP: SENIOR MANAGER - STRATEGIC PLANNING
SM - PR: SENIOR MANAGER - PROJECTS
SM - R: SENIOR MANAGER - RESEARCH
SZM : SENIOR ZONAL MANAGER

[Source] From TANESCO

Figure 3-1.4 Organization chart of TANESCO

TANESCO has a management / support department and four Business Units under the President (Managing Director): Power Generation, Transmission, Investment, Distribution and Customer Service. As of June 2018, there are about 6,784 employees. Figure 3-1.4 shows the organization chart of TANESCO.

The power generation headquarters has jurisdiction over all power generation facilities, and the transmission headquarters operates and maintains the transmission network in Tanzania. The Investment Headquarters has functions such as research and development, strategic planning, and execution of major projects. The Distribution and Customer Service Headquarters manages the distribution network. Large facilities are distributed at 33kV and 11kV, and ordinary houses are distributed down to 400 / 230V via the distribution network.

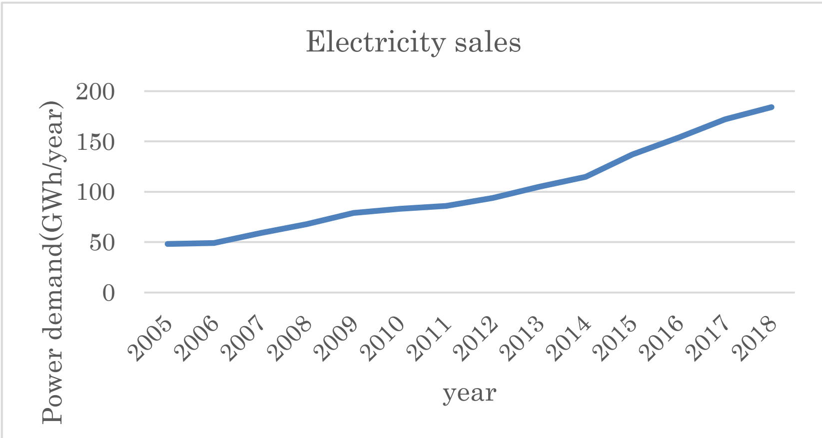
TANESCO's mission and vision are as follows.

MISSION: To generate, transmit and supply electricity in the most effective, competitive and sustainable
VISION: To be an efficient and commercially focused utility supporting the development of Tanzania

3-2 Power Demand

3-2-1 Transition of Power Demand

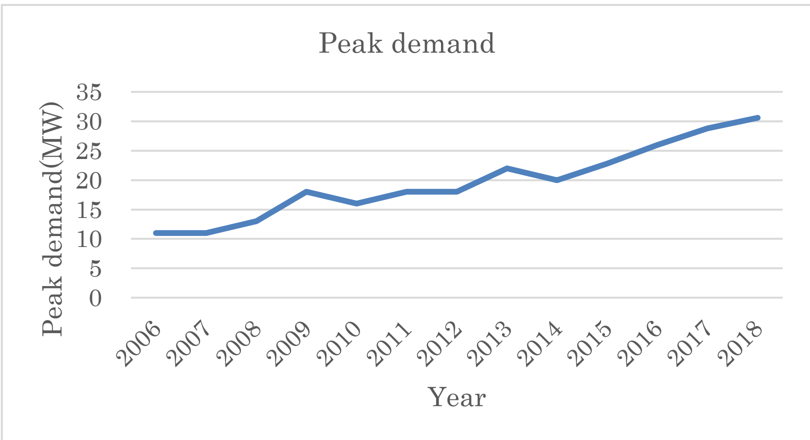
Figure 3-2.1 shows the trend of electric power sales (2005-2018) excluding the Kondoa area, which is a northern independent power grid system in Dodoma State. The electricity sales in 2018 is 183.7GWh, an increase of about 3.8 times in 13 years, i.e. from 2005. The growth rate is 10.9% on average, over 13 years.



[Source] TANESCO

Figure 3-2.1 Transition of power demand

Figure 3-2.2 shows the trend of peak demand (2006-2018) recorded in Dodoma. The peak demand of 2018was recorded 30.6MW in November. The annual average demand growth rate is 8.9% since 2006. In Dodoma states, the maximum peak demand is often recorded in October or November when the temperature is highest in the year. In addition, with confirmation of the daily update report of the Zuzu substation on the day of peak demand in 2017 and 2019, the distribution feeder for the eastern region that has long length of distribution lines was under power outage due to demand restrictions. Therefore, it is assumed that the potential demand is higher than the figure below.



[Source] TANESCO

Figure 3-2.2 Transition of peak demand

3-2-2 Access to power

According to the information from the National Bureau of statistics and TANESCO, the electrification rate in Dodoma state is 23.5% as of February 2017. This value is not much different from neighboring Singida (22.3%) and Morogoro (24.3%). The breakdown of electrification rate is as shown.

Table 3-2.1 Electrification rate in Dodoma

Total		Rural area		Urban area	
Total House hold	Electricity rate (%)	Total House hold	Electricity rate (%)	Total House hold	Electricity rate (%)
590,106	23.5	499,290	16.9	90,817	60

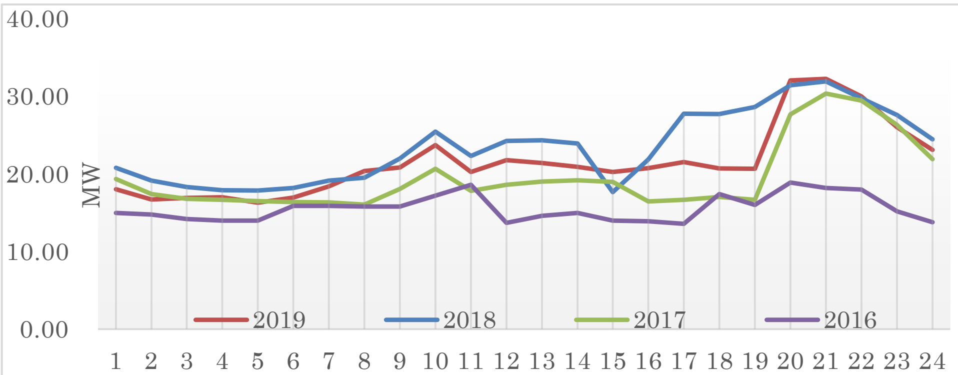
[Source] Energy Access situation report Feb 2017

TANESCO has set the target number of customers in the 2047 as 401,408 (current number is 138,675). The project is being implemented under the REA (Rural Electricity Agency) for improve electrification in 212 rural areas.

3-2-3 Load Characteristics

Most of the electricity in Dodoma state is supplied from the existing Zuzu substation except for the Kondoa area. The load curve of the day when the annual peak demand was recorded during the period 2016 to 2019 is shown below.

The peak demand is recorded between 20:00 and 21:00; therefore, it is assumed that this is due to an increase in demand for electricity light.



[Source] Created by JICA Study Team

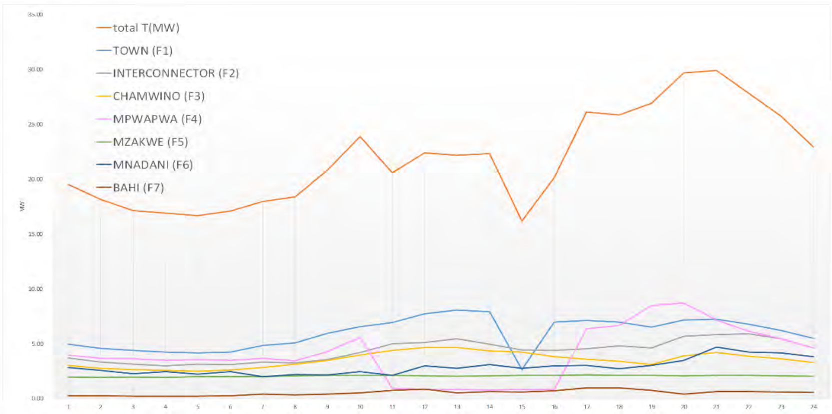
Figure 3-2.3 Demand curve

The existing Zuzu substation has seven feeders for 33 kV distribution line and supply power to within the state. The table below shows feeder name and each power supply area.

Table 3-2.2 Feeder name and each power supply area from Zuzu substation

№	Feeder name	Power supply area
1	Town	Dodoma central Area
2	Inter connector	Dodoma central area through to 33/11kv step-down transformer in Zuzu power station
3	Chamwino	Dodoma eastern area
4	Mpwapwa	Dodoma eastern south area
5	Mzakwe	Dodoma northern area include around planned Msalato airport area
6	Mnadani	Dodoma northern area
7	Bahi	Dodoma western area

In particular, the town feeder and Mpwapwa feeder have higher loads than other five feeders. The figure below shows the daily load curve for each distribution feeders recorded 28 November 2018, at the Zuzu substation.



[Source] Created by JICA Study Team

Figure 3-2.4 Load curve for each distribution feeder

3-2-4 Power demand forecast

For the reinforcement of power supply in Dodoma, a long-term demand forecast was formulated by TANESCO in 2018. This demand forecast takes into account the achievement of the electrification rate target of 75% in the 2025, set by the Tanzanian government, and specific load accompanied by the transfer of government functions has also being considered.

On the other hand, in 2019.11, the feasibility study report for Feasibility Study for Distribution Master Plan Study for Arusha, Dodoma, Mbeya and Mwanza reported long-term power demand forecast that reflected Dodoma Capital MP. This forecast estimated by the land area that described and planned on Dodoma capital MP and typical load capacity set for each category such as residential, commercial and industrial facilities. In addition, this forecast consider for energy access rate and population rate. As described above, the demand forecast is based on the Dodoma capital MP, which is different from the TANESCO expected value that was implemented before the master plan was formulated. Although the Kondoa and Chemba areas on the northern region are not subject to TANESCO's demand forecast, but SMEC report consider for these area. Table 3-2.3 shows comparison of result of each load forecast assumption.

The below table shows comparison of result of each load forecast assumption.

Table 3-2.3 Comparison of load forecast

Assumption (MW)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
TANESCO	31.4	34.2	48.1	62.2	76.6	90.6	104.7	119.0	133.6	148.5
SMEC	35.5	39.5	86.4	101.1	115.9	130.1	146.2	164.7	183.5	251.1
Assumption (MW)	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
TANESCO	163.6	179.1	184.1	189.4	195.1	201.2	207.7	214.7	222.2	230.2
SMEC	274.6	298.2	320.0	342.0	364.3	386.7	501.2	528.8	556.6	584.4
Assumption (MW)	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
TANESCO	236.3	242.7	249.5	256.5	264.0	271.8	280.0	288.6	297.6	307.1
SMEC	612.4	640.5	662.6	684.7	707.0	729.4	751.8	-	-	-

[Source] TANESCO Establishment of power demand forecast in Dodoma capital city (2018), SMEC final feasibility study report of 400 kV Chalinze- Dodoma transmission line project.

3-3 Basic Information related to Power System Plan

3-3-1 Existing Power system

The below table shows planned and implemented project around Dodoma.

Table 3-3.1 Summary of the power project around Dodoma

No	Project	Progress
1	400kV Iringa-Shinyanga Transmission Project (Backbone)	Transmission Line is completed. Substation construction is in Progress
2	400kV North East Grid	Procurement of Consultant to package the project on EPC is ongoing.
3	400kV Rufiji to Chalinze – Dar es Salaam Transmission line	Procurement of Consultant for feasibility study in progress.

To describe the outline of the ongoing project in the above table No.1. The construction of 400kV transmission line is already complete. The Zuzu substation is being expanded to connect four new transmission lines from Iringa and Singida substations. Table 3-3.1 shows conceptual diagram for Zuzu expansion plan, the black line shows existing facilities whilst the red line shows the facilities for expansion. Currently the newly constructed 400kV transmission line is operated at 220 kV, after completion of Zuzu expansion works, Zuzu will be a 400/220/33kV voltage class substation.

In addition, each of the existing 220kV bay for the Iringa and Singida substations will be bay for the transformer secondary circuit, with plan to install new 400/220kV 250MVAx2 transformers. Furthermore, after completing installation of the new 220/33kVx2 transformers, they will supply power to distribution lines through the 33kV switchgear.

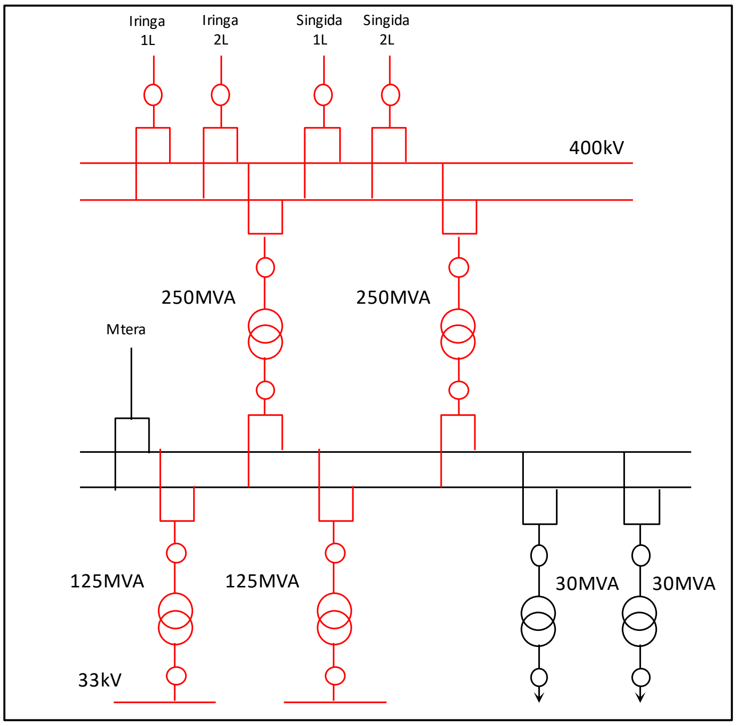


Figure 3-3.1 Schematic diagram of Zuzu substation

3-3-2 Existing Power System Plan the Challenges

The power system development plan in Dodoma Capital is described in the Technical supplement No.3 Dodoma capital master plan(2019-2039) (April 2019 draft) (hereinafter referred to as the Dodoma capital MP), organized based on the proposal from TANESCO.

This plan will be described below as a basic plan.

Currently Zuzu is the only substation in Dodoma state and the basic plan describes the Zuzu as the supply base for power transmission and distribution to the Dodoma capital and surrounding areas.

The Study Team discussed and prepared six (6) power development plans that includes, the base plan that considered proposal from TANESCO in the first survey at Dodoma.

The summary of each case and comparison results are described below.

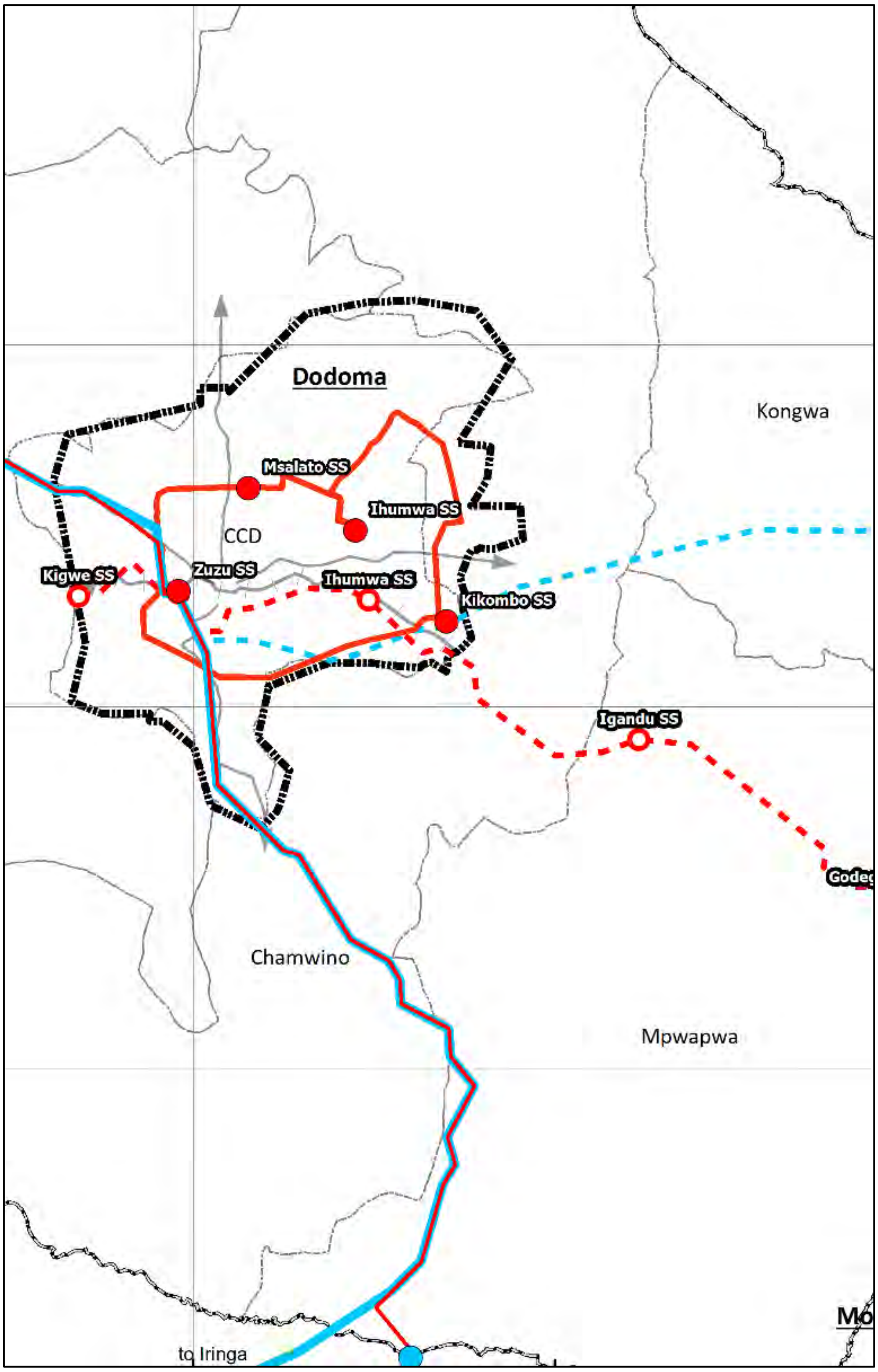
(1) Summary of the power system development plan

1) Base case

The substations in Dodoma are configured as follows.

- Zuzu S/S →Power supply base
- Msalato S/S→Mainly supply for northern area and new international airport
- Ihumwa S/S→Mainly supply for new government city
- Kikombo S/S→Mainly supply for eastern and southern areas

For the above four (4) substations, it is planned to connect double circuit transmission lines as a ring configuration. As for the transmission line route in the base case, various development of Dodoma Capital MP are considered, and the transmission line length is the shortest. . The specification of transmission line conductor is ACSR (aluminum conductor 564mm^2 called Blue jay), and configured as single conductor per phase. The Blue jay conductor is widely used in TANESCO 220kV power transmission lines.



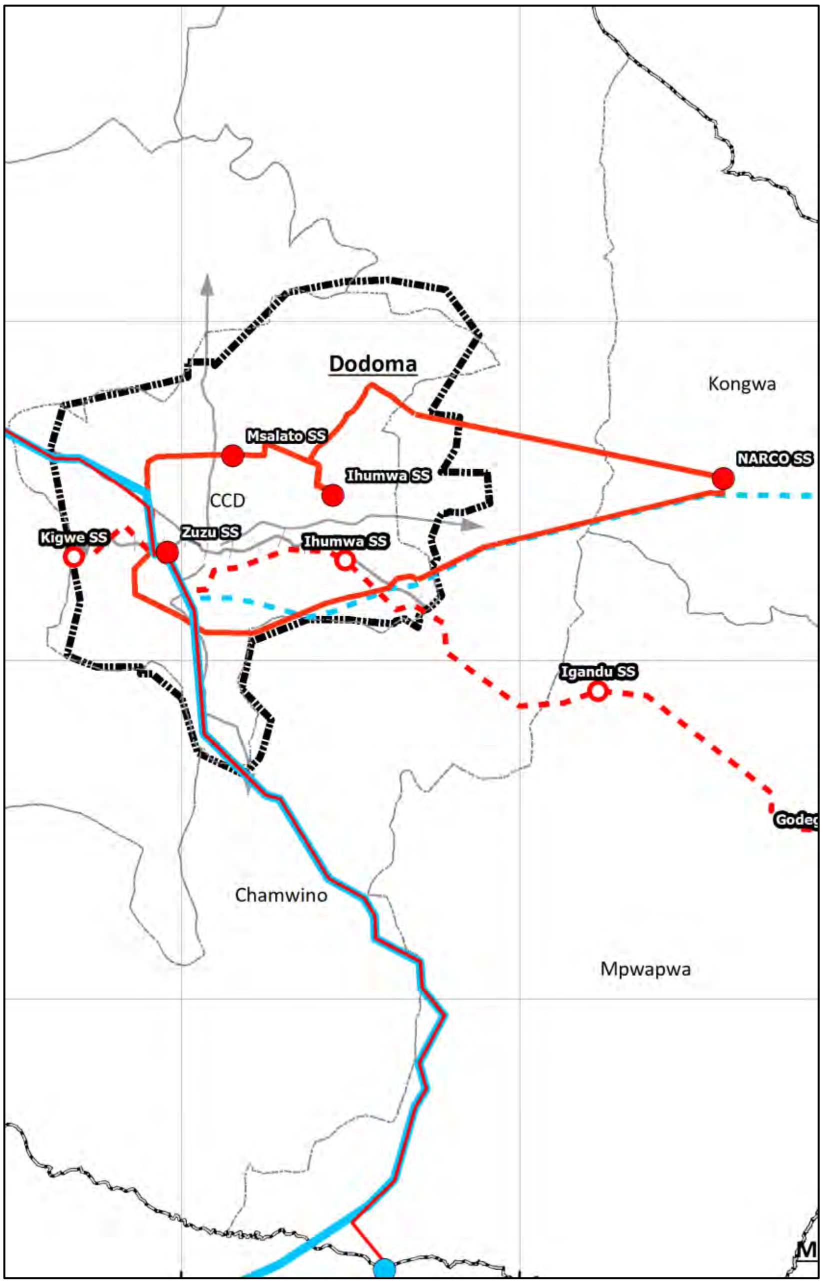
[Source] JICA Study Team

Figure 3-3.2 Power development plan (Base case)

The red circles shows planned substation locations and the red line indicates planned transmission line routes in Figure 3-3.2. The blue line shows 400kV transmission lines (solid line is existing, dotted line is planned line), red line shows 220kV transmission lines (dotted line is planned line for SGR) (the legend is common for following each case)

2) Option-1

Option-1 is a case where a substation is constructed in the Narco area located in the eastern part instead of Kikombo substation that specified in the base case, expanding the transmission ring more widely. Because currently Kongwa and Mpwapwa areas that located the eastern and southeastern sides of Dodoma, has 30% population, the substation should located in close proximity power consumers. Currently the above areas received power from Zuzu substation, but pointing out the problem of voltage drop due to long distance distribution lines. In the Dodoma MP, the power demand is expected to shoot up due to increase in population, and new substation has been planned to eliminate the decline of power quality.

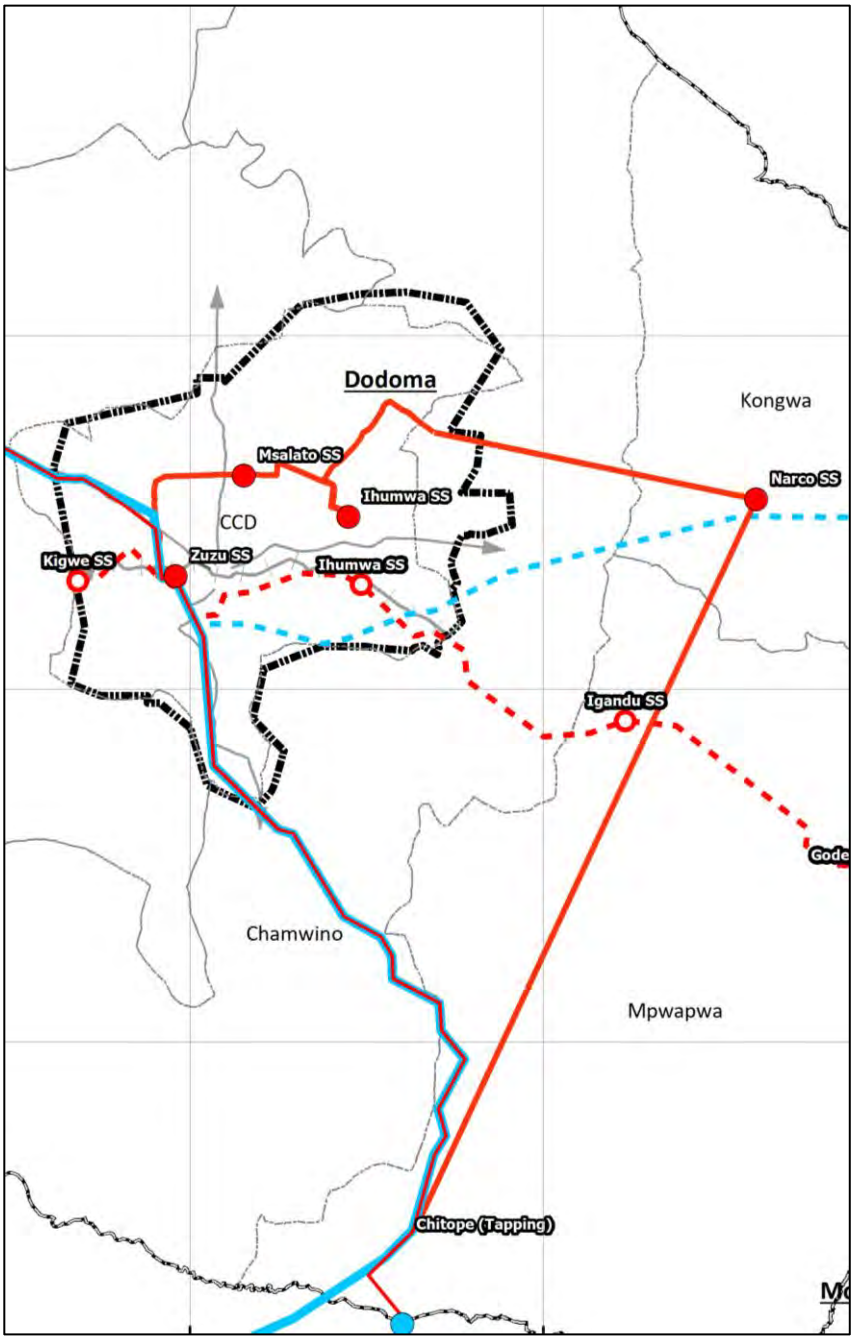


[Source] JICA Study Team

Figure 3-3.3 Power development plan (option-1)

3) Option-2

Option -2 is a proposal that expands the ring circuit system in order to secure power supply other than from the Zuzu substation. As mentioned earlier, existing Zuzu substation is connected to Iringa Singida transmission line and other transmission lines from Mtera hydro power plant located in southern part of Dodoma. In addition, to configure larger ring circuit by tapping between existing transmission lines and new transmission line from Narco substation. The tapping point is located in Chitope area, near the Mtera hydro power plant.

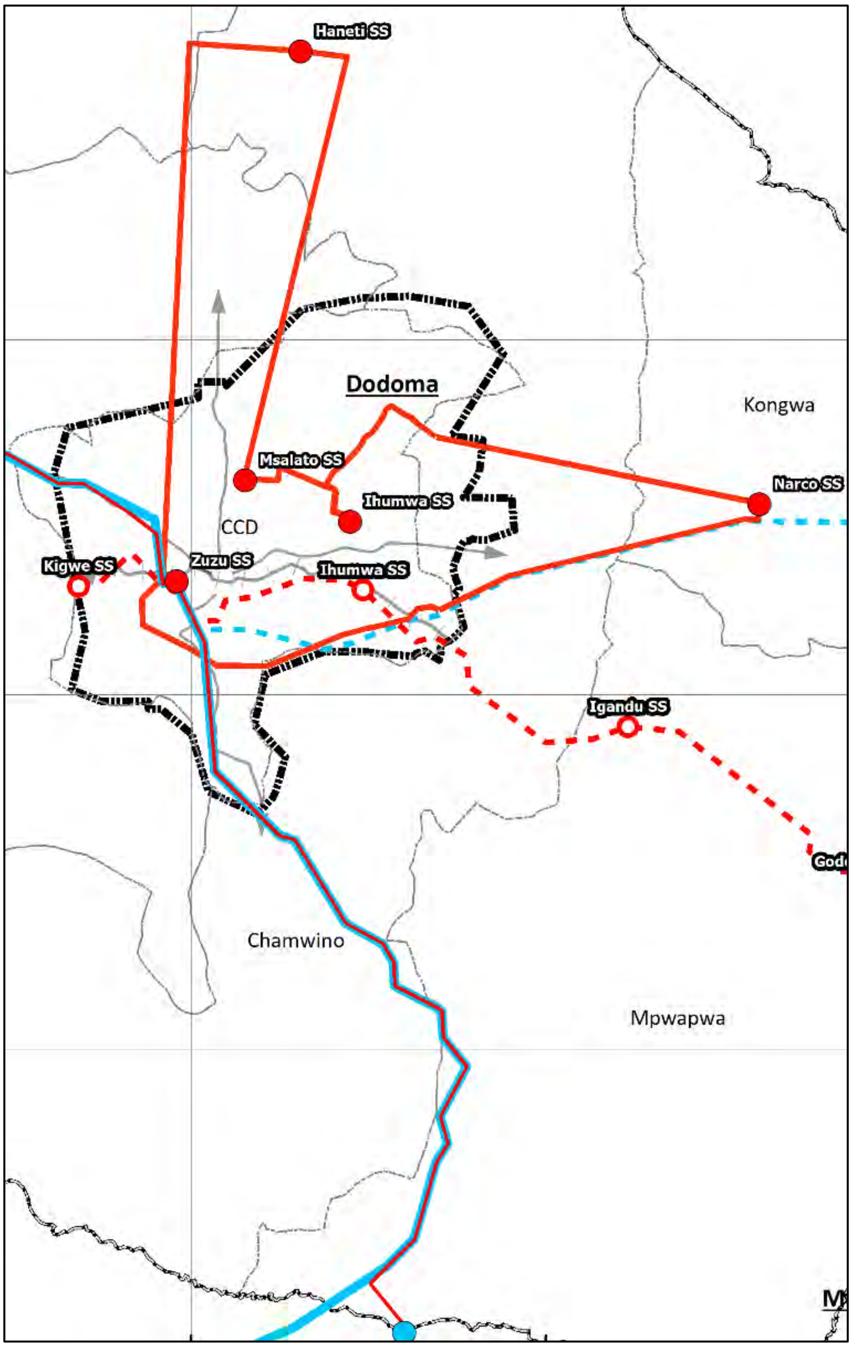


[Source] JICA Study Team

Figure 3-3.4 Power development plan (option-2)

4) Option-3

Based on the option-1, the ring circuit expanded to northern part in order to reinforce the distribution power supply to Dodoma northern area. Power supply to the northern region of Dodoma is currently from the Kondoa substation connected by 66kV transmission line from the Babati substation in the province of Manara, and it is independent of the distribution system of the Zuzu substation. Therefore, the planned Haneti substation located in the northern part Dodoma is to be incorporated into the Dodoma ring circuit.

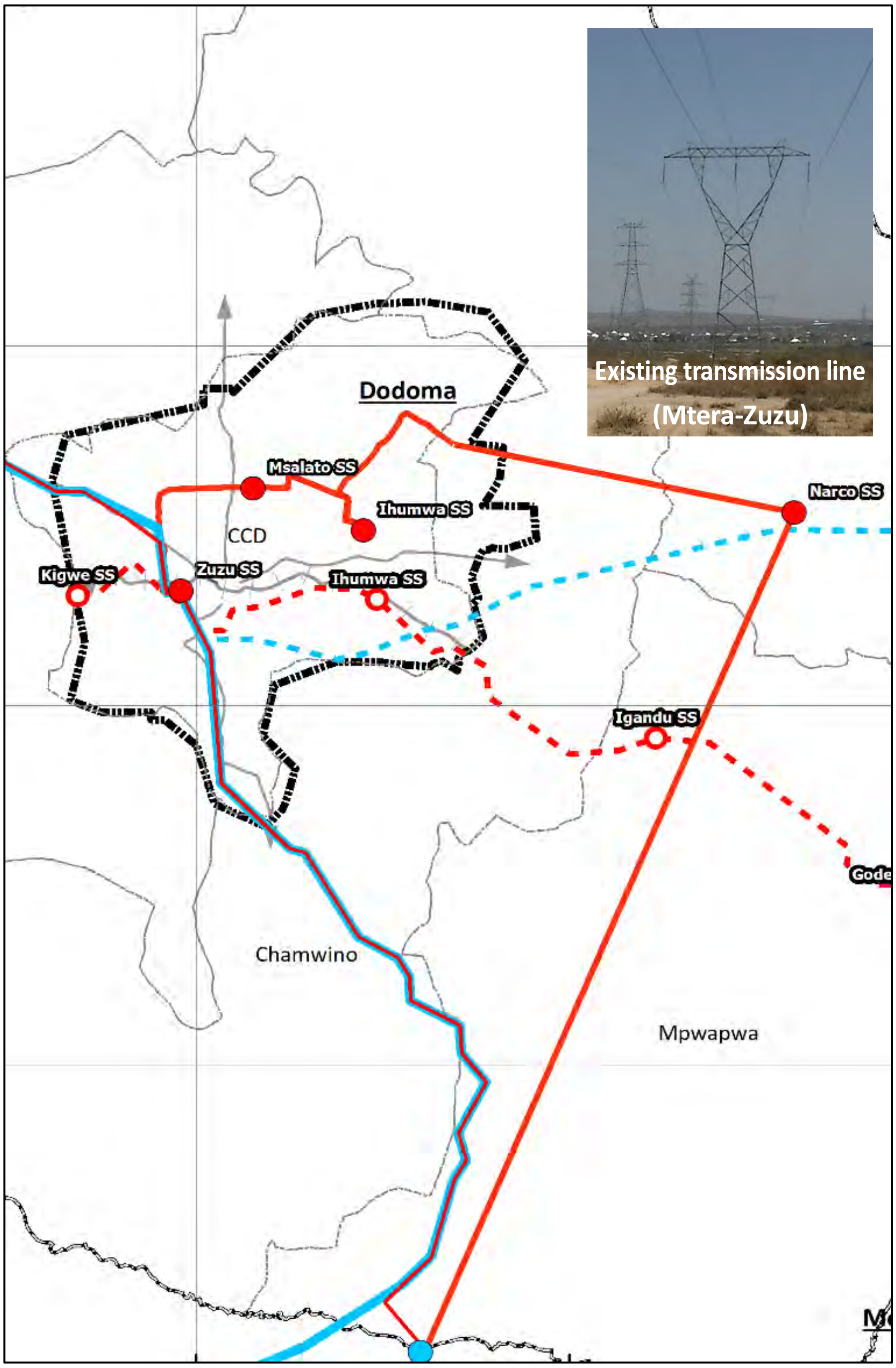


[Source] JICA Study Team

Figure 3-3.5 Power development plan (option-3)

5) Option-4

This is the same idea as option-2, but modifies the connecting point of the transmission line from Narco substation described in option-2. To connect to Mtera hydro power plant by expansion of substation bay instead of tapping at Chitope. The tapping works assumed is very difficult because of the existing transmission constructed in1985, with a vertical tower type configuration.

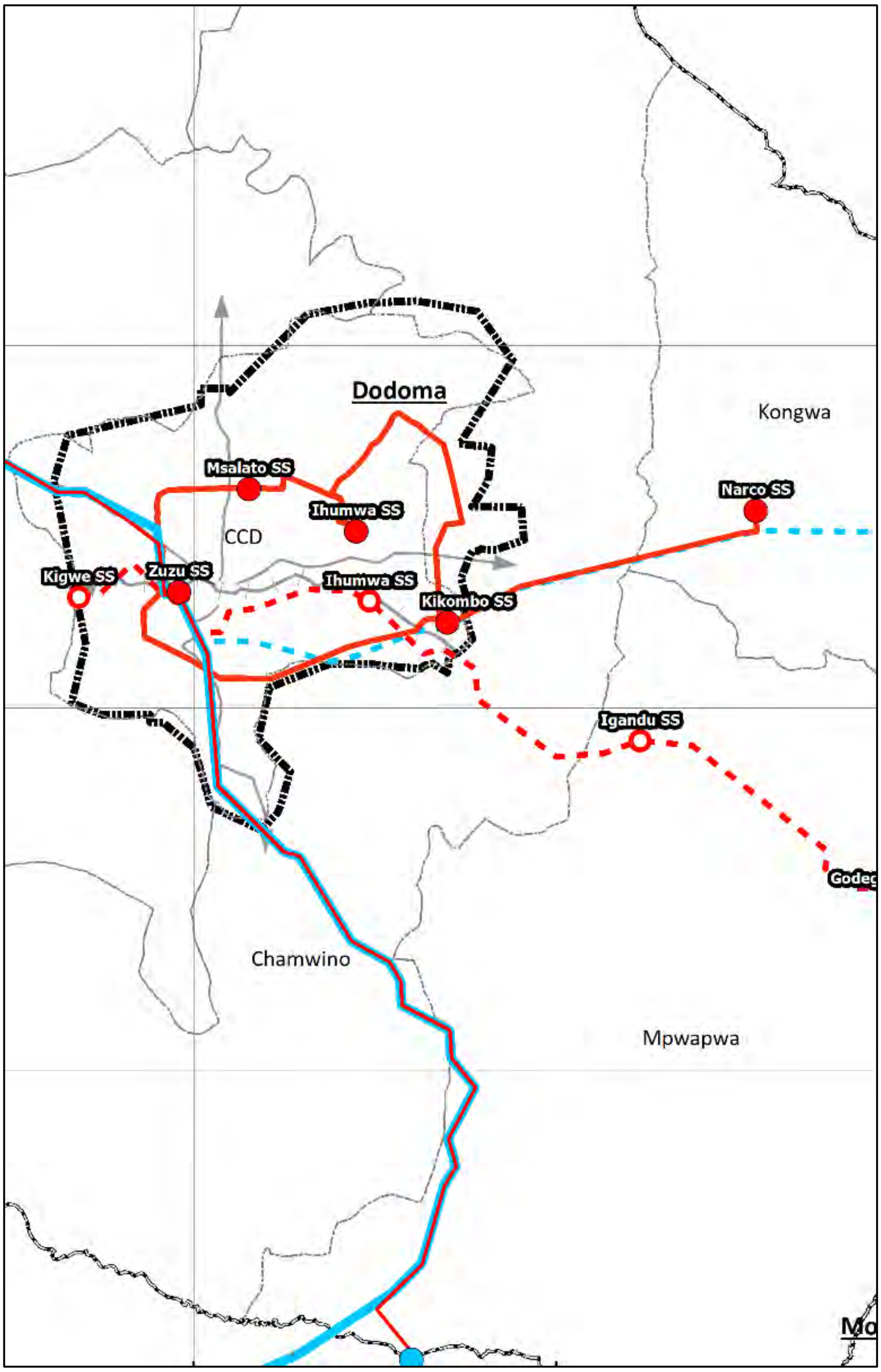


[Source] JICA Study Team

Figure 3-3.6 Power development plan (option-4)

6) Option-5

Based on the ring circuit configuration of the base case, the Narco substation in the eastern part is connected to Kikombo substation with a single transmission line. It aims to ensure the quality of power supply to eastern areas, while ensuring the reliability of supply to the city of Dodoma without expanding the transmission line of the ring system.



[Source] JICA Study Team

Figure 3-3.7 Power development plan (option-5)

(2) The result of comparison development plan

To consider power supply reliability to Dodoma capital and economic efficiency, the above-mentioned development planning cases were compared. The results of comparative study are shown in Table 3-3.2. Concerning system reliability, Power supply to Ihumwa substation that supplies power to government city is to be first priority. Specifically, as the length of the transmission line increases, the probability of failure including the effects of natural disasters such as lightning increases. Therefore, comparative study should conducted based on the length of the ring transmission system.

Table 3-3.2 Summary of the comparison result

	Base Case	Option-1	Option -2	Option -3	Option -4	Option -5
Line Length (Newly Construction)	165km (165km)	235km (235km)	355km (245km)	390km (390km)	390km (260km)	215km (215km)
Rough Cost estimation	◎ Base	○ Base x 1.4	○ Base x 1.5	△ Base x 2.3	○ Base x 1.6	◎ Base x 1.2
Grid reliability ***1**	◎	○	△	△	△	◎
Social Impact ***2**	○	○	◎	○	◎	○
Note	—	—	Tapping is very difficult (Existing tower is Cat head Type)	—	—	Ring T/L: 165km *Same as base case Tree T/L: 50km (Kikombo to Narco)
Result of Comparison	◎	○	△	△	△	◎

*1 Evaluated by the total length of Ring transmission line

*2 Evaluated by length of transmission line that pass through near the residential area

Based on the above result, it is required to conduct development plan about base case and option-5.

(3) Challenges in development plan

In the base case described, the ring circuit system has high reliability since it consists of two (2) circuit transmission lines. However, the problem is that the power supply to ring circuit system is limited to one substation, Zuzu. Connected transmission lines consist of multiple lines, also the facilities located in substation are of redundancy type, and hence N-1 criteria is considered.

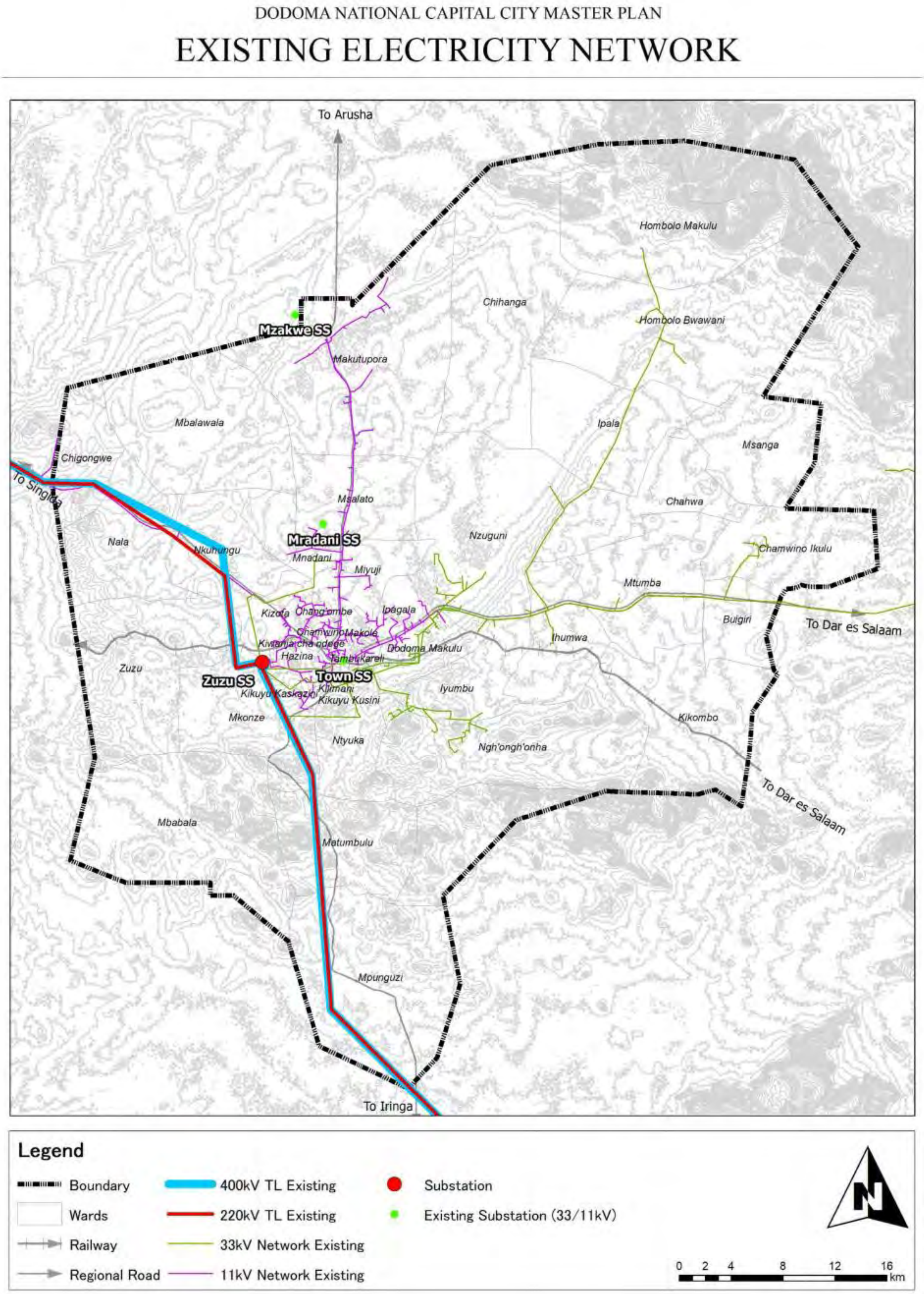
When an emergency (disaster, etc.) occurs in the substation, it is assumed that the entire Dodoma area will be out of power. Therefore, in view of the importance of maintaining power supply to the government functions, it is necessary to plan at least one more substations that can supply power to ring system.

3-4 Basic Information related to Transmission Facilities

3-4-1 Existing Transmission Facilities

(1) Outline of Existing Transmission Facilities

The route map of transmission lines in the Dodoma capital area and line specifications are shown in Figure 3-4.1 and Table 3-4.1. At present, the Zuzu substation located in the eastern part of the Dodoma capital area is the only substation, and is interconnected to the Iringa substation, Mtera power station, and Singida substation at 220kV. The transmission lines between Iringa substation and Zuzu substation and the double circuit transmission lines between Zuzu substation and Singida substation are designed for 400kV but are presently operating at 220kV. The status of existing transmission lines around the Zuzu substation is shown in Figure 3-4.2 and Figure 3-4.3.



[Source] Created by JICA Study Team

Figure 3-4.1 Route map of existing transmission lines

Table 3-4.1 Specifications of existing transmission lines

Voltage class	Number of circuits	Section	Line length	Line specifications
220kV*	Double circuit	Iringa-Zuzu	237km	Bluejay (Double-conductor)
220kV	Single circuit	Mtera-Zuzu	130km	Bison (Single conductor)
220kV*	Double circuit	Zuzu-Singida	210km	Bluejay (Double-conductor)
220kV	Single circuit	Zuzu-Singida	210km	Bison (Single conductor)

*400kV design, 220kV operation

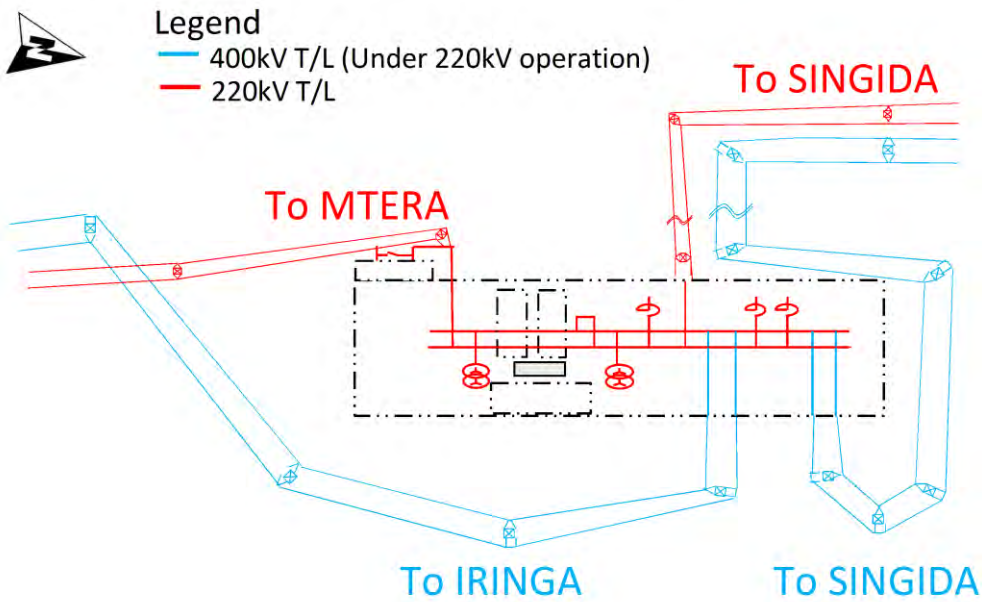
[Source] Created by JICA Study Team

From the left,
220kV single circuit Zuzu-Singida transmission line,
220kV double circuit Zuzu-Singida transmission line

From the left,
220kV single circuit Mtera-Zuzu transmission line,
220kV double circuit Iringa-Zuzu transmission line

[Source] Photographed by JICA Study Team

Figure 3-4.2 Installation status of existing transmission lines



[Source] Created by JICA Study Team

Figure 3-4.3 Status of lead-in to Zuzu substation

(2) Problems with Existing Transmission Facilities

The 220kV single circuit Mtera-Zuzu transmission line and Zuzu-Singida transmission line, which were constructed in the 1980s, are not equipped with arcing horns. Arcing horns are mainly installed to protect insulators from lightning strikes. Therefore, if a lightning strike occurs without the arcing horns installed, a flashover will occur on the insulator surface, possibly damaging the insulator. The status of the top of the 220kV transmission tower is shown in Figure 3-4.4.

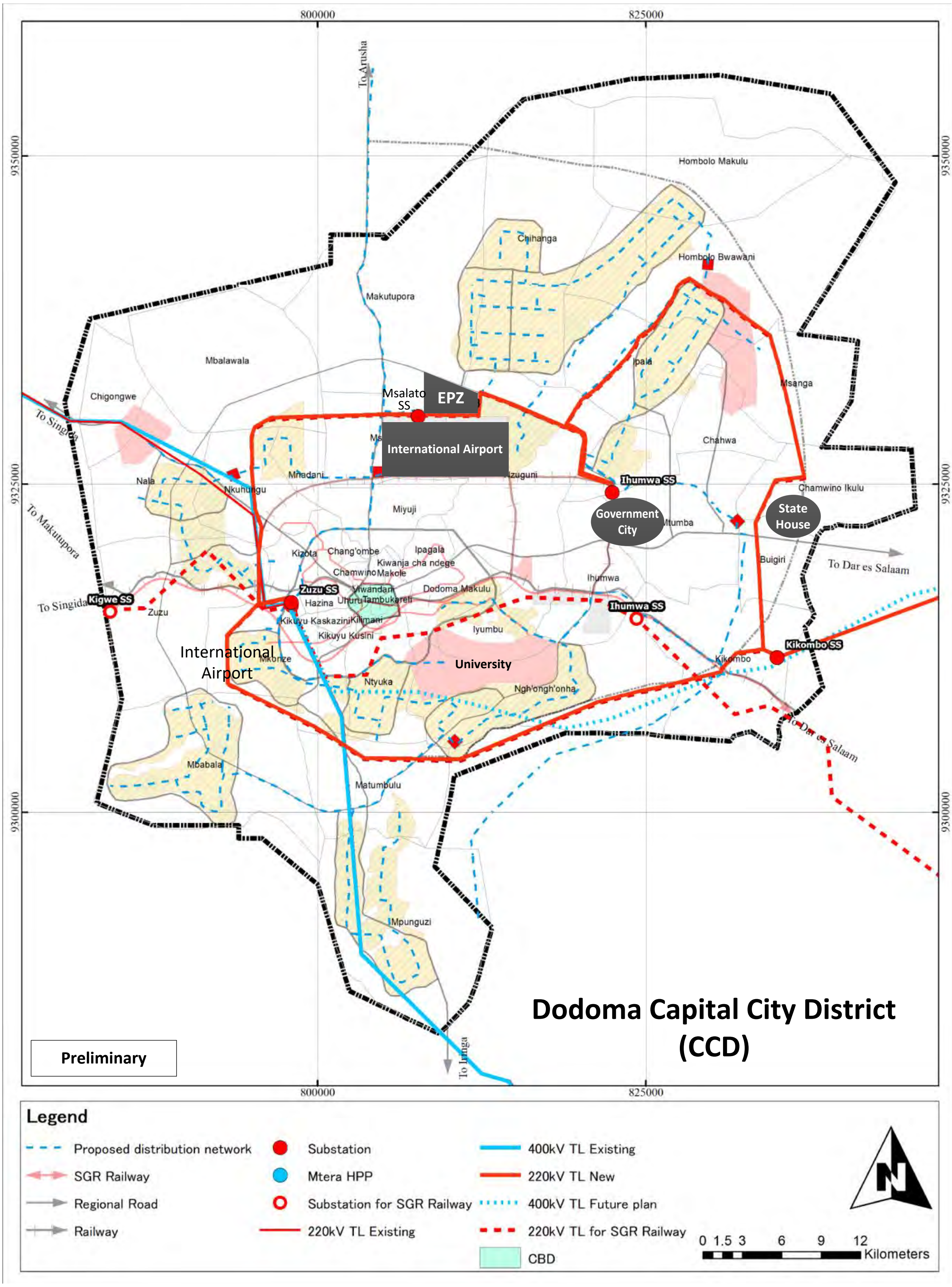
[Source] Photographed by JICA Study Team

Figure 3-4.4 Status of top of existing 220kV single circuit transmission line (no arcing horns)

3-4-2 Existing Transmission Facilities Plan and the Challenges

(1) Existing Transmission Facilities Plan

We acquired from TANESCO and confirmed the coordinates of the existing transmission facilities plan. An outline is shown in Figure 3-4.5 and Table 3-5-2-1.2.



[Source] Created by JICA Study Team

Figure 3-4.5 Existing transmission facilities plan

Table 3-4.2 Specifications of existing transmission facilities plan

Voltage class	Number of circuits	Transmission line section	Line length	Line specifications	Commencement period
220kV	Double circuit	Zuzu-Msalato	27km	Undetermined	Undetermined
220kV	Double circuit	Msalato-Ihumwa	25km	Undetermined	Undetermined
220kV	Double circuit	Ihumwa-Kikombo	62km	Undetermined	Undetermined
220kV	Double circuit	Kikombo-Zuzu	51km	Undetermined	Undetermined
220kV	Single circuit	Kikombo-Narco	50km	Undetermined	Undetermined

[Source] Created by JICA Study Team

(2) Issues with Existing Transmission Facilities Plan

With regard to the existing transmission facilities plan, the routes were selected by TANESCO, but then some sections were changed by the CCD in accordance with CCD's land utilization plan. Therefore, there are many curves, and there are several locations where the route selection is uneconomical and inefficient.

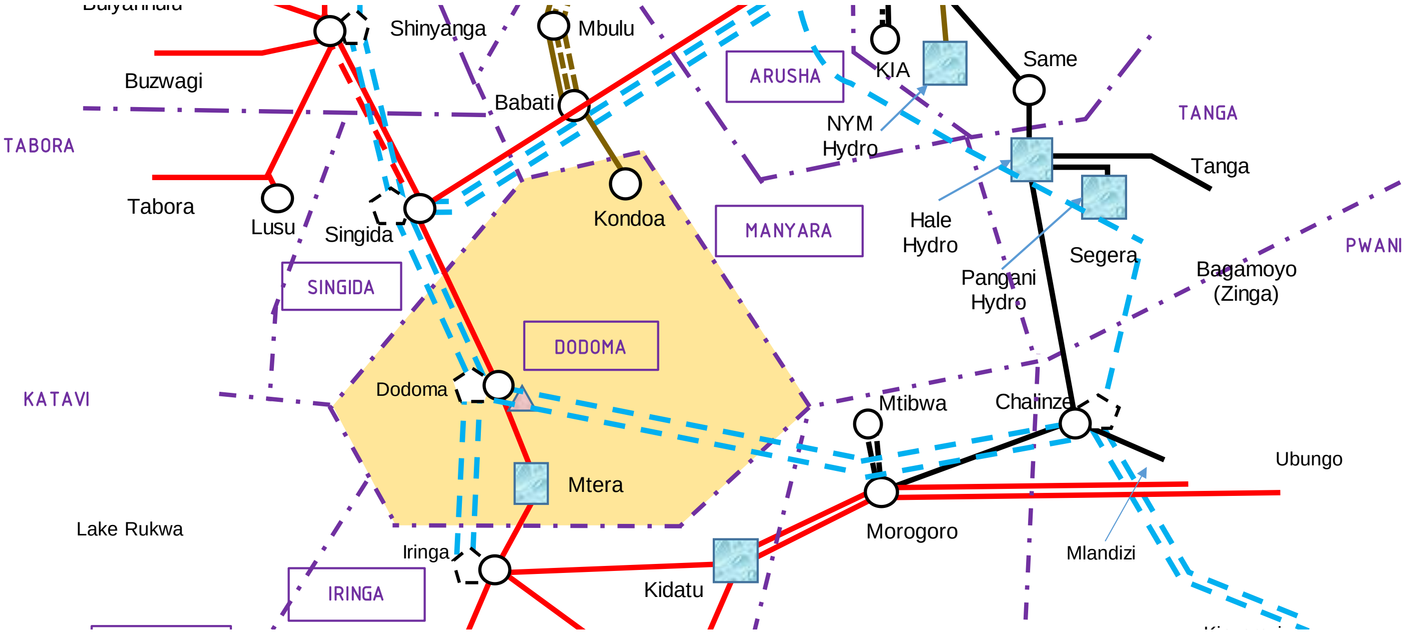
With regard to the area around the Zuzu substation, not only is there no collaboration with other new transmission line construction plans, interference with existing transmission lines (crossovers between transmission lines and a lack of space necessary for construction, maintenance, and management) has not been taken into consideration.

3-5 Basic Information related to Substation Facilities

3-5-1 Existing Substation Facilities

(1) Overview

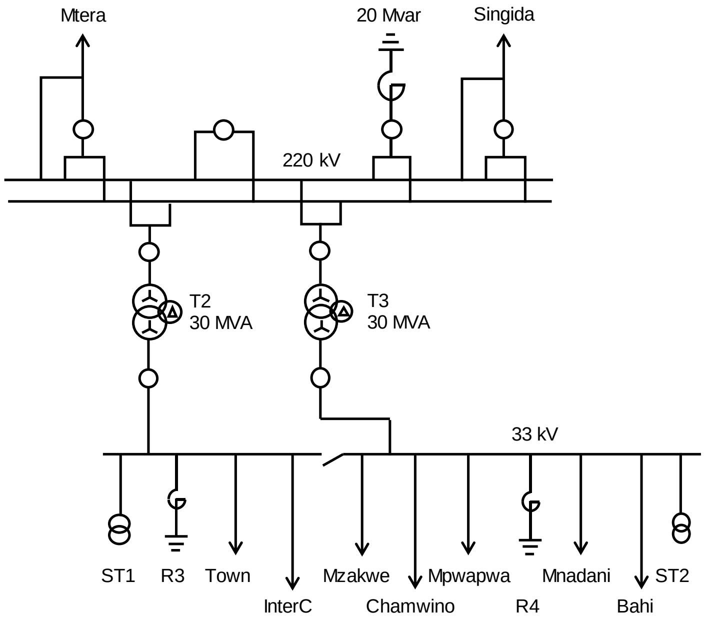
There are two substations in the Dodoma region, one is the 220kV Dodoma substation supplying power to Dodoma capital city and its surrounding areas, and the other is the 66kV Kondoa substation supplying power to the northern area of Dodoma region as shown in Figure 3-5.1. In addition, 220/33kV transformer installation project is now going on at Mtera power plant and 33kV distribution from Mtera power plant will commence after the completion of the construction.



[Source] PSMP 2016 (partially revised by JICA Study Team

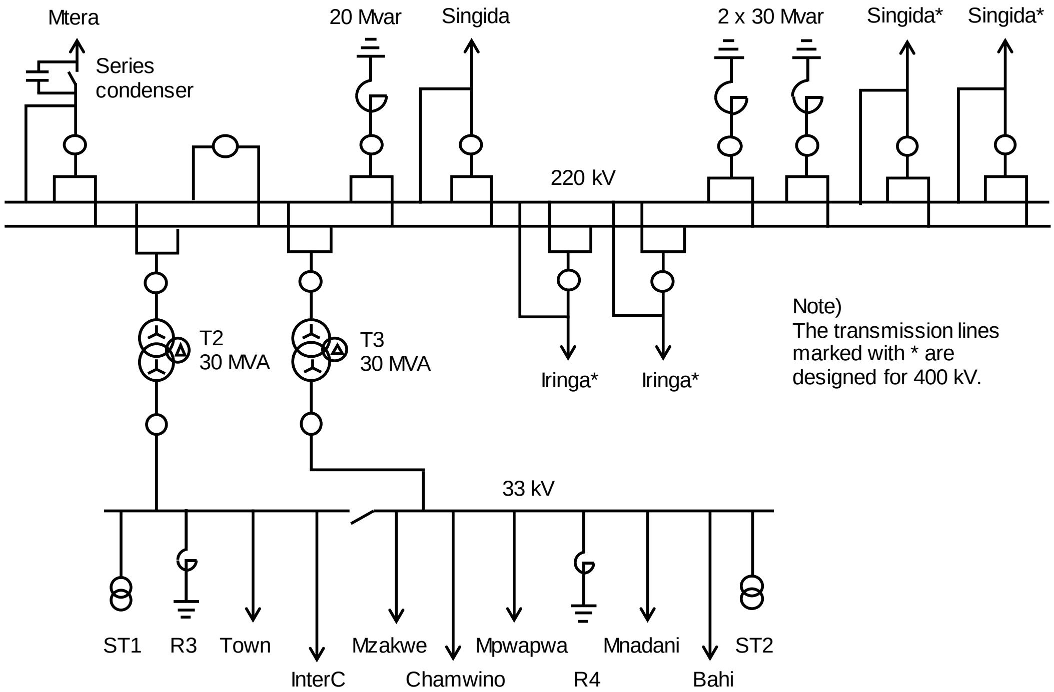
Figure 3-5.1 Network Diagram in and around Dodoma Region

The 220kV Dodoma substation (hereinafter Zuzu substation) was commissioned on 11 May 1986. Figure 3-5.2 shows the single line diagram of Zuzu substation at the time of the first construction. There are two 220kV transmission lines from Mtera hydro power plant and Singida substation. After that, according to BTIP (Backbone Transmission lines Investment Project) of TANESCO, 400kV transmission lines have been constructed from Shinyanga to Iringa through Singida and Zuzu. Consequently, 400kV transmission lines are introduced at Zuzu substation. As of today, the 400kV transmission lines in Zuzu substation are energized temporarily with 220kV, until the construction of 400kV substations (Shinyanga, Singida, Zuzu and Iringa) is completed. The single line diagram and the illustrative layout drawing of Zuzu substation at present (2019) is shown in Figure 3-5.3 and Figure 3-5.4, respectively.



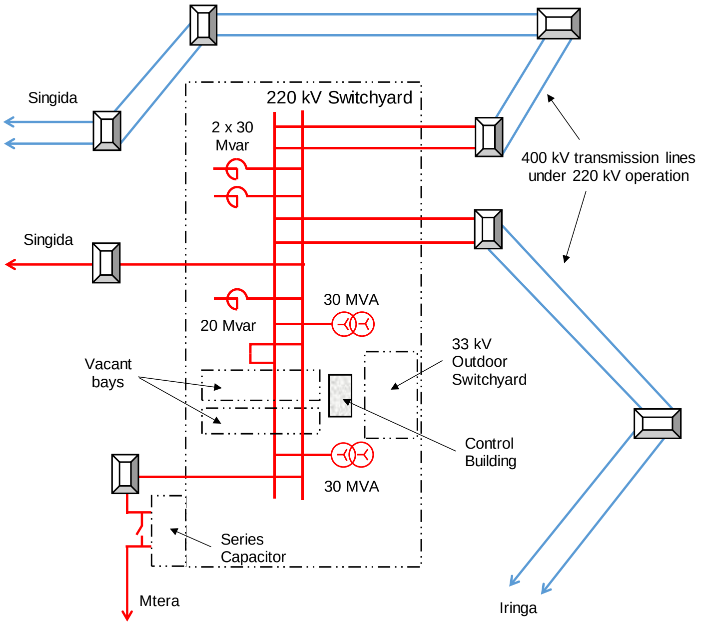
[Source] JICA Study Team

Figure 3-5.2 Single Line Diagram of Zuzu Substation in 1986



[Source] JICA Study Team

Figure 3-5.3 Single Line Diagram of Zuzu Substation in 2019



[Source] JICA Study Team

Figure 3-5.4 Illustrative Layout Drawing of Zuzu Substation in 2019

As shown in the diagram, a bypass circuit is provided on each 220kV feeder bay to maintain its circuit breaker without shutdown of the feeder.

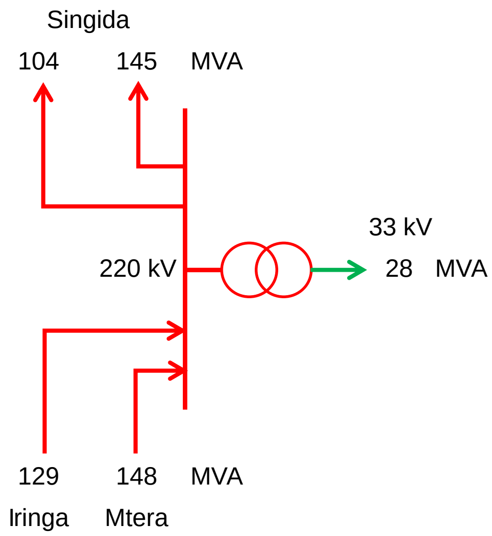
TANESCO had suffered from voltage drop and un-stabilization of the system due to the inductive reactance on the Mtera line. To solve this problem, series condensers were introduced on the Mtera line in 2008. However, the phenomenon has been solved with construction of the 400kV Iringa double circuit in parallel the with Mtera line. Thus, the series condensers on Mtera line are no more utilized.

(2) Power Flow

Figure 3-5.5 indicates the power flow of Zuzu substation at 12:08 on September 28, 2019. The power comes from the south (Iringa substation and Mtera hydro power plant), going to north (Singida). The demand in Dodoma city was approximately 28 to 29MVA on this day.

Consequently, there is enough power for Dodoma city as of today.

Since the installation of two (2) sets of new 125 MVA, 220/33 kV transformer is in progress, the total distribution capacity will be 310 MVA (existing 2 x 30 MVA plus 2 x 125 MVA). Thus, it is expected that Zuzu substation has enough capacity for distribution, considering the development plan of Dodoma capital city explained later in this report.

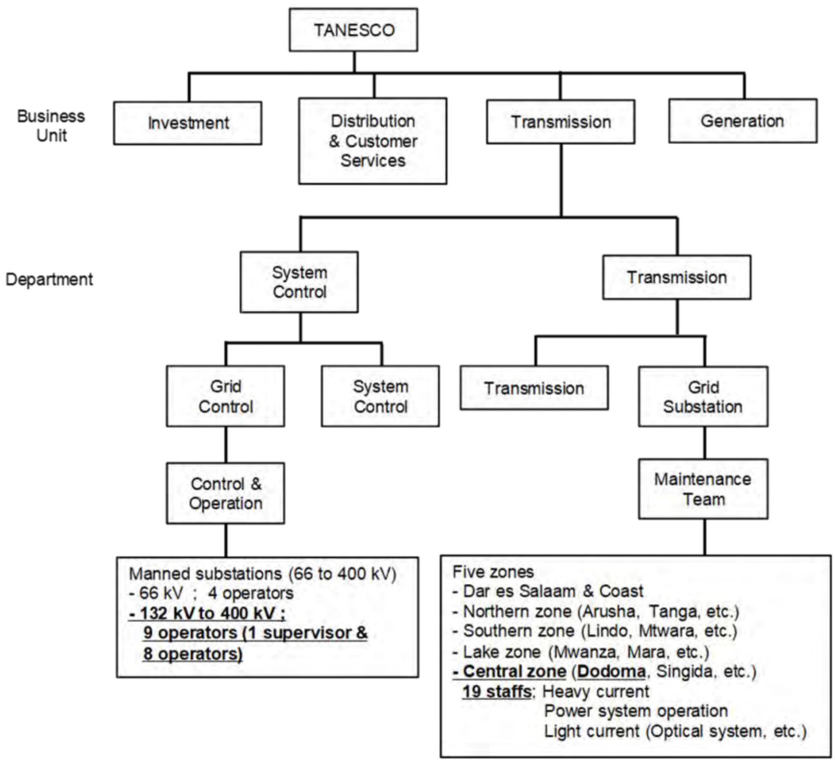


[Source] Confirmed at site by JICA Study Team

Figure 3-5.5 Power Flow of Zuzu Substation

(3) Operation and Maintenance

Figure 3-5.6 shows a part of TANESCO Organization chart.



[Source] Hearing at site by JICA Study Team

Figure 3-5.6 Organization of Operation and Maintenance in Zuzu Substation

Operators and maintenance staff belong to the "Control & Operation" group and "Maintenance Team" group, respectively, as shown below. There are a total of nine (9) operators for operations, consisting of 1 supervisor and 8 operators (4 shifts) and nineteen (19) staff for maintenance, consiting of the "Heavy current", "Power System Protection" and "Light current" groups.

(4) Equipment specifications

The specifications of major equipment in Zuzu substation are as shown in Table 3-5.1 and Table 3-5.2.

Table 3-5.1 30MVA Transformer

Description			Specifications
Equipment No.			T2 and T3
Rated capacity			20/30MVA
Cooling			ONAN/ONAF
Rated voltage	Primary		220kV +/- 8 x 1.25%
	Secondary		33kV
	Vector group		YNyn0(d)
Lightning impulse withstand voltage (kV-p)			1,050（HV）, 95（HVN）,170（LV）
Power frequency withstand voltage (kV)			395（HV）, 38（HVN）, 70（LV）
%Z (@20MVA)		T2	13.18% （@Center tap）
		T3	13.21% （@Center tap）
Altitude			1,200 m

Table 3-5.2 220kV Circuit breakers

Description	Unit	Mtera	New Singida	Bus coupler
Rated voltage	kV	245	245	245
Rated current	A	1,600	1,600	3,150
Rated frequency	Hz	50	50	50
Lightning impulse withstand voltage	kV-p	1,050	1,050	1,050
Power frequency withstand voltage	kV rms	No description	460	460
Rated interrupting current	kA	40	40	40
Rated short-time	S	1	3	3
Operating duty	-	O - 0.3 s – CO – 1 min. - CO	O - 0.3 s – CO – 3 min. - CO	O - 0.3 s – CO – 3 min. - CO
Standard	-	IEC 56 (1987)	IEC 62271-100	IEC 62271-100

3-5-2 Existing Substation Plan and the Challenges

(1) Proposed substation projects

According to the information by TANESCO, the projects related to Dodoma region are as follows;-

1) Completed projects in Dodoma

a) Expansion and Upgrading of 220/33kV Substation at Dodoma Substation under BTIP Phase 1
b) Construction of 400kV double circuit transmission line from Dodoma to Singida and from Dodoma to Iringa under BTIP Phase 1

2) Ongoing projects in Dodoma

a) Construction of 400/220/33kV Substation at Dodoma (Zuzu)
b) Upgrading of Mtera Substation by installation of 220/33kV transformer

3) Proposed project in Dodoma

a) Construction of Chalinze Kilosa to Dodoma 400kV line

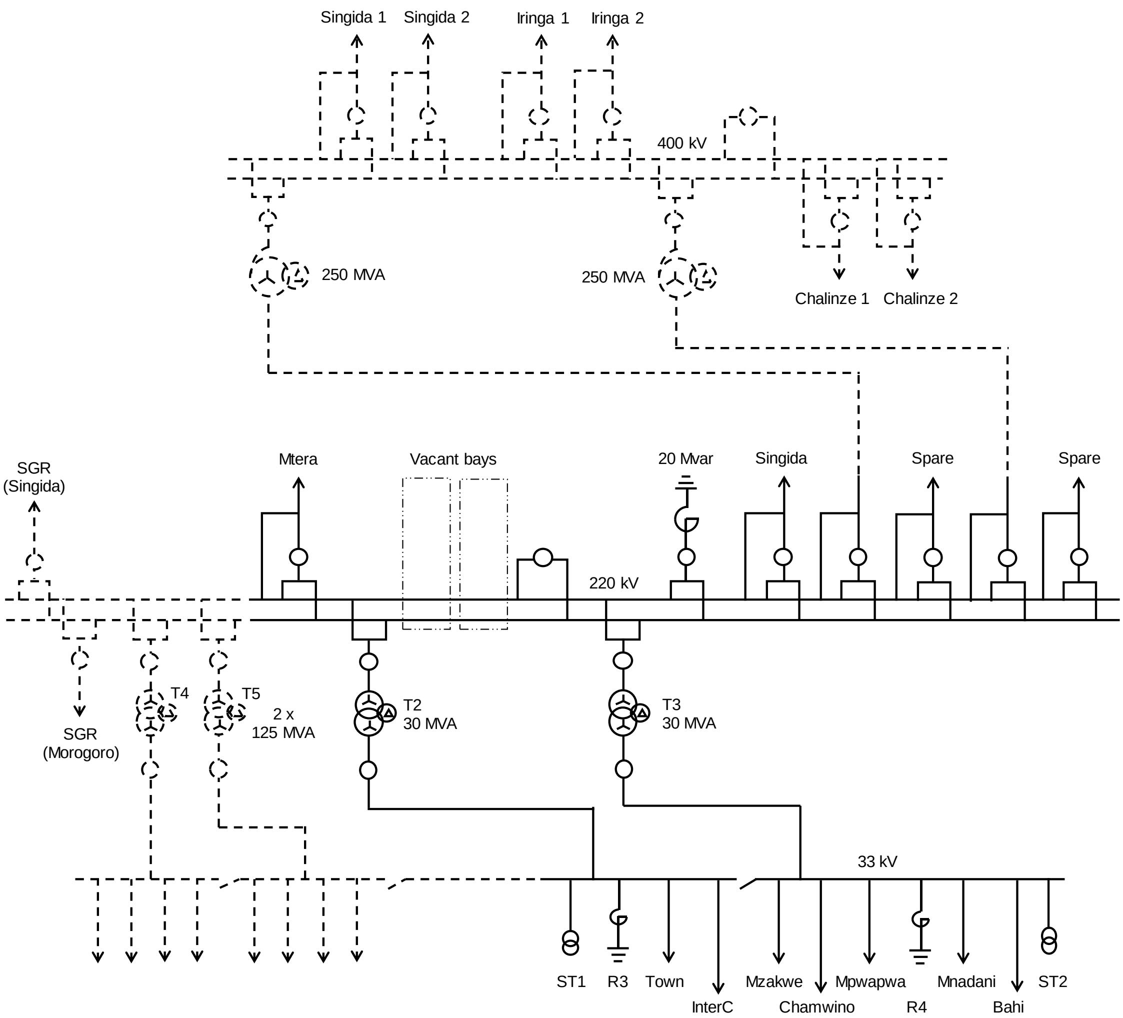
4) The following works are at present ongoing projects at Zuzu substation.

a) Installation of 2 sets of 125MVA, 220/33kV transformers and the associated 220kV switchgear, and

b) Construction works on 400kV switchyard with 2 sets of 250MVA, 400/220kV transformers and associated 400kV switchgear, reactors and other facilities

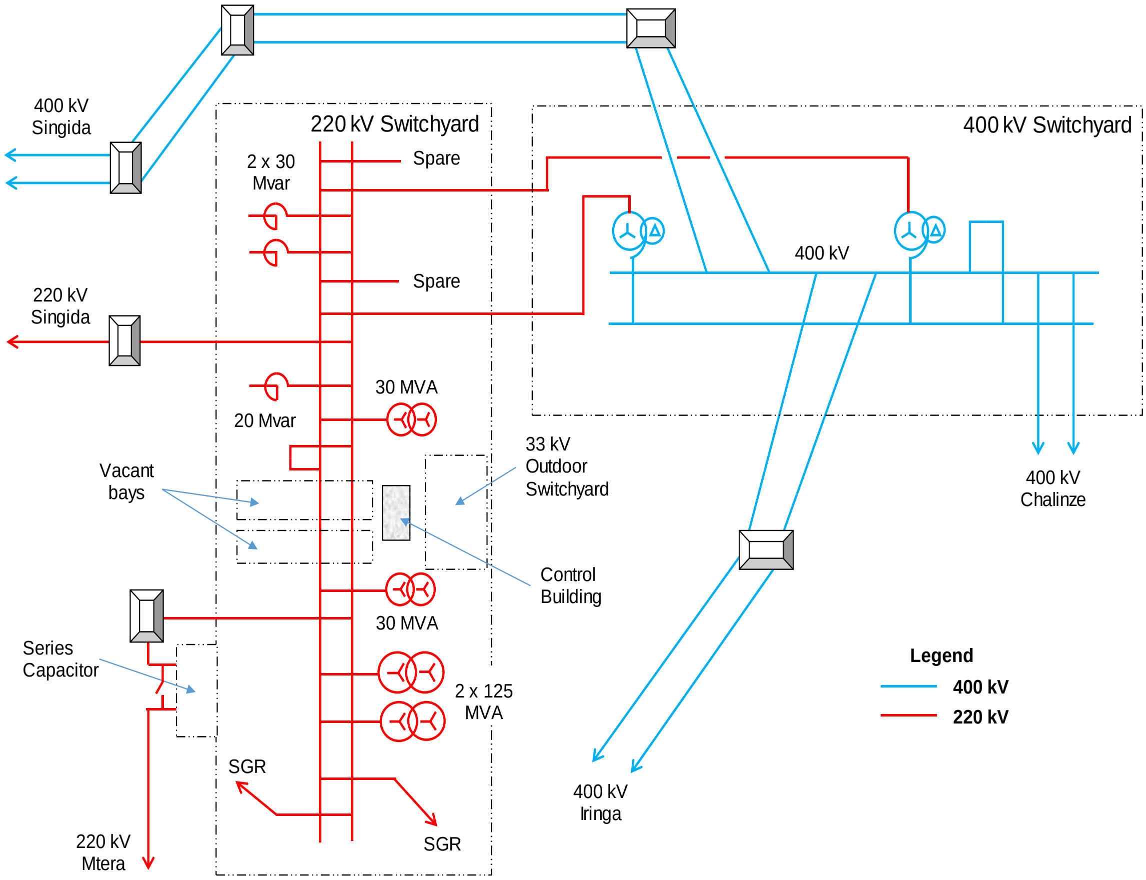
As listed above, 400kV transmission lines (Double circuit) will be constructed from Chalinze substation. In addition, 220kV transmission lines for SGR (Standard gauge railway) will also be connected to 220kV busbar of Zuzu substation from Morogoro and Singida.

According to TANESCO, two sets of 250MVA, 400/220kV transformers will be connected to the present Iringa1 feeder and Singida1 feeder, respectively. Thus, the new single line diagram and the illustrative layout drawing of Zuzu substation is expected as shown in Figure 3-5.7 and Figure 3-5.8, respectively.



[Source] JICA Study Team

Figure 3-5.7 Single Line Diagram of 400/220/33kV Zuzu Substation



[Source] JICA Study Team

Figure 3-5.8 Illustrative Layout Drawing of 400kV Zuzu Substation

(2) Challenges

It is envisaged that two challenges may arise in the future in Zuzu substation.

1) Busbar capacity

According to the hearing at site, the material of 220kV busbar is a single conductor of ACSR Bluejay, i.e., the capacity of the 220kV busbar is approximately 400MVA, while the total capacity of 400/220kV transformer will be 500MVA (2 sets of 250MVA). Thus, the busbar operation should be considered, not to concentrate the power to a part of the busbar when the load of 400/220kV transformers is operated over 400MVA.

2) Control room

There is a little vacant space in the present control room. Since the control and protection panels for the new 125MVA transformers and SGR will be installed soon, it is supposed that there is no more space for further installation of control, protection, communication and other panels. Thus, expansion of the present control room or new control room would be necessary for future projects.

3-6 Basic Information related to Distribution Facilities

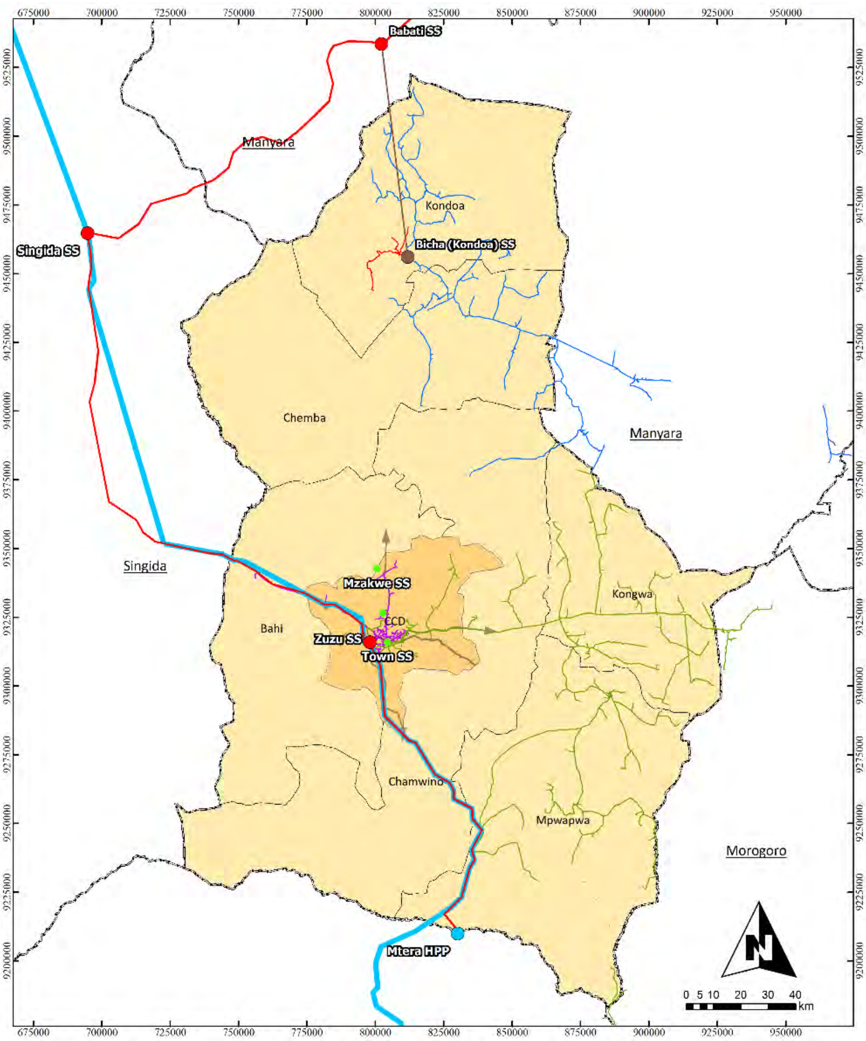
3-6-1 Existing Distribution Facilities

(1) Distribution Network of Dodoma Urban and Suburban areas

1) Outline of the Distribution Network

As shown in Figure 3-6.2, power to the Dodoma Capital City District is supplied by 33kV and 11kV distribution lines from the Zuzu substation, however suburban areas such as Kongwa and Mpwapwa are also supplied power from Zuzu by extending distribution network in radial form, because there is no substation in those areas.

As for the supply from other power systems other than the Zuzu substation, Kondoa area is supplied from Babati substation in Manyara, and some other areas in Dodoma region are supplied from the distribution system in Tanga, Morogoro, and Iringa regions as well.



[Source] Created by JICA Study Team based on the information from TANESCO

Figure 3-6.1 Distribution Network in Dodoma Urban and Suburban areas

2) Outline of the Distribution Facilities

Table 3-6.1 shows the number of distribution transformers, distribution line length of medium voltage and low voltage, number of customers, and distribution area supplied by Zuzu Substation. Table 3-6.2 shows the same information on distribution facilities supplied from other power systems to Dodoma region.

Table 3-6.1 Distribution Feeders of Zuzu substation

220kV S/S	33/11kV Substation Name and Capacity	Names of 11kV and 33kV Feeders	Number of Transformers	Length of 11kV and 33kV Line (km)	Length of LV Line (km)	Number of Customers	Remarks/area of Feeder Supply
ZUZU		MPWAPWA	363	1,389	726	30, 855	CHAMWINO, KONGWA, MPWAPWA&GAIRO
		CHAMWINO	73	87	146	6,205	CHAMWINO
		MZAKWE	1	33	1	1	MZAKWE WATER PUMP
		MNADANI	-	15	-	-	MNADANI SUBSTATION
		TOWN	-	7.2	-	-	DODOMA MUNICIPAL
		BAHI	33	61	66	2,805	BAHI DISTRICT
		INTERCONNECTOR	-	1	-	-	POWER STATION
		MPWAPWA-TOWN	17	26	34	1,445	MPWAPWA DISTRICT COUNCIL
	TOWN (10MVA)	INDUSTRIAL	36	32	72	3,060	ILAZO, MAKOLE, IPAGALA
		TOWN NORTH	32	34	64	2,720	MAJENGO, AIRPORT, JAMHURI, MJI MPYA
		TOWN SOUTH	22	17	44	1,870	UZUNGUNI, GENERAL HOSPITAL
	POWER STATION (5MVA)	ZUZU SOUTH	28	16	56	2,380	UZUNGUNI, KIKUYU
		BRICK/BUSH	38	142	76	3,230	MVUMI, MPUNGUZI, BIHAWANA
		ZUZU NORTH	59	21	118	5,015	NDACHI, NKUHUNGU, AREA A
	MNADANI (15MVA)	MNADANI-TOWN	43	28	86	3,655	AREA C, AREA D, AREA E, MAILI MBILI
		MNADANI-VEYULA	27	33	54	2,295	MAKUTOPOLA, VEYULA, MSALATO
	MZAKWE	MAMBA YA MBALI	10	12	20	850	MAMBA YA MBALI
		BOOSTER PUMP	2	0	4	170	MZAKWE BOOSTER PUMP
		KILUNGULE and MUNDEMU	11	15	22	935	KILUNGULE, MUNDEMU

[Source] TANESCO Dodoma Regional Office

Table 3-6.2 Distribution Feeders supplied from other than Zuzu substation

Source Region/ District	Source Substation	Names of Feeders	Number of Transformers	Length of HT Line (km)	Length of LV Line (km)	Number of Customers	Remarks/area of Feeder Supply
IRINGA	TAGAMENDA	KILOLO	14	82	84	1,063	MPWAPWA
TANGA	KILOLE	HANDENI	2	33	12	165	KITETO KIJUNGU
MOROGORO	MSAMVU	BEREGE	4	12	24	126	GAIRO IYOGWE, MAKUYU
KONDOA	BICHA	KIBAYA	87	320	174	7,395	KONDOA and KITETO
		PAHI	33	230	66	2,805	PAHI, KOLO, MNENIA
		KONDOA	23	58	46	1,955	KONDOA DISTRICT COUNCIL

[Source] TANESCO Dodoma Regional Office

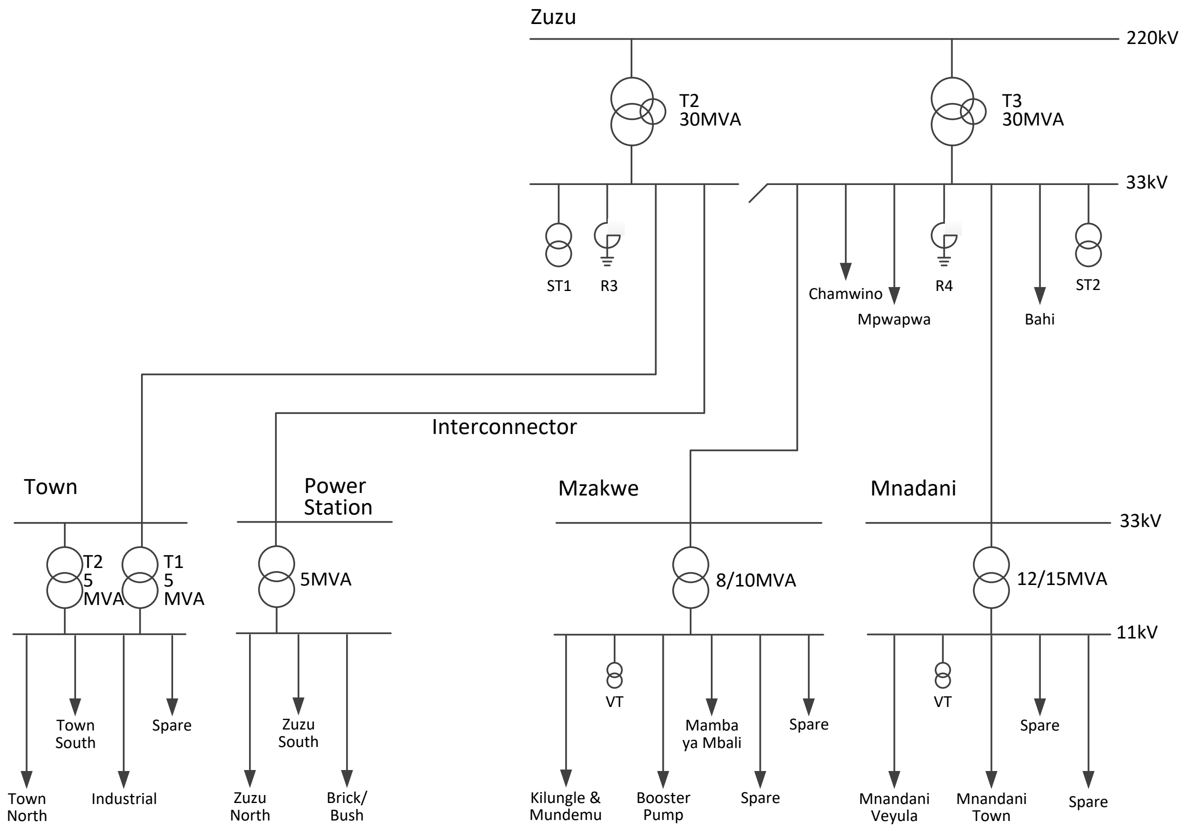
The total line length of one distribution line is 1400km. In such situation, TANESCO is currently facing difficulty in proper customer service management, because of serious voltage drops and power loss. This becomes a major challenge, as TANESCO needs to supply quality power to the suburban areas, in addition to considering the rehabilitation and expansion of power distribution facilities, or countermeasures against increasing power demand.

(2) Existing Distribution Facilities in Dodoma Capital City District

1) Distribution System

The system voltages for medium voltage distribution are 33kV and 11kV, and the low voltage is generally distributed at 400 / 230V using three-phase 4 wire or single-phase 2 wire systems, adopting a radial distribution system. The electric power that is stepped down from 220kV to 33kV at Zuzu substation is supplied to the distribution substation (33/11kV substation), or is directly distributed to the customer and stepped down to the low voltage at 400 / 230V to supply power.

Currently, within the Dodoma Capital City District, voltage is stepped down to 11kV at Zuzu substation and three distribution substation (33/11kV substation), and distributed to demand areas, but also stepped down to 400V / 230V in the demand areas. Figure 3-6.2 shows the distribution system configuration of Dodoma Capital City District.



[Source] Created by JICA Study Team based on the information from TANESCO

Figure 3-6.2 Current Distribution Network of Dodoma Capital City District

In Tanzania, there is a Tanzanian Grid Code defined by the Energy and Water Utilities Regulatory Authority (EWURA), with TANESCO having their own Engineering Instruction and standard specifications to maintain and operate distribution facilities. Table 3-6.3 shows typical criteria related to distribution facilities.

Table 3-6.3 Code and/or Standard related to Distribution System

Contents	33kV System	11kV System	Low Voltage
Frequency (Permissible Variation)	50Hz (±2.5%)		
Nominal Voltage (Permissible Limit)	33kV (±10%)	11kV (±10%)	400V (±5%)
Neutral Earthing System	Effectively Earthed		
Wayleave (Distance from the center)	10.0m (5.0m)	5.0m (2.5m)	—
Phase to Earth Clearance	600mm	350mm	—
Phase to Phase Clearance	600mm	350mm	—
Ground Clearance (Normal)	6.0m	6.0m	5.5m

[Source] Created by JICA Study Team based on the information from TANESCO

2) Conductor

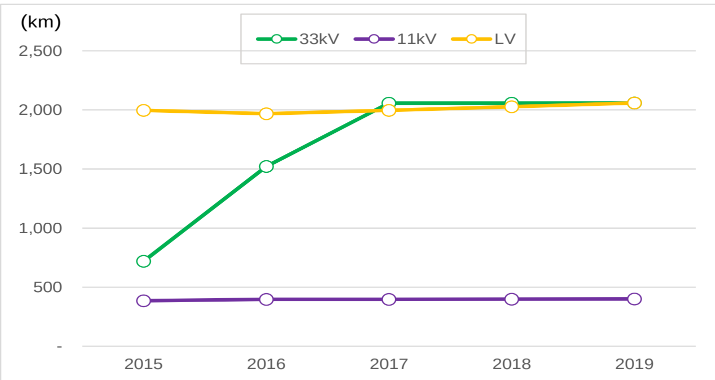
Most of the existing distribution lines in the Dodoma Capital City District are overhead distribution, and ACSR100mm^2 (dog) is often used as conductor. Recently TANESCO standard ACSR150mm^2 (Dingo) is often adopted. Table 3-6.4 below shows the referential distribution capacity when each conductor is adopted for 33kV and 11kV.

Table 3-6.4 Distribution Capacity (Reference)

Conductor	Code (BS standard)	Current Rating	33kV	11kV
			Capacity MVA	
ACSR 100mm^2	Dog	390A	22.29	7.43
ACSR 150mm^2	Dingo	473A	27.03	9.01

[Source] Calculated by JICA Study Team based on manufacturer's catalogue

Figure 3-6.3 shows transition of the length of the distribution lines under the jurisdiction of TANESCO Dodoma Regional office from 2015 to 2019. According to an interview with TANESCO, expansion of the 33kV distribution line was promoted from 2015 to 2017 as a voltage drop countermeasure. As a result, the 33kV medium voltage line is approximately 2,060km, the 11kV medium voltage line is 401km, and the low voltage line is 2,060km as of June 2019.



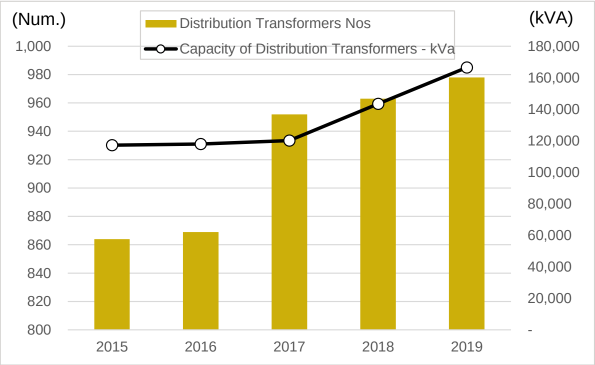
[Source] TANESCO Monthly Report
[Remark] Total length is for all Dodoma Region

Figure 3-6.3 Total Distribution Line Length in Dodoma Region

3) Distribution Transformer

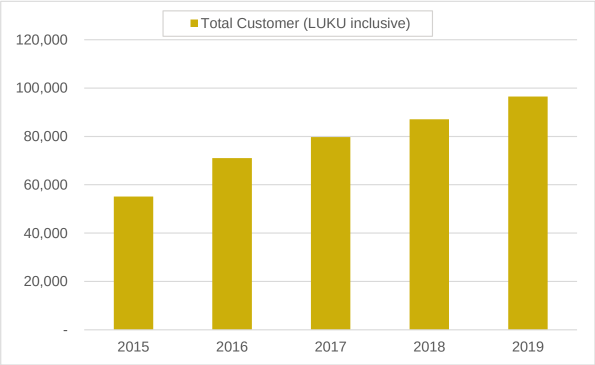
There are six types of Pole Mounted distribution Transformers (PMT) with capacities of 25kVA, 50kVA, 100kVA, 200kVA, 315kVA and 500kVA, and Ground Mounted distribution Transformers (GMT) with capacities of 630kVA, 800kVA and 1,250kVA that step down the voltage from 33kV to11kV, and to low voltage.

The number of distribution transformers managed by TANESCO Dodoma Regional Office is shown in Figure 3-6.4, and the transition in the number of customers from 2015 to 2019 is shown in Figure 3-6.5. While the number of customers in the right figure shows a certain increase, the increase in the number of transformers and capacity has shown a steady increase since 2017. It seems like a result of countermeasures against power demand increasing, and expansion of the demand area.



[Source] TANESCO Monthly Report
[Remark] Total number is for all Dodoma Region

Figure 3-6.4 Number of Distribution Transformer in Dodoma Region



[Source] TANESCO Monthly Report
[Remark] Total number is for all Dodoma Region

Figure 3-6.5 Number of Customers in Dodoma Region

4) Support

Wooden poles are used as support for overhead lines in the Dodoma Capital City District. TANESCO uses 9m and 10m for low-voltage distribution lines and 11m and 12m for medium-voltage distribution lines.

The span distance is typically 100m for single-line distribution in the residential area and 80m for 2 circuit lines, but as a typical example outside the Dodoma Capital City, three-phase single circuit distribution line using a 150mm^2 conductor has 90m span standard, while maximum span is 100m.

5) Insulators

Pin insulators, disc insulators, and post insulators are used as standard, but materials such as glass, porcelain, and synthetic resin are mixed.

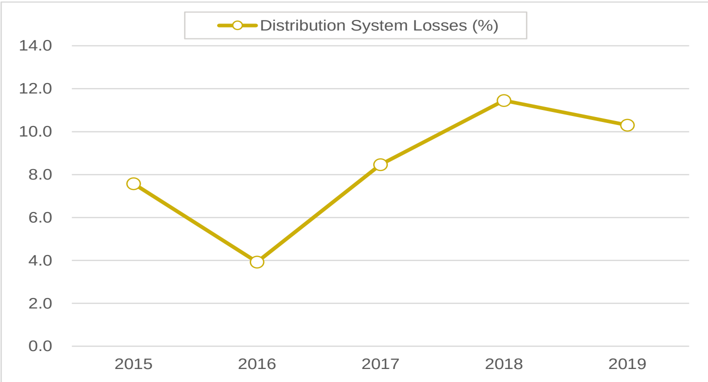
6) Switching device

On the distribution line, cut out fuse (Drop Out Fuse (DOF) is typically used for line protection, load switching.

(3) Condition of the existing distribution network

1) Distribution Loss

Figure 3-6.6 shows the distribution loss (system loss) for the entire Dodoma region from 2015 to 2019. System loss has increased since 2017, when there was a significant increase in facilities such as 33kV distribution lines and transformers, but it is gradually improving forward to 2019. The cause of the high loss is speculated, but it is also thought that the increase in facilities more than the increase in demand.



[Source] TANESCO Monthly Report
[Remark] Figures are based on the annual average for Dodoma Region

Figure 3-6.6 Distribution System Loss in Dodoma Region

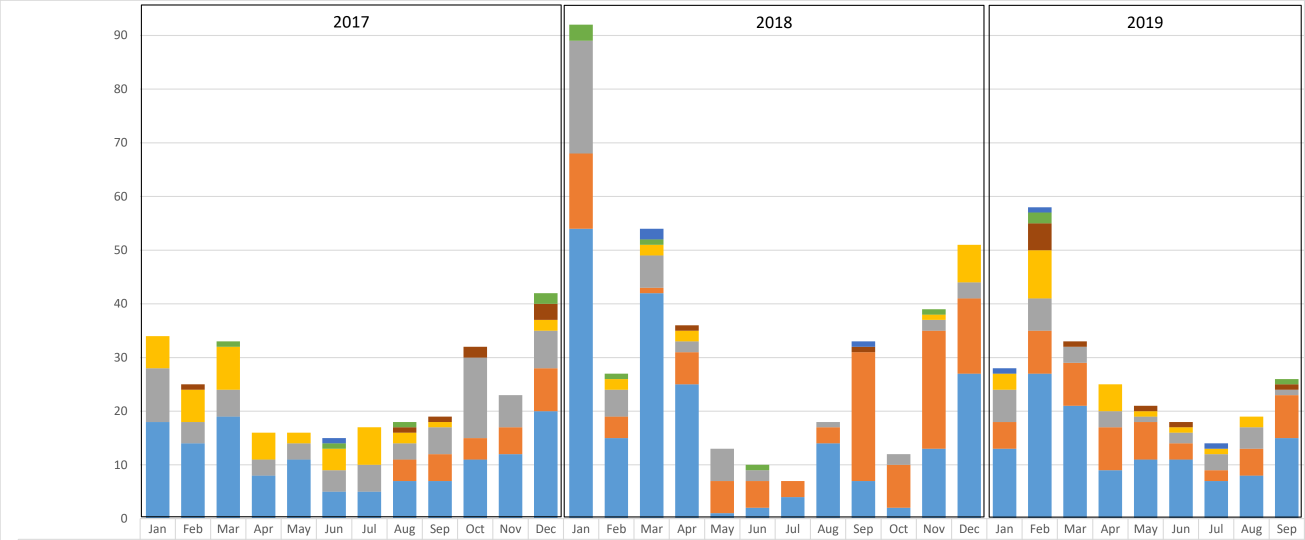
2) Distribution Reliability

The distribution reliability evaluation indicators include 2) the average number of power outages per customer per year, b) the average power outage time per customer, and c) the power interruption caused by a single accident. Although TANESCO provided the Study Team with monthly reports for a period of five years, i.e. from 2015 to 2019, the team was not able to evaluate the data because of Numerical discrepancy in the data.

For this reason, the power outage records for each distribution feeder in the Dodoma Capital City District for the past three years, which were obtained separately, were used as part of the distribution reliability.

Figure 3-6.7 shows the number of power outages at the 33kV distribution feeders at Zuzu Substation.

In total 924 power outages were recorded for about 3 years. Mpwapwa feeder accounted for 465 times 50.3% of the total, followed by 190 times (20.6%) for Bahi feeder and 149 times for Chamwino feeder (16.1%). Clearly, the number of accidents on the three feeders distributed over a long distance to the demand area at 33kV is increasing in fact. In addition, the trend is that the number of power outages from November to March, when rainfall is high throughout the year, is high.



2017	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
33KV ICI	0	0	0	0	0	1	0	0	0	0	0	0
33kV TOWN	0	0	1	0	0	1	0	1	0	0	0	2
33KV MNADANI	0	1	0	0	0	0	0	1	1	2	0	3
33KV MZAKWE	6	6	8	5	2	4	7	2	1	0	0	2
33KV CHAMWINO	10	4	5	3	3	4	5	3	5	15	6	7
33KV BAHI	0	0	0	0	0	0	0	4	5	4	5	8
33KV MPWAPWA	18	14	19	8	11	5	5	7	7	11	12	20

2018	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
33KV ICI	0	0	2	0	0	0	0	0	1	0	0	0
33kV TOWN	3	1	1	0	0	1	0	0	0	0	1	0
33KV MNADANI	0	0	0	1	0	0	0	0	1	0	0	0
33KV MZAKWE	0	2	2	2	0	0	0	0	0	0	1	7
33KV CHAMWINO	21	5	6	2	6	2	0	1	0	2	2	3
33KV BAHI	14	4	1	6	6	5	3	3	24	8	22	14
33KV MPWAPWA	54	15	42	25	1	2	4	14	7	2	13	27

2019	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
33KV ICI	1	1	0	0	0	0	1	0	0
33kV TOWN	0	2	0	0	0	0	0	0	1
33KV MNADANI	0	5	1	0	1	1	0	0	1
33KV MZAKWE	3	9	0	5	1	1	1	2	0
33KV CHAMWINO	6	6	3	3	1	2	3	4	1
33KV BAHI	5	8	8	8	7	3	2	5	8
33KV MPWAPWA	13	27	21	9	11	11	7	8	15

[Source] TANESCO FEEDER OUTAGE 2015-2019
[Remark] Figures are the total number of Unplanned and Planned power outages, and load shedding

Figure 3-6.7 Record of Power Outages on Zuzu 33kV Distribution Feeders (2017 - 2019)

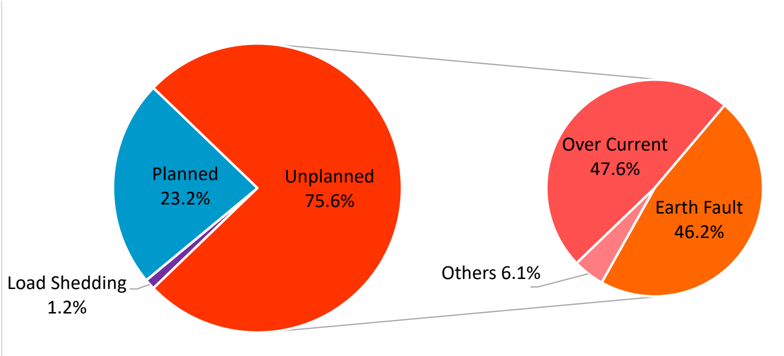
As of October 2019, there are 11 number of 11kV distribution feeders in Dodoma Capital City District, and there is a feeder with a total length of 140km in the long one, but there are few accident records for each feeder.

According to an interview with TANESCO, the distribution substation (33/11kV substation) that supplies 11kV in distribution feeder are unmanned (only security guard); furthermore, the accident reports after the accident removal may not be recorded properly.

Next, Figure 3-6.8 shows the ratio of power outages by type, and total number of outages of 924 for approximately 3 years at 33kV distribution feeders at Zuzu Substation.

Power outages due to accident accounts for about 75% of the total, power outages for maintenance are about 23%, and power outages by load shedding are less than 2%.

The types of power outages by accident are about 47% and 46% respectively due to overload and earth fault. In Dodoma Capital City District, bare wires are generally used, and it is thought that there are many power supply interruptions due to touch with trees, birds, and beasts. Since bare wires are generally used in 11kV distribution lines and low voltage distribution lines in addition to 33kV, electric shock by accident might occur.



[Source] TANESCO FEEDER OUTAGE 2015-2019

Figure 3-6.8 Percentage by type of power outage of Zuzu 33kV distribution feeders (2017 - 2019)

3-6-2 Existing Distribution Plan and the Challenges

TANESCO Dodoma Regional Office is busy with consultations and complaints from customers and local government agencies, etc., and as countermeasures against gradual expansion of demand areas as demand increases with aging of existing facilities, extension, replacement and reinforcement of distribution network and facilities.

(1) Existing Distribution Plan

Basically, TANESCO has the policy of continuously operating existing overhead distribution lines due to cost and manageability; however, the areas where future expansion and maintenance are planned such as the Government City and the Capital Business District (CBD) are expected to become highly dense areas with underground distribution lines preferred instead of existing overhead distribution lines.

In addition, as previously implemented in Dar es Salaam and the coastal region (Pwani), the distribution network management, to monitor and control at the distribution Control Center (DCC) with Geographic Information System (GIS) is planned.

(2) Improvement and renewal of the existing distribution facilities

The typical power distribution improvement or renewal plans in Dodoma Capital City District planned by TANESCO are as follows.

1) Upgrade of Brick feeder route length 70km from 11kV to 33kV

2) Upgrade of Zuzu North route length 8km from 11kV to 33kV

3) Improvement of substation facilities at Zuzu Power Station

a) Addition of two transformers of 2x8MVA capacity
b) Addition of 3x11kV distribution feeders for Zuzu north, Zuzu south and Brick
c) Construction of new control building

4) Upgrade of Town substation

a) Addition of two transformers of 2x15MVA capacity

b) Addition of 6x11kV outgoing feeders
c) Construction of new control building

5) Upgrade of Mzakwe substation

a) Addition of a new transformer (10MVA, 33/11kV)

6) Upgrade of Mnadani substation

a) Addition of a new transformer (15MVA, 33/11kV)

(3) Distribution Master Plan

Currently, TANESCO has conducted with the consultant (SMEC) distribution master plan study in four regions, Arusha, Dodoma, Mbeya and Mwanza, and shall be complete the formulation of the master plan by the end of June 2020.

The scope of the master plan study in brief includes the following activities:

a) Review of existing transmission and distribution system in Arusha, Mwanza, Dodoma and Mbeya regions;
b) Data collection and analysis for existing transmission and distribution networks in Arusha, Dodoma, Mbeya and Mwanza;
c) Load forecast study for short term (5 years), medium term (10 years) and long term (25 years);
d) Power system modelling and studies and analysis of interconnected networks;
e) Identification of sub-projects for system upgrade / reinforcement or new system installation for Arusha, Dodoma, Mbeya and Mwanza cities/regions for short, medium and long term to meet the load growth requirement;
f) Preparation of conceptual design for these identified sub-projects;
g) Carry out environmental and social assessment and prepare environmental management plan of these identified sub-projects;
h) Prepare cost estimates for identified sub-projects;
i) Carry out technical and economic analysis of identified sub-projects;
j) Prepare project implementation plan for identified sub-projects;
k) Prepare distribution planning manual;
l) Recommend the way forward for smart grid system;
m) Prepare underground cable distribution system plan for cities of Arusha, Mwanza, Dodoma and Mbeya;
n) Carry out capacity building and training of Client counterpart staff.

(4) Challenges

The following challenges can be considered in the current distribution planning.

1) System Voltage

At the present, TANESCO has two types of voltages in 11kV and 33kV for distribution system in Dodoma Capital City District. From the viewpoint of countermeasures to increasing power demand, superiority in voltage operation and future operation manageability, etc., there was an idea in TANESCO to upgrade and to unify 11kV distribution voltage to 33kV. Actually, in Dodoma Capital City, such effort has been planned and carried out in some parts of the entire distribution network. However, because a unified office view within TANESCO has not yet been finalized, thus the existing plans to improve distribution system still include a mix of 33kV and 11kV distribution line expansion and extensions, etc.

2) Distribution System

Based on the provided drawings and interviews with TANESCO, the existing power distribution system is a typical radial system. This is because of natural derivation by repeating extension or expansion of distribution network to accord power demand increase or new connection or necessary service for the customers. As a result, the total length of the distribution line becomes longer, increasing the risk of power distribution loss and accidents on distribution feeders. In addition, in case of accident, since there are few devices to confine areas on the distribution lines, it is not easy to ensure the safety of workers in terms of maintenance manageability, and results in longer power outages, etc. It is recommended to consider taking drastic measures such as adaption of new distribution system and/or facilities to make more reliable power supply to customers.

Chapter 4 Basic Policy and Plan for reinforcing Dodoma Transmission and Distribution Network

Chapter 4 Basic Policy and Plan for reinforcing Dodoma Transmission and Distribution Network

4-1 Basic Policy for Dodoma Transmission and Distribution Development Plan

In Chapter 4, Transmission and Distribution System Development is recommended in order to contribute to cooperation policy consideration based on the demand allocation, review of power demand forecast, current development progress of the capital city, current conditions of the existing transmission, substation and distribution facilities and their development plans, and challenges described in Chapter 2 and Chapter 3.

As for the distribution development plan stated in this report, the Study Team has provided some recommendations based on the information exchange with TANESCO that might contribute to the development of the ongoing distribution master plan study.

4-2 Power demand forecast

4-2-1 Outline of the review

(1) Precondition for power demand forecast

The power demand forecast in this survey is a judgment on the validity of the demand assumption in Dodoma (details described in 3-3-4) implemented by TANESCO. The judgment is performed based on the power demand forecast that was implemented in PSMP2016.

In detail, to adjust the demand forecast implemented in PSMP2016 with recent actual power consumption, after comparing adjustment assumption with TANESCO's assumption.

Therefore, it is first reported that the demand forecast is not implemented by reviewing the basic data.

The precondition of power demand forecast is described as follows.

- ✓ Regarding the demand forecast implemented in PSMP2016, to modify the forecasted value with currently GDP growth rate, the trend of population growth and the grid connection situation of large-scale customer. Then confirm whether the reviewed demand forecast is closer to the growth case of High, Base or Low set by PSMP2016.
- ✓ The major load added by transfer of government functions (hereafter called specific load) was not considered by PSMP2016. Based on the information of Dodoma MP and TANESCO, to clarify the contents of specific load and commissioning date.

1) GDP

For the transition of real GDP, the Study Team referred to Country Strategy Paper 2016-2020 prepared by AfDB and Tanzania in figures 2018 of National bureau of statics Dodoma.

Average real GDP has not reached 7% growth level in any of the statics.

Table 4-2.1 GDP growth rate

Reference	National Bureau of statistics Dodoma								AFDB
Year	2012	2013	2014	2015	2016	2017	2018	Average (2012-2018)	Average (2011-2015)
Actual GDP (Billion TZS)	77,980	83,268	88,874	94,349	100,828	107,657	115,140	-	-
GDP growth rate	-	6.78%	6.73%	6.16%	6.87%	6.77%	6.95%	6.71%	6.4%

[Source] Tanzania in figures 2018 National Bureau of statistics Dodoma and Country strategy paper 2016-2020 AFDB

In addition, the estimated GDP growth rate for each case in PSMP2016 is as shown below. As result of comparison with the above-mentioned actual value of GDP growth rate, it is assumed that the value is close to the low case set in PSMP2016.

Table 4-2.2 Scenario setting for GDP growth in PSMP2016

	2013-15	2015-20	2020-25	2025-30	2030-35	2035-2040
HIGH	7%	8%	8%	8-10%	8-10%	8-10%
BASE	7%	7%	7%	6%	6%	5%
LOW	7%	6%	6%	5%	5%	4%

[Source] PSMP2016

2) Trend of population growth

The table below compares the trend of population growth in Dodoma State in recent years and the expected value of population growth in PSMP2016.

Table 4-2.3 Comparison of trend of population growth and expected value

Yrar	2012	2015	2016	2017	Population growth rate (%) 2017/12
Actual value (Dodoma M/P)	2,083	-	2,265	2,312	2.1%
Assumption (PSMP2016)	2,083	2,234	2,281	2,329	2.3%

[Source] PSMP2016 and Dodoma Master Plan

The Dodoma Master Plan mentions the transfer of government employees to Dodoma during 2018-2019. They are as follows: 6,960 ministries, 1,271 other government employees, and 7,988 Tanzania military personnel. The total number of personnel is 16,219. If the families of the personnel are included, an upside of around 50,000-60,000 is expected. In response, construction of government offices for Tanzania military personnel in Dodoma State is almost complete, whilst construction of schools and housing complexes for employee families are proceeding at a rapid pace.

3) Grid connection situation of large-scale customer.

The following is a list of large customers who have already applied for grid connection to TANESCO and are waiting for approval. They are expected to connect in the future.

Table 4-2.4 Large customers (Applied for grid connection)

No	Name of project	Capacity
1	Bodi ya Nafaka na Mazao Mchanganyiko	1.5MW
2	KASCO Mundemu	1.8MW
3	Pyxus kizota	0.8MW
	total	4.1MW

[Source] TANESCO

Table 4-2.5 Large customers (Expected to be connected customer)

No	Name of project	capacity	No	Name of project	Capacity
1	Noli Mining	2.9MW	6	Maji ya shamba mining site	2.9MW
2	Mtembeta & Chigongwe	5.9MW	7	Tumbelo mining site	1.5MW
3	Quarry-Haneti	1.5MW	8	Mulembule mining area	1.5MW
4	Fufu Mining site	0.8MW	9	Gulwe mining area	0.8MW
5	Itiso Mining site	2.9MW		total	20.7MW

[Source] TANESCO

In PSMP2016, the large-scale customers such as mining, industrial parks, etc., are organized with expectation that they have capacity of 0.5MW or more, and results of local surveys are described.

The large scale projects are not always carried out as planned, so new power demands up to 2025 are derived based on "establishment of feasibility" (establishment of achievement) set for each region.

Table 4-2.6 Estimating new power demand

		2015	2020	2021	2022	2023	2024	2025
①	Power demand of big project	0	15.3	15.3	15.3	15.3	15.3	15.3
②	Realization probabilities of big project	100 %	85.9 %	83.3 %	80.8 %	78.4 %	76 %	73.7 %
③	Additional power demand of big project (③=①x②)	-	13.1	12.7	12.4	12.0	11.6	11.3

[Source] PSMP2016

Total capacity of the applied customers and expected customer calculated is 24.8MW (4.1+20.7). The value multiplied by the diversity factor of 0.6 is 14.88MW. The initial forecast for additional demand assumed for 2020 by PSMP is 15.3MW, which is considered the diversity factor as well. The large-scale customers who will connect to the grid in medium to long term are unknown, but it was confirmed that the forecasted value in PSMP for 2020 is almost equal to the demand of customers who are expected to be connected to the grid near future. Thus, it is judged that the forecasted demands of large-scale customers in PSMP would be applicable for further utilization.

4-2-2 Study conditions

(1) Study for specific load

The specific load that accompanies Dodoma capital function relocation was calculated with reference "2-3-2 Expansion of Urban area and Infrastructure Development". Regarding the development period, commissioning date of specific load will be completed by 2029, described as the final year of phase-2 (completion of government building and government agency) in Dodoma MP.

For government facilities and embassies in each country, the number of facilities was calculated with reference to the city plan, prepared by the Ministry of Lands, Housing and Human settlements Development. The assumed load capacity is based on the similar load that has been supplied by TANESCO. As a result, the total specific load added with the transfer of capital function was approximately 105.0MW. The breakdown of specific load is as follows.

Table 4-2.7 Specific load

No	Specific load in Dodoma	Capacity (MW)	Progress
1	Dry Port	1.00	Not start
2	EPZ (Msalato)	16.00	Not start
3	Marshalling Yard	2.40	Not start
4	Airport (Msalato)	12.00	Not start
5	State House (Chamwino)	1.00	Construction completed
7	Butcher Factorie (Ihumwa)	1.00	Not start
8	Quarters 40,000 plots	3.20	unknown
9	TPDF Quarters	2.00	Not start
10	Industrial area (Nala Nala area)	36.00	Not start
11	Government city [See Table 4-2.8]	100.08	Land plan completed
	Total	174.68	
	Diver city factor - 60%	104.81	

[Source] TANESCO

Table 4-2.8 Break down of load of Government city

No.	Specific load	Capacity (kW)	For
1	Vice President's Offices - Union and Environment	600	OFFICES FOR MINISTRIES
2	Vice President's Office Policy and Parliament	600	
3	Prime Minister's Office-Work, Youth, Employment and Disability	600	
4	President's Office - Region Administration and Local Governance	504	
5	President's Office -Public Service Recruitment Secretariat and Good Governance	252	
6	Ministry of Finance and Planning	600	
7	Ministry of Industries, Trade and Investment	600	
8	Ministry of Lands, Housing and Settlements Development	800	
9	Ministry of Home Affairs	400	
10	Ministry of Veterinary and Fishing	252	
11	Ministry of Agriculture	600	
12	Ministry of Natural Resources and Tourism	400	
13	Ministry of Construction, Transport and Communication	504	
14	Ministry of Water and Irrigation	400	
15	Ministry of Health, Community Development, Gender, Elderly and Children	800	
16	Ministry Constitution and Legal Affairs	600	
17	Ministry of Information, Culture, Art and Sports	600	
18	Ministry of Foreign Affairs and East Africa, Regional and International Cooperation	600	
19	Ministry of Education Science, Technology and Vocational Training	600	
20	Ministry of Minerals	600	
21	Ministry of Energy	600	
22	Ministry of Defence and National Service	600	
23	CAG	400	GOVERNMENT OFFICE
24	Quarters(131)	33,012	GOVERNMENT QUARTERS
25	Diplomatic offices(647)	25,600	DIPLOMATICS
26	Hotels	3,600	COMMERCIAL CENTRE
27	Shopping Malls	2,560	
28	Banks	4,800	
29	Cinema Halls	800	
30	Public Parkings	1008	
31	Community Halls	504	
32	Petrol Stations	800	
33	Restaurants	504	

No.	Specific load	Capacity (kW)	For
34	Future Use plot	1,200	
35	Football grounds	756	CITY PARK
36	Tennis and Badminton	640	
37	Public Parking and Water Rock Garden	400	
38	Basketball	640	
39	Netball	640	
40	Cricket	160	
41	Volleyball	640	
42	Handball	640	
43	Cycling and Skating	160	
44	Hockey	160	
45	Terminal site	160	
46	Amusement park	160	
47	Commemorative Square	160	
48	Procession way	160	
49	Indoor Sports Hall	252	
50	Flora and Fauna	80	
51	Memorial Hall	80	
52	Fountains	80	
53	Gazebos Aquarium	80	
54	Nyerere Status	80	
55	Passenger waiting Hall	80	
56	Square	80	
57	Control Center	80	
58	Boarding Bay	80	
59	Disembarking Bay	80	
60	Monument	80	
61	Swings	80	
62	Seimming Pools	160	
63	Skating Court	80	
64	Taxi Bay	80	
65	Tram Platform Bay	80	
66	Kids Store (Toys)	80	
67	Mobile Retails	80	
68	Roller Coaster	80	
69	Truck Ride System	80	
70	Horror Square Attraction	80	
71	National Library	504	CIVIC CENTRE
72	Court of Appeal	400	
73	NEC	252	
74	COSTECH	252	
75	Community Halls	252	
76	Theatre	252	
77	National Museum	252	
78	Art Gallery & Cultural Centre	160	
89	Registrar of Political Parties	160	
80	Open space with food Palou	252	
81	Future Use plot	400	
82	Hospital	640	PUBLIC FACILITIES
83	Control Centre	252	
84	Police Post	400	
85	One Stop Service Centre	200	

No.	Specific load	Capacity (kW)	For
86	Post Office	252	
87	International School	160	
88	WASTE WATER TREATMENT	252	WATER STATION
89	WASTE WATER PUMPING STATION	400	
	sub-total (kW)	**100,080**	
	sub-total (MW)	**100.08**	

[Source] TANESCO

(2) Power demand growth rate

Based on the "4-2-1 Outline of the review", the demand forecast in Dodoma state is examined based on the rate of Low case described in PSMP2016.

In order to facilitate comparison with TANESCO assumptions, demand forecasts for the relevant period are extracted and calculated from PSMP2016 according to the assumed period of TANESCO and listed in Table 4-2.9. Therefore, by PSMP 2016, the regional power demand are consisted of residential demand and industry demand. Residential demand was calculated by regional population forecasts, Electrification rate forecasts, Population to use power, Actual regional power consumption, Power consumption per person to use power, Future regional power consumption. Industry demand was calculated by Actual industrial GDP, Regional contribution of industrial GDP, Regional contribution of industrial GDP, Future regional power demand, Power demand for Future big projects, power demand for gold mining. Hence it does not accumulate individual demands other than the recent years. therefore there is difference in the demand growth rate because the approach method is different from the TANESCO assumption rate.

Table 4-2.9 Comparison of demand growth rate

Year	PSMP2016 LOW case	TANESCO assumption rate
2019-2022	8%	9%
2023-2037	7.8%	7%
2038-2047	6.4%	5%

[Source] TANESCO and PSMP2016

(3) Power demand forecast

Based on the above precondition for demand forecast, the peak demand value for each year is calculated. In addition, the following value is used as starting point for calculated peak demand.

Actual peak demand in 2018：30.6MW(recorded on November 28 2018)

4-2-3 Comparison result

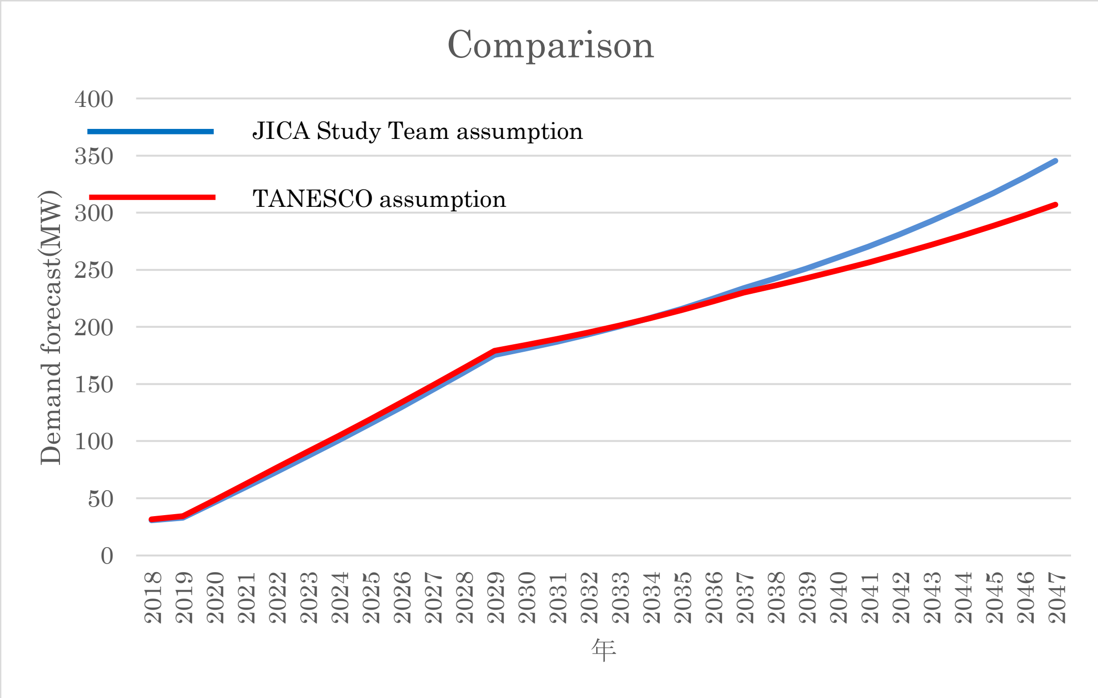
The result of the demand forecast and comparison to TANESCO assumption is shown below.

Table 4-2.10 Result of demand forecast

(MW)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
JICA Study Team assumption	30.6	33.0	46.16	59.489	73.0	86.791	100.8	115.1	129.6	144.5
TANESCO assumption	31.4	34.2	48.1	62.2	76.6	90.6	104.7	119.0	133.6	148.5

(MW)	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
JICA Study Team assumption	159.8	175.4	181.0	186.9	193.4	200.3	207.8	215.9	224.6	234.0
TANESCO assumption	163.6	179.1	184.1	189.4	195.1	201.2	207.7	214.7	222.2	230.2
(MW)	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
JICA Study Team assumption	242.3	251.1	260.5	270.5	281.1	292.5	304.5	317.3	330.9	345.4
TANESCO assumption	236.3	242.7	249.5	256.5	264.0	271.8	280.0	288.6	297.6	307.1

[Source] JICA Study Team



[Source] JICA survey team

Figure 4-2.1 Comparison demand forecast curve

From the above result, the estimated demand in the year 2047 exceeds TANESCO's estimated value by about 12%. The table below shows a comparison of the power consumption between actual value and expected value in PSMP2016.

Table 4-2.11 Comparison power consumption

(GWh)	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2018/14
Actual value	68	79	83	86	94	105	115	137	154	172	184	12%
PSMP assumption	-	-	-	-	-	-	146	162	170	184	202	8%

[Source] PSMP2016

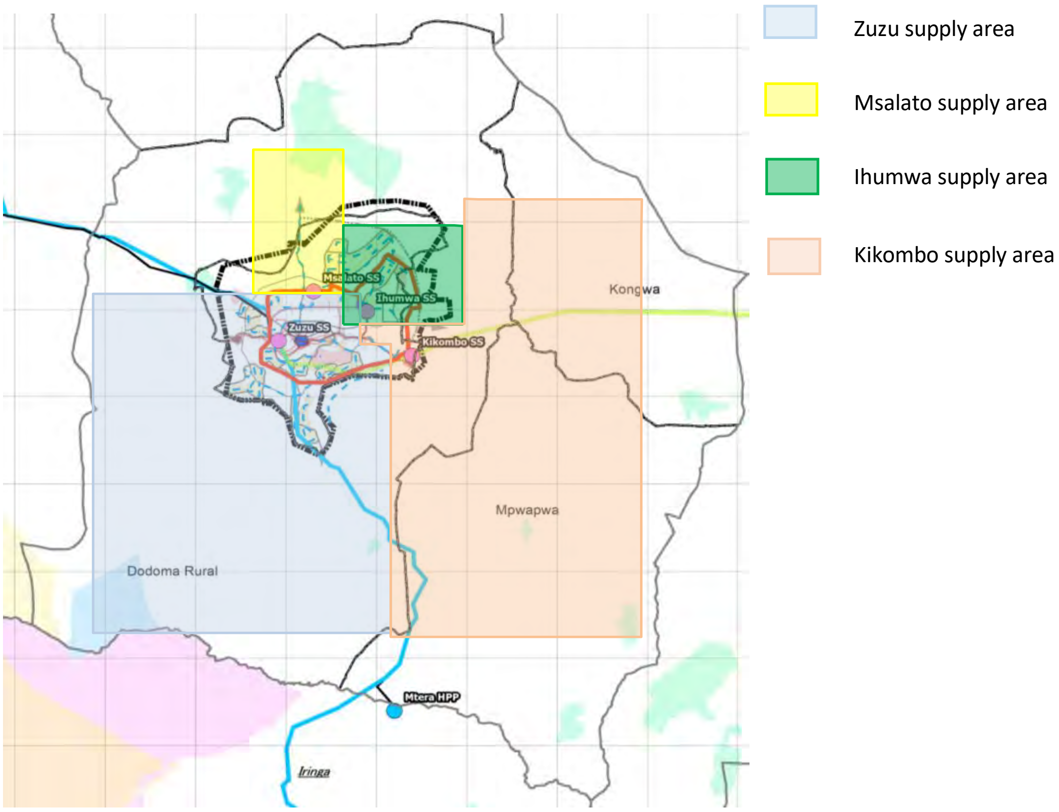
The increase in power demand has been remarkable in recent years, but was delayed by about one year from the PSMP2016 assumption. In addition, three distribution substations in Dodoma (Town, Mnadani, Mzakwe) are under reinforcement works, and expansion of distribution network is ongoing. Power demand is expected to increase steadily in the future. Based on the survey result, JICA Study Team concluded that the demand forecast based on PSMP2016 Low case is appropriate.

4-2-4 Demand allocation to substations

(1) Precondition of load allocation

Based on the result of power demand forecast, demand allocation to substations expecting development shall be implemented. Demand will be allocated for the following four substations that are assumed in the base case of the development pattern.

Ihumwa S/S	Power supply for government city Power supply for Dodoma east and southern area
Zuzu S/S	Power supply to Dodoma central area Power supply to new industrial zone(Dodoma western area)
Msalato S/S	Power supply to Dodoma Northern area Power supply to new international airport and EPZ
Kikombo S/S	Power supply for Dodoma east and southern area



[Source] JICA Study Team

Figure 4-2.2 Assumed supply area of each substation

(2) Basic policy of load allocation

- Three substation excluding Zuzu are assumed to be operation in 2025
- The feeder load currently supplied from the existing Zuzu substation will be allocated to other three substations by considering each supply area after 2025. The load distribution ration for each feeder shall be calculated based on the actual value as recorded on 28 November, 2018. The feeder load allocation result is shown in following table.

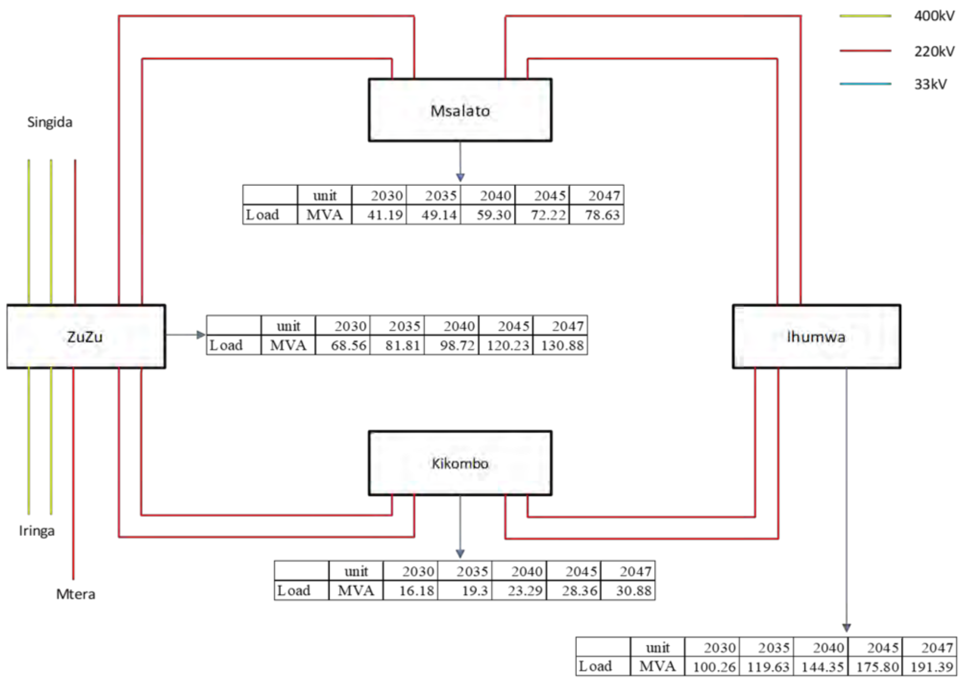
Feeder	Substation	Remarks
Town feeder	Zuzu S/S	-
Inter connect	Zuzu S/S	-
Mzakwe	Msalato S/S	-
Mnandani	Msalato S/S	-
Chamwino	Ihumwa S/S Kikombo S/S	50% load allocated to each substation
Mpwapwa	Ihumwa S/S Kikombo S/S	50% load allocated to each substation
Bahi	Zuzu S/S	-

- Specific load will also be allocated to each substation by considering each supply area. From 2020 to 2024, specific load will be supplied from Zuzu substation, and after construction of other three substations in 2025, the load will be allocated to Msalato and Ihumwa substations.

Specific load	2020-2024	After 2025
Industrial	Zuzu S/S	Zuzu S/S
TPDF quarters	Zuzu S/S	Zuzu S/S
EPZ	Zuzu S/S	Msalato S/S
Airport	Zuzu S/S	Msalato S/S
Dry port	Zuzu S/S	Ihumwa S/S
Marshaling yard	Zuzu S/S	Ihumwa S/S
State house	Zuzu S/S	Ihumwa S/S
Butcher	Zuzu S/S	Ihumwa S/S
Quarters 40000	Zuzu S/S	Ihumwa S/S

(3) Result of the load allocation

Result of the load allocation shows Table 4-2.12 and   respectively.



[Source] JICA Study Team

Figure 4-2.3 Demand allocation for each substation

Table 4-2.12 Result of the load allocation for each substations

Zuzu

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Town	7.49	8.09	8.73	9.43	10.17	10.97	11.83	12.76	13.76	14.84	16.00	16.51	17.05	17.64	18.28	18.96	19.70	20.49	21.35	22.11	22.91	23.77	24.68	25.65	26.68	27.78	28.95	30.19	31.52
Inter connect	6.04	6.52	7.04	7.61	8.20	8.85	9.54	10.29	11.10	11.97	12.91	13.32	13.76	14.23	14.74	15.29	15.89	16.53	17.22	17.83	18.48	19.17	19.91	20.69	21.52	22.41	23.35	24.35	25.42
Mzakwe	2.21	2.39	2.58	2.79	3.01	3.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mwandani	4.87	5.26	5.68	6.13	6.62	7.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chamwino	4.33	4.68	5.05	5.46	5.89	6.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mpwapwa	7.41	8.00	8.64	9.33	10.06	10.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bahi	0.68	0.74	0.80	0.86	0.93	1.00	1.08	1.16	1.25	1.35	1.46	1.50	1.55	1.61	1.67	1.73	1.80	1.87	1.95	2.02	2.09	2.17	2.25	2.34	2.43	2.53	2.64	2.75	2.87
Indusrial	-	2.16	4.32	6.48	8.64	10.80	12.96	15.12	17.28	19.44	21.60	22.28	23.02	23.81	24.67	25.59	26.59	27.66	28.82	29.84	30.93	32.08	33.31	34.62	36.01	37.49	39.07	40.75	42.54
TPDF quarters	-	0.12	0.24	0.36	0.48	0.60	0.72	0.84	0.96	1.08	1.20	1.24	1.28	1.32	1.37	1.42	1.48	1.54	1.60	1.66	1.72	1.78	1.85	1.92	2.00	2.08	2.17	2.26	2.36
EPZ	-	0.96	1.92	2.88	3.84	4.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Airport	-	0.72	1.44	2.16	2.88	3.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dry port	-	0.06	0.12	0.18	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marshalling yard	-	0.14	0.29	0.43	0.58	0.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
State house	-	0.06	0.12	0.18	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butcher	-	0.06	0.12	0.18	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quaters 40000	-	0.19	0.38	0.58	0.77	0.96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Goverment City	-	6.00	12.01	18.01	24.02	30.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Capacity(MW)	33.04	46.16	59.49	73.04	86.79	100.79	36.13	40.17	44.35	48.68	53.17	54.85	56.66	58.62	60.72	63.00	65.45	68.09	70.94	73.45	76.13	78.97	82.00	85.22	88.65	92.30	96.18	100.31	104.71
Total Capacity(MVA)	41.30	57.70	74.36	91.31	108.49	125.99	45.16	50.21	55.44	60.85	66.46	68.56	70.83	73.27	75.91	78.75	81.81	85.11	88.68	91.82	95.16	98.72	102.50	106.53	110.81	115.37	120.23	125.39	130.88

Msalato

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
EPZ	-	-	-	-	-	-	5.76	6.72	7.68	8.64	9.60	9.90	10.23	10.58	10.96	11.37	11.82	12.29	12.81	13.26	13.74	14.26	14.80	15.39	16.01	16.66	17.37	18.11	18.90
Airport	-	-	-	-	-	-	4.32	5.04	5.76	6.48	7.20	7.43	7.67	7.94	8.22	8.53	8.86	9.22	9.61	9.95	10.31	10.69	11.10	11.54	12.00	12.50	13.02	13.58	14.18
Mzakwe	-	-	-	-	-	-	3.50	3.77	4.07	4.39	4.73	4.88	5.04	5.21	5.40	5.60	5.82	6.06	6.31	6.53	6.77	7.03	7.30	7.58	7.89	8.21	8.56	8.92	9.32
Mwandani	-	-	-	-	-	-	7.70	8.30	8.95	9.65	10.41	10.74	11.09	11.48	11.89	12.34	12.81	13.33	13.89	14.38	14.91	15.46	16.06	16.69	17.36	18.07	18.83	19.64	20.50
Total Capacity(MW)	0.00	0.00	0.00	0.00	0.00	0.00	21.27	23.83	26.46	29.16	31.94	32.95	34.04	35.21	36.48	37.84	39.32	40.90	42.62	44.13	45.73	47.44	49.26	51.19	53.25	55.45	57.78	60.26	62.90
Total Capacity(MVA)	0.00	0.00	0.00	0.00	0.00	0.00	26.59	29.79	33.07	36.45	39.93	41.19	42.55	44.02	45.60	47.30	49.14	51.13	53.27	55.16	57.16	59.30	61.57	63.99	66.57	69.31	72.22	75.32	78.63

Ihumwa

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Dry port	-	-	-	-	-	-	0.36	0.42	0.48	0.54	0.60	0.62	0.64	0.66	0.69	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.09	1.13	1.18
Marshalling yard	-	-	-	-	-	-	0.86	1.01	1.15	1.30	1.44	1.49	1.53	1.59	1.64	1.71	1.77	1.84	1.92	1.99	2.06	2.14	2.22	2.31	2.40	2.50	2.60	2.72	2.84
State house	-	-	-	-	-	-	0.36	0.42	0.48	0.54	0.60	0.62	0.64	0.66	0.69	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.09	1.13	1.18
Butcher	-	-	-	-	-	-	0.36	0.42	0.48	0.54	0.60	0.62	0.64	0.66	0.69	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.09	1.13	1.18
Quaters 40000	-	-	-	-	-	-	1.15	1.34	1.54	1.73	1.92	1.98	2.05	2.12	2.19	2.27	2.36	2.46	2.56	2.65	2.75	2.85	2.96	3.08	3.20	3.33	3.47	3.62	3.78
Goverment City	-	-	-	-	-	-	36.03	42.03	48.04	54.04	60.05	61.94	63.99	66.20	68.58	71.14	73.91	76.90	80.12	82.95	85.97	89.18	92.60	96.24	100.11	104.23	108.62	113.28	118.25
Chamwino	-	-	-	-	-	-	3.42	3.69	3.98	4.29	4.63	4.78	4.94	5.11	5.29	5.49	5.70	5.93	6.18	6.40	6.63	6.88	7.14	7.42	7.72	8.04	8.38	8.74	9.12
Mpwapwa	-	-	-	-	-	-	5.85	6.31	6.80	7.34	7.91	8.16	8.43	8.72	9.04	9.38	9.74	10.13	10.56	10.93	11.33	11.75	12.20	12.68	13.19	13.74	14.31	14.93	15.58
Total Capacity(MW)	0.00	0.00	0.00	0.00	0.00	0.00	48.40	55.65	62.95	70.32	77.75	80.21	82.86	85.71	88.80	92.12	95.70	99.57	103.74	107.41	111.32	115.48	119.91	124.62	129.63	134.97	140.64	146.68	153.11
Total Capacity(MVA)	0.00	0.00	0.00	0.00	0.00	0.00	60.50	69.56	78.69	87.90	97.19	100.26	103.57	107.14	110.99	115.15	119.63	124.46	129.67	134.26	139.15	144.35	149.88	155.77	162.04	168.71	175.80	183.36	191.39

Kikombo

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Chamwino	-	-	-	-	-	-	3.42	3.69	3.98	4.29	4.63	4.78	4.94	5.11	5.29	5.49	5.70	5.93	6.18	6.40	6.63	6.88	7.14	7.42	7.72	8.04	8.38	8.74	9.12
Mpwapwa	-	-	-	-	-	-	5.85	6.31	6.80	7.34	7.91	8.16	8.43	8.72	9.04	9.38	9.74	10.13	10.56	10.93	11.33	11.75	12.20	12.68	13.19	13.74	14.31	14.93	15.58
Total Capacity(MW)	0.00	0.00	0.00	0.00	0.00	0.00	9.27	10.00	10.79	11.63	12.54	12.94	13.37	13.83	14.33	14.86	15.44	16.06	16.74	17.33	17.96	18.63	19.35	20.11	20.91	21.78	22.69	23.67	24.70
Total Capacity(MVA)	0.00	0.00	0.00	0.00	0.00	0.00	11.59	12.50	13.48	14.54	15.68	16.18	16.71	17.29	17.91	18.58	19.30	20.08	20.92	21.66	22.45	23.29	24.18	25.13	26.14	27.22	28.36	29.58	30.88

[Source] JICA Study Team

4-3 Power System Plan

4-3-1 Outline of Study

The basic system plan described in the Dodoma National Capital City MP ("Base case" described in Chapter 3-3 of this report) is a 220kV double circuit line (two lines on the same tower) starting from / ending at the Zuzu substation, with a plan to construct a ring circuit system that relays the three substations of Msalato, Ihumwa and Kikombo. Here, the basic policy for system planning is established at first, and it is confirmed that the basic system plan is an appropriate system configuration for the forecasted future demand in light of the policy, and a better system configuration is recommended if necessary.

4-3-2 Study conditions

(1) Basic Policy on Power System Plan

The confirmation and recommendation of the basic plan in the transmission system plan for power supply to the Dodoma National City area will be implemented in consideration of the following basic policy.

1) Ensuring high reliability in power supply to government offices district

Since power to the government offices district is distributed from the Ihumwa substation, the power supply to the Ihumwa substation is considered as the first priority.

2) High-quality power supply (maintain voltage level and low power interruption rate)

In order to maintain the quality of the supplied power, consideration is given by not only maintaining the voltage within allowable range, but also reducing the possibility of power outage and enabling recovery in a short time even if a power outage occurs.

3) Back-up capable system configuration

The system should be configured in a way that power can be supplied through the back-up system, taking into account shortage condition (N-1 philosophy), such as the occurrence of an accident in the system or a maintenance stoppage. This back-up system will be configured with appropriate facilities considering the importance and demand growth of the corresponding area. (It is not always the case that the same facility is simply multiplexed.)

4) Long life facilities with a target of 30 years

It should be planned that the facilities to be selected have enough capacity to withstand 30 years of use and to prevent renewal due to lack of capacity unless there is an unexpected increase in demand once the facilities have been constructed. However, in response to increasing demand, facilities that can be additionally installed in substations (such as transformers) will be added at appropriate times to reduce initial investment.

5) Appropriate specification of facilities

It should be considered for the specification of facilities to be applied that the voltage class selected is suitable for demand capacity, and for facilities that can be accommodated by increasing the number in the substation in response to increased demand as mentioned above in (4), careful study is given to the introduction of facilities with the appropriate capacity at the appropriate time.

6) Economy

Choice of facilities should be economically cost-effective, considering the initial investment amount as well as the maintenance and operation costs.

7) Low loss

For those that can select low-loss equipment, recommendations for adoption should be made taking into account the economics including operating costs.

(2) Role of each substation

As described in the section on load allocation to substations in Chapter 4-2-4, it is necessary to determine the importance by grasping the demand supplied by each substation. In addition, since it is necessary to develop transmission and distribution facilities according to the Dodoma National City development steps, the power supply role of each substation is described again.

Table 4-3.1 Power supply role of each substation in Dodoma city

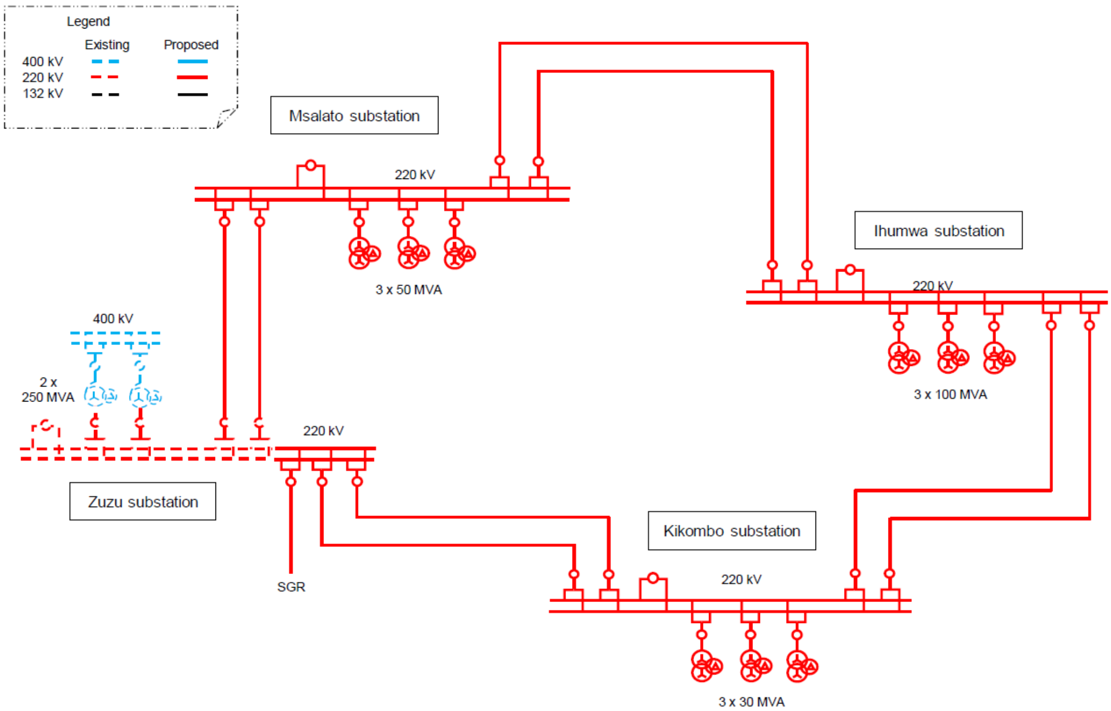
Ihumwa Substation	Power supply to government offices district Power supply to eastern and southern areas of Dodoma	Highest priority in government offices district
Zuzu Substation (existing)	Power supply to central area of Dodoma Power supply to new industrial area (Western Dodoma)	・ Power supply to the ring circuit system ・ Distribution Tr. : 60MVA (existing) + 250MVA(expanding)
Msalato Substation	Power supply to northern area of Dodoma Power supply to new international airport and special economic zone	Determining the time of necessity to meet the demand growth of the new airport and special economic zone
Kikombo Substation	Power supply to eastern and southern areas of Dodoma	Urgent measures required on maintaining voltage level

[Source] JICA Study Team

4-3-3 Study Result and Proposed Power System Plan

(1) Study on voltage class of ring circuit system

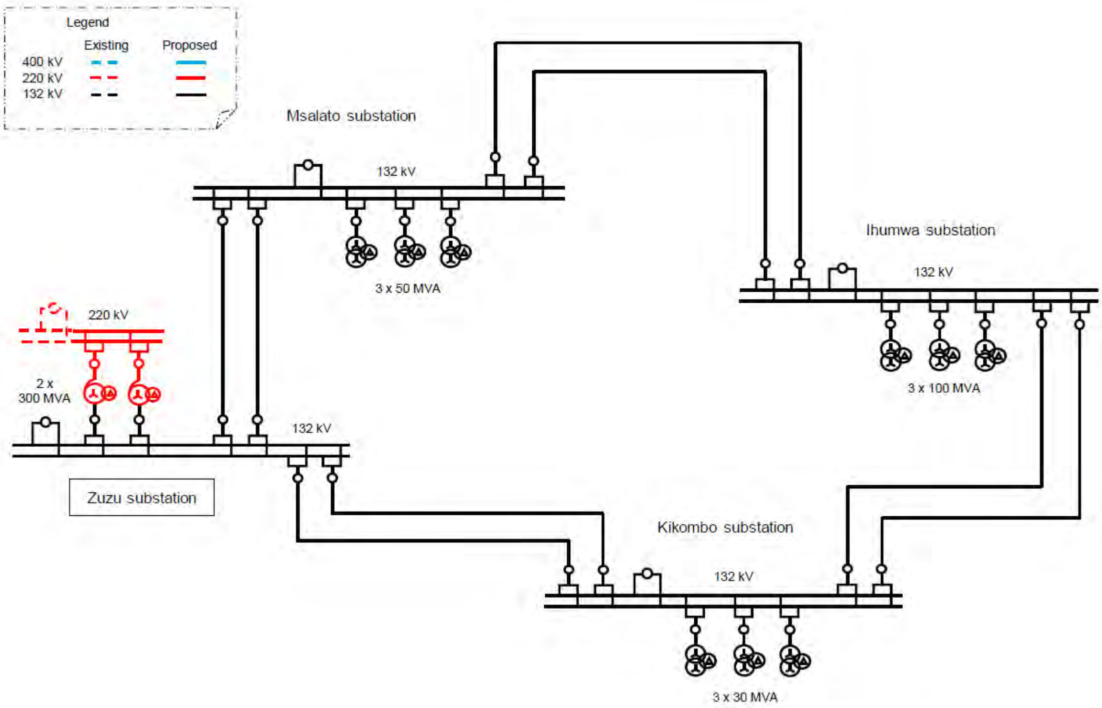
In the basic plan of Dodoma National Capital City MP, the voltage class of 220kV is selected, but it is judged that the 132kV voltage can be adopted according to the assumed demand, so that the appropriate voltage class is studied. There are two types of grid configurations, which are radial and ring circuits, and the concept of capacity to be secured for transmission lines is different for each configuration. Since the transmission route secured in the development plan in the Dodoma National City MP is suitable for the ring circuit configuration, the capacity of transmission line conductor should be determined by the ring system configuration. In the case of a ring system, it is necessary to supply power to the load of all substations in the ring with a route that avoids the power outage point, by not in service of the one transmission line. In particular, when supplying power from a single location, as in the case of the Zuzu substation in the Dodoma metropolitan area, it is necessary to use the conductor with capacity that can accommodate almost the total capacity[1] of the ring circuit system load. Based on the above-mentioned demand assumption, it is necessary to cover the demand of approximately 400MVA in 2047, so the conductor that can accommodate 300MVA or more is selected from TANESCO standard conductors. Figure 4-3.1 and Figure 4-3.2 show schematic system diagrams when the transmission line of the basic plan (Base case) is configured with 220 kV and 132 kV respectively. When configured with 132kV, the region does not currently have a 132kV system, so a large-capacity of 220/132kV transformer and 132kV switchgear are additionally required in Zuzu substation, which is the total power supplier of Dodoma metropolitan area. Table 4-3.2 shows the results of a comparative study focusing on economics under these conditions. Considering the operational costs, the use of 220 kV is overwhelmingly advantageous in the case of the Base case system in the Dodoma metropolitan area.



[Source] JICA Study Team

Figure 4-3.1 Schematic system diagram with 220kV network

[1] "Almost the total capacity" means precisely that the capacity of total ring system loads minus the supply loads from the supplier substation.



[Source] JICA Study Team

Figure 4-3.2 Schematic system diagram with 132kV network

Table 4-3.2 Results of a comparative study between 220kV and 132kV

Item	220kV		132kV	
Conductor of transmission line	ACSR 564mm^2 (Single Bluejay)		ACSR 242mm^2 x 2 (Twin Hawk)	
Substations (Transformer)	Ihumwa	220/33kV	Ihumwa	132/33kV
	Msalato	220/33kV	Msalato	132/33kV
	Kikombo	220/33kV	Kikombo	132/33kV
	Zuzu (existing)	No additional facilities	Zuzu (existing)	2 sets of 220/132kV, 300MVA transformers expansion Additional 132kV switchyard
Capital cost	1 (Base)		1 (Equivalent to Base) The unit prices of 132kV facilities are low, but it is equivalent because of the additional large transformers and 132kV switchyard costs in Zuzu Substation.	
System loss	1 (Base)		Approximately 5	
Result	◎		△	

[Source] JICA Study Team

(2) Maximum demand study suitable for 132kV system voltage adoption

The scale of demand commensurate with the 132kV system voltage adoption was studied in case demand growth is small. When the assumed demand is slightly reduced in the Base case, there is no change in the system components and only the transformer capacities in the substations are reduced so that the reduction of the purchase price of the 220/132kV transformer capacity in Zuzu substation is the main initial cost reduction item. Here, the transformer capacity of Zuzu substation are reduced from

300 MVA (base) to 275 MVA, 250 MVA, 225 MVA, 200 MVA, 175 MVA & 150 MVA and the demand required in 2047 was assumed to correspond to the capacities of the transformer. The amount of system losses for both 132kV and 220kV were calculated from 2025, and the year when the accumulated cost due to system loss deference between 132kV and 220kV reached the initial cost reduction by selecting each 220/132kV transformer was also calculated. At the point where the capacity is reduced from 175MVA to 150MVA, the single conductor can be applied for the 132kV transmission line instead of the double bundled conductor, so the additional initial cost reduction was considered. In the Base case, there are two transmission lines with ring circuit configuration, but a comparative study was also conducted for a single transmission line configuration. When calculating the cost (USD) from the system loss (Wh), 0.1USD/kWh was used as a electricity price.

Table 4-3.3 Years required for 220kV to be economically advantageous

Capacity of 220/132kv Transformer in Zuzu (MVA)	Reaching Year in two-line system ( ) : elapsed year	Reaching Year in single-line system ( ) : elapsed year
300	2025（0 year）	2025（0 year）
275	2028（3 years）	2028（3 years）
250	2032（7 years）	2030（5 years）
225	2035（10 years）	2033（8 years）
200	2039（14 years）	2037（12 years）
175	2044（19 years）	2041（16 years）
150	After 2048	After 2048

[Source] JICA Study Team

As can be seen in Table 4-3.3, the amount of loss varies depending on the number of lines, so there are differences in the year in which 220 kV is economically advantageous. It can be said that a sufficient demand point of 150 MVA of 220/132 kV transformer capacity at Zuzu substation, which will reach after the forecasted demand period of 2048 or more, is one of the guidelines for adopting 132 kV. Considering the power factor , the active power is 120 MW, and the distribution supply power from Zuzu substation can be added to the value above, so that the boundary between the voltage class of 132 kV and 220 kV in the case of the Dodoma metropolitan system would be judged by the range from 150MW to 200 MW. Therefore, even if the future demand falls below the current demand forecast and reaches more than 150 MW in 2047, adoption of 220 kV system voltage is advantageous from the viewpoint of life cycle cost.

(3) Concept of ensuring reliability

As stated in the basic policy on power system plan, the power supply to the metropolitan area where government office facilities are located is estimated to require more reliable power supply than the general area. Therefore, the ensuring reliability of the system planning is discussed below.

1) Transmission Line

In the Base case planning, a ring system is composed with double circuit transmission lines constructed on the same tower. This configuration is highly reliable so that it does not hinder the power supply for all the substations (Msalato, Ihumwa & Kikombo) in the ring system, except the Zuzu substation even if the two locations of transmission lines are out of service (N-2 condition). This is a system that can be maintained without worrying about a power outage, and even if it shows an increase in demand more than forecasted in the future, it can be easily replaced with increased capacity conductors so that the Base case system has a very high operability. The Study Team believes that developing a step-by-step construction project in line with the development steps of the National Capital City MP, instead of constructing this system configuration of the Base case all at once, is realistic because it reduces the initial investment amount. Therefore, it is understood that the final form that the staged construction project is proceeding with the demand increase while ensuring reliability (N-1) becomes the above mentioned ideal high reliability system configuration.

In this case, considering the possibility of an accident with respect to the double circuit transmission lines constructed on the same tower, the two lines that were collocated with a single lightning strike on the tower simultaneously becomes an accident, and the two lines are shut down (i.e. two lines down due to one cause). Since there is a possibility of simultaneous interruption of two lines, the double circuit transmission lines installed on the same tower are not completely multiplexed. In order to avoid the simultaneous interruption of two lines due to one cause, it is necessary to construct two transmission lines with different route (without sharing towers). For example, assuming the case where the Ihumwa substation is constructed as the first step, there are two methods of constructing transmission line with either a northbound or a southbound line with double circuit installed on the same steel tower, or with both a northbound and southbound single lines, and the latter can ensure higher reliability. Although it is not directly related to ensuring reliability, it is expected that the construction of various facilities along with the development of the metropolitan area will make it difficult to secure new transmission line routes like in Dar es Salaam, which has grown and crowded. Therefore, it is recommended to construct a northbound and southbound transmission lines to secure the necessary wayleave of transmission lines in early stage.

It is recommended that when double circuit transmission lines installed on the same steel tower are used, a lightning arrester (external gapped transmission line arrester: EGLA) for transmission should be installed on each tower of the one line, and the other line be constructed with slightly higher insulation level. Moreover, it makes the possibility of avoiding simultaneous interruption of two lines highly probable. EGLA is described in detail in Chapter 5.

The current ring circuit system is planned with the transmission lines of approximately 160km length connecting four substations of Zuzu, Msalato, Ihumwa and Kikombo. In order to secure the first priority of reliable power supply in the Dodoma metropolitan area, it is strongly recommended not to expand the ring circuit transmission line in the future. Since the transmission line failure rate increases in proportion to the length of the transmission line, when planning to supply power to demand areas outside the metropolitan area, it should be interconnected by additional transmission line from the bus of the substation in the ring circuit through the appropriate switchgear, not to be branched from the ring circuit transmission line itself. Please refer to the discussion of system configuration option selection in Chapter 3-3.

2) Transformer

In order to ensure the reliability of power supply in the single shortage condition (N-1) of transformers, it is planned to install multiple transformers in the substations. If transformers are properly designed in the substation plan, it is not necessary to secure capacity for long-term future loads at the initial stage because expansion of transformer in the substation is easy and investment can be made according to demand growth.

As a basic policy for transformer installation, three transformers should be installed as the final form of the substation in 30 years. Specifically, it is planned to install two transformers with the capacity to meet the demand for about 15 years with one unit at the initial stage, and add the third unit just before it becomes impossible to cover with one transformer. In other words, the goal is to have an equipment configuration that can meet demand in 30 years with two units in one unit out of service condition. Please refer to the substation facility plan in detail in Chapter 4-5.

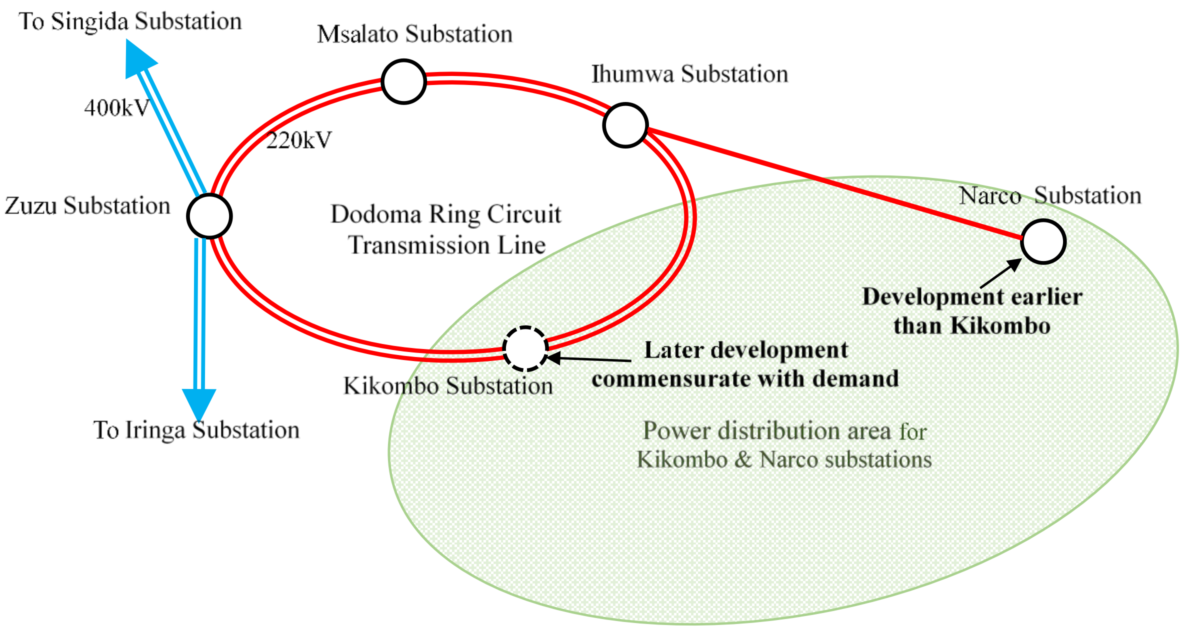
The transformer described here is 220/33kV transformer and is used for distribution. As mentioned above, the transformer capacity for one unit can always be secured as a margin. This margin can be used for rescue and supply of power when maintenance is performed on a distribution line from an adjacent substation or when a failure occurs. Therefore, from the viewpoint of ensuring high reliability in the 33kV distribution network, it is important to plan the remote supervisory & control system from the distribution control center with field switches that enable connection or switching distribution lines between adjacent substations being installed at appropriate locations in the distribution network.

(4) Narco Substation construction

1) Narco substation and Kikombo substation

Option-5 which is described in Chapter 3-3-2, the additional transmission line to be constructed from Kikombo substation to Narco substation which was proposed to solve the insufficient power quality that is already the issue in the power supply to the eastern and southern regions of Dodoma.

Here, reconfirming the role of substation, the power supply to the eastern and southern areas of Dodoma as described in 4-2-4 is Kikombo the same as that of Narco substation. The Narco substation existed instead of Kikombo substation when Option-1 in Chapter 3-3-2 was proposed. Therefore, the Study Team propose a new plan to start the power supply to the eastern and southern areas of Dodoma from Narco substation by interconnecting the new transmission line from Ihumwa substation. Kikombo substation is planned to be constructed when the development of the Dodoma metropolitan and its vicinity of the eastern and southern areas progresses and demand increases, and furthermore, there is a need for a power supply point there to ensure power supply quality. In other words, the order is to construct Narco substation first, to determine the demand growth and its regional characteristics, and then to construct Kikombo substation.



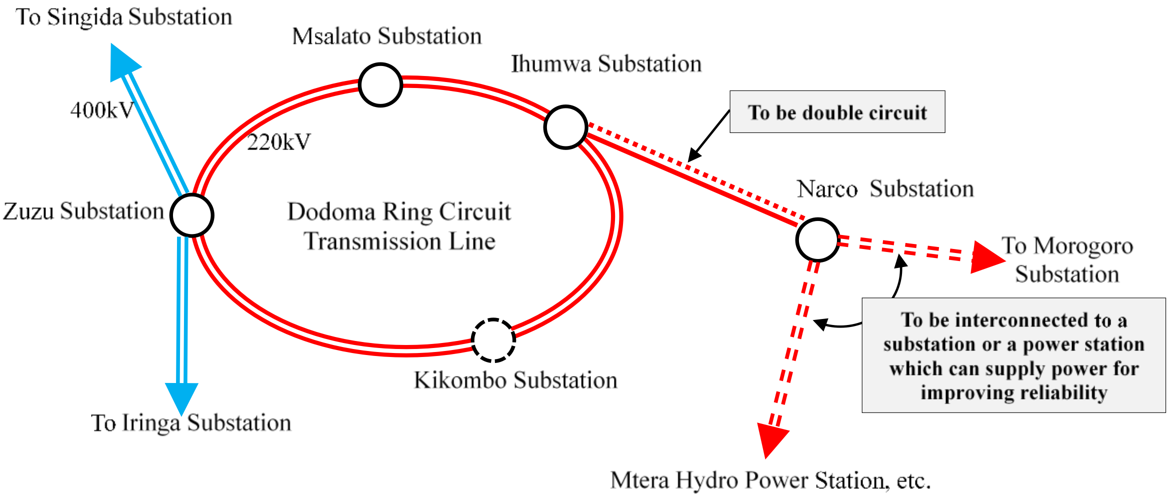
[Source] JICA Study Team

Figure 4-3.3 Narco Substation Connection System Configuration Proposed by the Study Team

2) Transmission line to Narco substation

As mentioned above, Narco Substation's power supply is in the eastern and southern areas of Dodoma. The demand forecast of the said area is approximately 60MVA in 2047. It is reasonable to apply 132kV voltage for supplying this load, because the standard conductors of TANESCO for 132kV transmission lines are Wolf (ACSR150mm^2) and Hawk (ACSR 242mm^2), which can accommodate 74MVA and 121MVA, respectively. The distance of the transmission line is approximately 80 km from Ihumwa substation and approximately 50 km from Kikombo substation, so it is not preferable to select a voltage class lower than 132 kV from the viewpoint of voltage drop.

The issue from the reliability aspect of the Dodoma metropolitan ring circuit power system is that the power source is only one, i.e. the Zuzu substation. Measures against N-1 shortage condition can be taken against individual equipment, but it is predicted that the power supply in the Dodoma area will be hindered in the event of an emergency at Zuzu substation itself. Measures should be taken so that external power can be supplied to substations other than Zuzu substation. Since Narco is located on the east side of Dodoma and on the Morogoro side, it is considered effective to plan a connection to Morogoro substation in the future, where the large hydropower plants are interconnected. As an alternative, it is possible to interconnect to the south-side Mtera hydropower plant, etc. proposed in Option-2 and 4 in Chapter 3-3-2. Once the Dodoma ring circuit system's rescue transmission line construction policy has been decided, the transmission line from Ihumwa substation (or Kikombo substation) to the Narco substation must have a capacity exceeding 300 MVA, and long-distance transportation is required so that the voltage of 220kV with Bluejay single conductor should be adopted. In this case, it is recommended that only one line installation with towers for double circuit be constructed when interconnecting to Narco substation from Ihumwa substation and the second line on the towers should be installed when interconnecting to Morogoro substation through Narco substation as a power supply line to the Dodoma ring circuit system.



[Source] JICA Study Team

Figure 4-3.4 System configuration plan to improve reliability of the ring system through Narco substation

For the 33 kV distribution line from the Zuzu substation for the eastern region after the completion of the Narco substation, it is recommended to continue operation by connecting the eastern part of distribution lines to Ihumwa substation (or Kikombo substation) as a supply starting point. By doing this, the length of the distribution line is shortened, and the loads near the Zuzu substation is excluded from the distribution line, so that the voltage drop will be reduced and it is possible to have a back-up function of the Narco substation distribution network.

4-4 Transmission Facilities Plan

4-4-1 Investigation Procedure

The investigation procedure is shown in Table 4-4.1.

Table 4-4.1 Investigation procedure

Step		Survey/investigation items
(1)	Confirmation of locations regulated by law and locations and scope restricted by land utilization	Survey whether there are any locations requiring consideration for environmental effects around the planned sites, including those locations below. Forest conservation areas, national parks, wildlife conservation areas, important bird habitats, cultural heritage sites, mines/quarries, existing facilities (homes/airports/factories/transmission lines, etc.), urban development plan (locations with height regulations near airports, locations planned for housing, locations planned for factories)
(2)	Desktop route confirmation	Fill in the starting point and ending point for the outline on a map and confirm matters including areas regulated by law, development areas, and the scope of wayleave.
(3)	Neighboring environment survey	Survey the effects of natural disasters such as wind and thunder.
(4)	Field survey	Survey the actual status of the desktop route. Confirm that there is no interference between the existing transmission lines and other new transmission lines plans.
(5)	Desktop detailed survey	Summarize the results of the field survey and confirm if any route revisions are required.
(6)	Route determination	Determine the route based on the desktop survey, field survey, and other matters requiring consideration.

[Source] Created by JICA Study Team

4-4-2 Study Result and Proposal

(1) Study Result

The result of studies on the existing transmission facilities plan is as shown below.

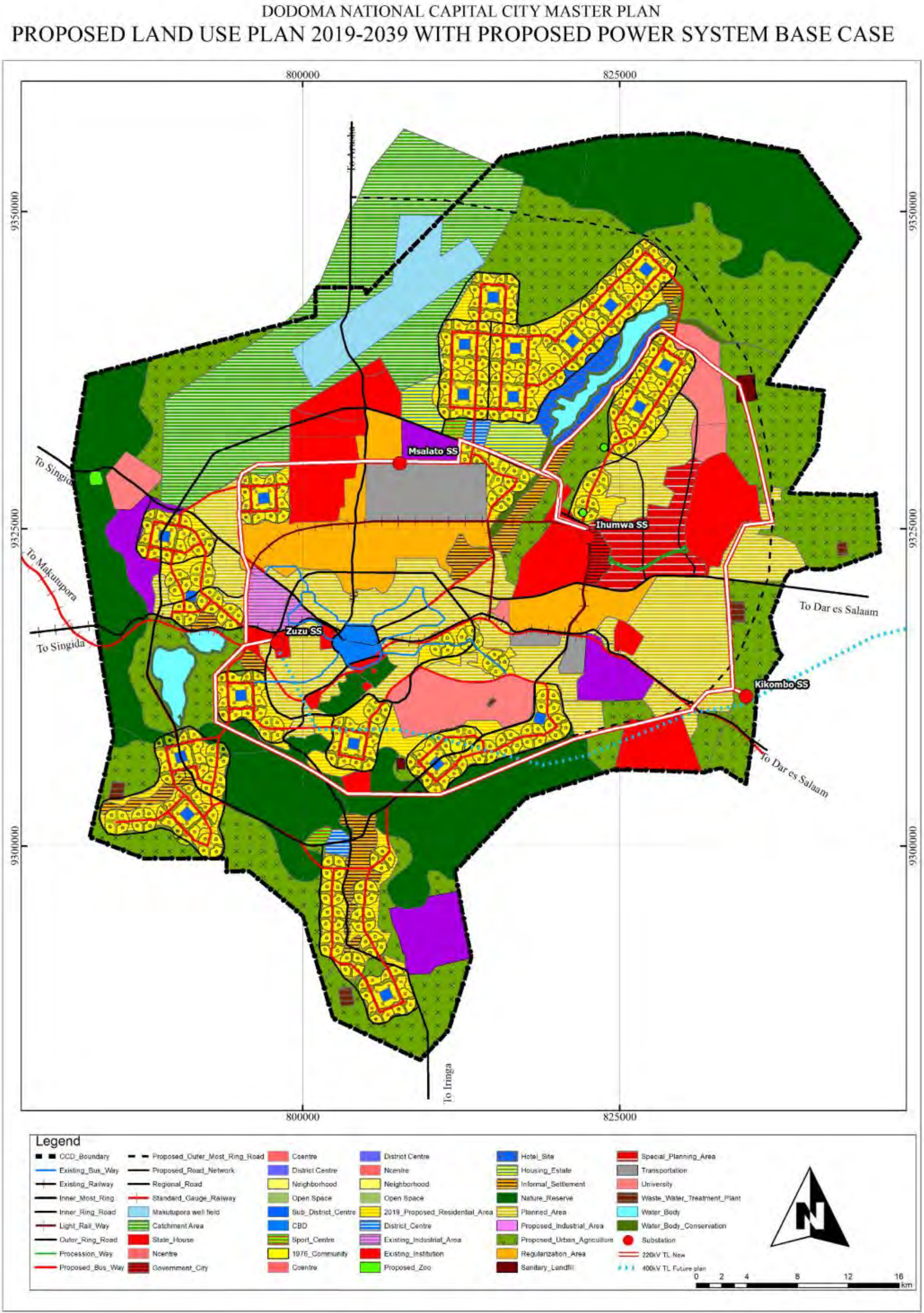
1) Confirmation of locations regulated by law and locations and scope restricted by land utilization

We held a hearing with TANESCO and the CCD (City Council Dodoma) and confirmed the locations regulated by law and the scope involved in locations restricted by land utilization. For locations regulated by law, there was no such location in particular. The land planning development map received from the CCD is shown in Figure 4-4.1.

2) Desktop route confirmation

Table 4-4.2 indicates the wayleave scope obtained in a hearing with TANESCO. Considering the land development plan acquired from the CCD, locations passing through the government office district and areas planned for housing may be subject to restrictions.

The road conservation areas determined by TANROAD are shown in Table 4-4.3.



[Source] Created by JICA Study Team based on land development plan acquired from the CCD

Figure 4-4.1 Land development plan map

Table 4-4.2 Wayleave scope for each voltage section

Voltage class	Wayleave scope
400kV	52 m (26.0 m one-way)
220kV	35 m (17.5 m one-way)
132kV	27 m (13.5 m one-way)
66kV	18 m (9.0 m one-way)

*The wayleave scope does not change depending on the number of circuits.

[Source] Hearing with TANESCO

Table 4-4.3 Road conservation areas

Road type	Road conservation area
Trunk roads and regional roads (1 lane)	30 m to each side from road center, total of 60 m
Trunk roads and regional roads (2 lanes)	30 m to each side from road center, total of 60 m
Collector roads	20 m to each side from road center, total of 40 m
Feeder roads	15 m to each side from road center, total of 30 m
Community roads	12.5 m to each side from road center, total of 25 m

[Source] Created by JICA Study Team based on TANROAD materials

3) Neighboring environment survey

Under normal circumstances, it is necessary to take into consideration if there are special geological locations where wind speed increase or where wind converges (ridges or valleys), history for lightning strikes at each location, and other such matters in the Dodoma capital area; however, such data was not possessed. Therefore, as an alternative method, we held a hearing with TANESCO regarding the history of accidents involving the existing transmission facilities. As a result, we confirmed that there was no history of accidents due to wind or lightning damage as far as staff know.

4) Field survey

The new transmission lines to be fed into the Zuzu substation in the future are in total five, including two ring transmission lines. The plan for new transmission lines in the future passing through the Dodoma capital area is shown in Table 4-4.4. Lack of cooperation between organizations has led to each organization's plan proceeding independently. Therefore, not only are there crossovers with existing transmission lines, there are also crossovers between new transmission lines. If crossovers occur, for overhead transmission lines, not only do towers for the new transmission lines have to be made higher, restrictions occur as well, such as the full outage of the transmission lines being crossed during construction. Outage restrictions may also occur in terms of maintenance and management, so this should be avoided if at all possible. In addition, if the crossover point is to use underground transmission lines, there will be concerns about increasing cost.

Considering the mutual separation from the existing transmission lines (Zuzu-Singida transmission lines), the ring transmission line (between Zuzu-Msalato) new route is set for a location where construction is impossible, and the plan needs to be reviewed.

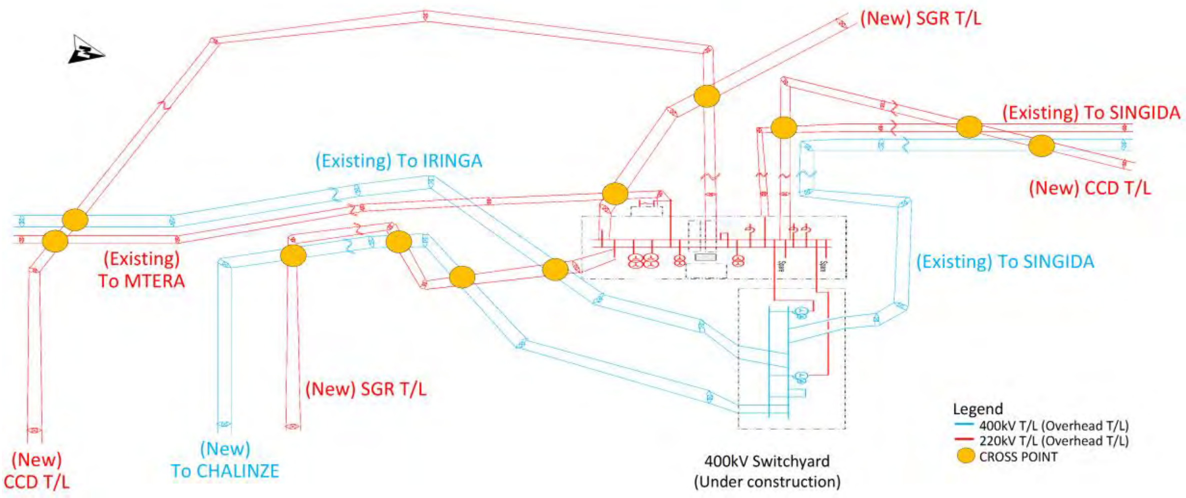
The new transmission lines to pass through the Dodoma capital area planned at current are shown in Figure 4-4.2. To avoid mutual interference with these lines, it is necessary to cooperate in the planning stages and aim for a consensus.

Table 4-4.4 Plan for newly established transmission lines passing through the Dodoma capital area

Voltage class	Number of circuits	Transmission line section	Scheduled commencement of operation	Notes
400kV	Double circuit	Chalinze-Zuzu	Undetermined	-
220kV	Double circuit	Zuzu-Msalato	Undetermined	Ring transmission line
220kV	Double circuit	Kikombo-Zuzu	Undetermined	Ring transmission line
220kV	Single circuit	Ihumwa*-Zuzu	Undetermined	SGR-dedicated line
220kV	Single circuit	Zuzu-Kigwe	Undetermined	SGR-dedicated line

*Different from the Ihumwa substation in the Dodoma capital area transmission grid

[Source] Created by JICA Study Team



[Source] Created by JICA Study Team

Figure 4-4.2 Planning status of newly established transmission lines around the Zuzu substation

5) Desktop detailed survey

Locations pending in light of the above situation are shown in Table 4-4.5.

Table 4-4.5 Pending locations in ring transmission line construction plan

Transmission line section	Pending location	Pending matter
Zuzu-Msalato	Zuzu substation exit point	Construction is planned between the existing transmission lines heading to the Singida substation; however, there is not enough space for transmission line construction
	About 2 km from Zuzu substation	Crossover with existing transmission lines occurs
	About 6 km from Zuzu substation	Crossover with existing transmission lines occurs
	About 3 km from Msalato substation	Passes through housing area (near crossover with the A104 road)
	Near Msalato substation	Neighbors the new airport and therefore may be affected by airport construction plan May partially interfere with EPZ planning zone
Msalato-Ihumwa	Msalato substation exit point	May interfere with road conservation area for buses planned in the future
	About 5 km from Msalato substation	Route goes along the EPZ zone and therefore is significantly roundabout
	About 7 km from Ihumwa substation	Passes through area dense with housing

Transmission line section	Pending location	Pending matter
	Within 7 km from Ihumwa substation	Route follows the planning zone for the government office district, and is also likely to be affected by changes in the government office district development plan An uneconomical route is selected, with lines travel quite far to the south for lead-in to the Ihumwa substation As it will become a government office district after commencement of operation, work involved in later maintenance and management may be subject to restrictions
Ihumwa-Kikombo	Within 7 km from Ihumwa substation	Same as above
	About 23 km from Ihumwa substation	Passes through area dense with housing
	About 23 km from Kikombo substation	Passes through area dense with housing (near Msanga)
	About 17 km from Kikombo substation	Passes through area dense with housing (near Chamwino) As it will become an urban area after commencement, later maintenance and management may become difficult As it neighbors the zone planned for the presidential office, work involved in later maintenance and management may be subject to restrictions The route is uneconomical because it has been changed following the land utilization planning zones
	About 9 km from Kikombo substation	Passes through housing area (near Buigiri)
	About 2 km from Kikombo substation	Passes through housing area
Kikombo-Zuzu	About 2 km from Kikombo substation	Passes through housing area
	About 7 km from Kikombo substation	Crossover with newly established SGR transmission lines
	About 11 km from Kikombo substation	Passes through housing area
	About 19 km from Kikombo substation	Crossover with newly established Chalinze-Zuzu transmission lines
	About 19 km from Zuzu substation	Crossover with existing transmission lines
	About 17 km from Zuzu substation	Passes through housing area
	About 2.5 km from Zuzu substation	Crossover with newly established SGR transmission lines
	Within 19 km from Zuzu substation	The route is uneconomical and believed to have been selected following land utilization planning zones

(2) Proposal

1) Proposal routes

We propose the routes indicated in Figure 4-4.3. In addition to making the lengths as short as possible, we took into consideration interference with existing transmission lines and locations passing through the government office district and urban areas. An outline is shown in Table 4-4.6.

In the area around Zuzu substation, there are not only existing transmission lines, but also many plans for newly established transmission lines, thus necessitating the use of underground transmission lines only for the lead-in sections of the substation. The construction cost of underground transmission lines is approximately four times that of using overhead transmission lines. However, since this method will be used only in the substation lead-in section, the increase in costs is limited. Furthermore, as the total length of the proposal routes is approx. 193 km compared to the approx. 215 km length of the existing transmission facilities plan, cost can be reduced for the approx. 22 km of the reduced length.

Table 4-4.6 Specifications of proposal routes

Voltage class	Number of circuits	Transmission line section	Line length	Change
220kV	Double circuit	Zuzu-Msalato	32km	+5km
220kV	Double circuit	Msalato-Ihumwa	12km	▲ 13km
220kV	Double circuit	Ihumwa-Kikombo	52km	▲ 10km
220kV	Double circuit	Kikombo-Zuzu	47km	▲ 4km
220kV	Single circuit	Kikombo-Narco	50km	—

a) **Zuzu-Msalato**

We propose a route constructed along a regional road, in order to avoid interference with existing transmission lines, passing through housing areas, and interference with the new airport and EPZ. Related to this, we propose changing the area planned for the Msalato substation to the EPZ north side. Because of this, it will no longer be affected by changes to the plans for the new airport or EPZ, but because it is along a road, will also make it easier to bring in machinery, materials, and monitor facilities during construction or maintenance and management.

b) **Msalato-Ihumwa**

We propose changing the Ihumwa substation to the north side in order to avoid passing through housing areas and interference with the government office district. As it can be assumed that restrictions will be placed on work near the government office district in the future, it would be ideal to leave a certain amount of distance. Therefore, not only can the length be suppressed, we can also avoid harming the view from the government office district.

c) **Ihumwa-Kikombo**

Taking into consideration the ease of maintenance and management in the future, we propose a route constructed along the outer ring road, which is to be built in the future. However, as interference with the SGR-dedicated transmission lines that cross the Dodoma capital area cannot be avoided, consultation is required from the planning stages.

Also, there was a request from TANESCO to investigate the possibility of implementing the shortest route that connects Ihumwa and Kikombo substations in a straight line; however, considering that this would involve passing through the government office district and areas planned for housing, as well as harm the view, affect the wayleave, and make maintenance and management more difficult in the future, it is better to avoid this.

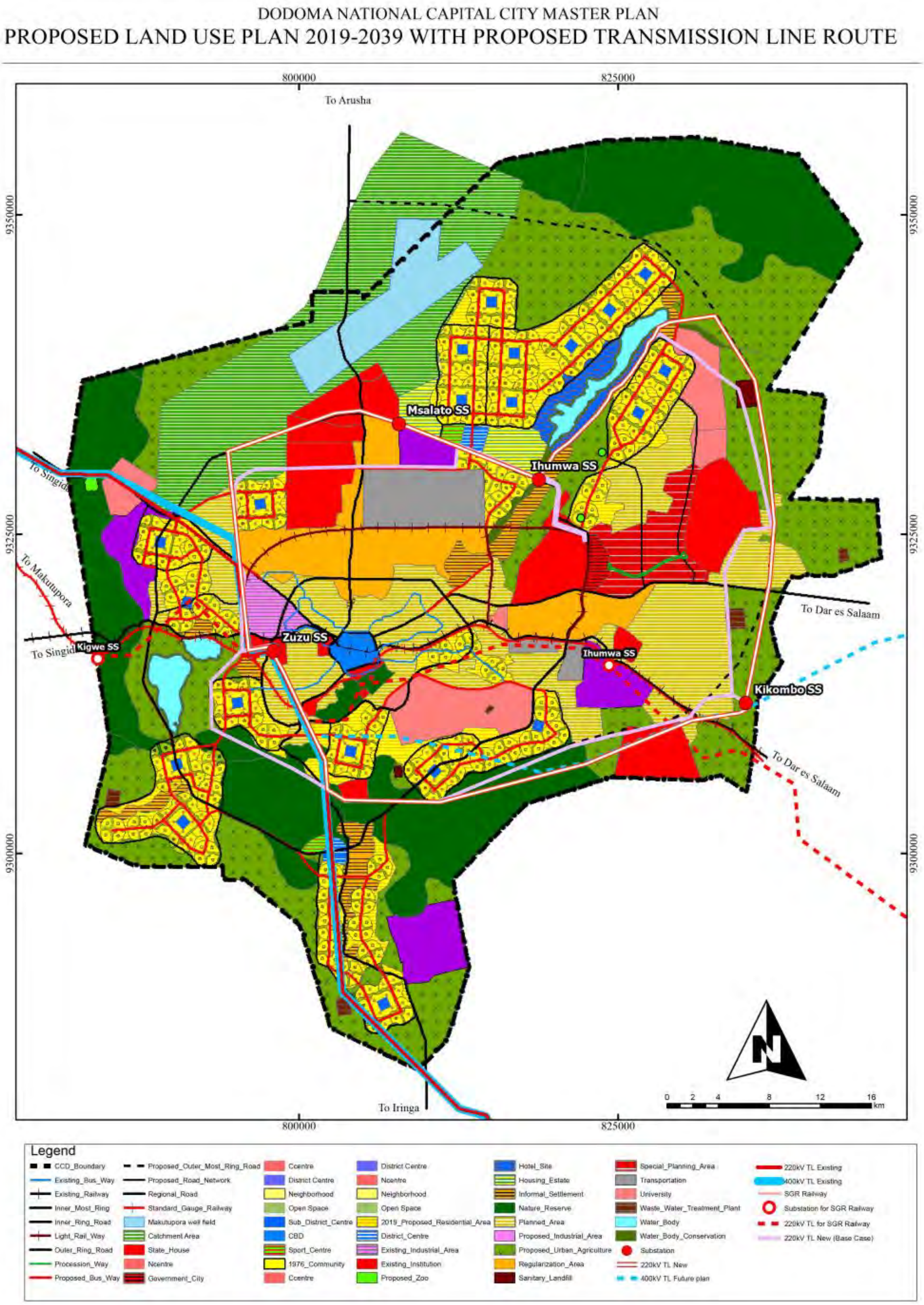
d) **Kikombo-Zuzu**

To avoid interference with existing transmission lines, we propose a route constructed along the existing transmission lines near the Zuzu substation.

Furthermore, as there is a risk of interference with the new Chalinze-Zuzu transmission lines passing through virtually the same route, cooperation is required from the planning stages. If collaboration were possible, it would be ideal to jointly use towers in consideration of wayleave.

e) **Kikombo-Narco**

There is a risk of interference with the new Chalinze-Zuzu transmission lines passing through virtually the same route; cooperation is required from the planning stages. If collaboration were possible, it would be ideal to jointly use towers in consideration of wayleave.

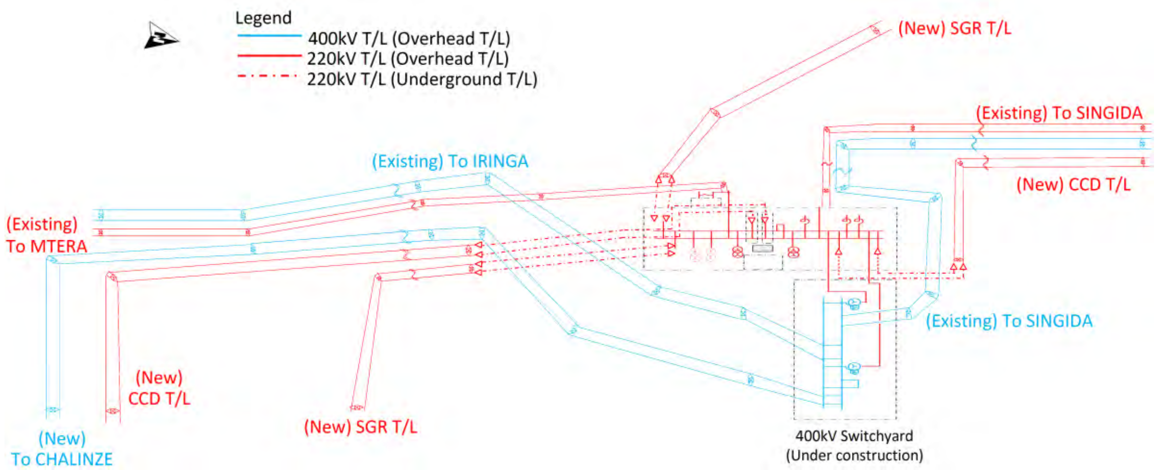


[Source] Created by JICA Study Team

Figure 4-4.3 Proposal routes (As of Second Field Survey)

2) Area around Zuzu substation

In order to avoid crossovers between new transmission lines, we also propose changing the new transmission line routes around the Zuzu substation. With only overhead transmission lines, crossover with existing transmission lines cannot be avoided regardless of which route is selected. Therefore, we propose using underground transmission lines only for the outgoing sections from Zuzu substation in the ring transmission lines and SGR-dedicated transmission lines. In addition, as we have not confirmed matters such as underground facilities around the Zuzu substation, the route uses a straight line. If the underground transmission lines are used, it will be necessary to investigate a detailed route that considers such matters. An outline figure is shown in Figure 4-4.4.



[Source] Created by JICA Study Team

Figure 4-4.4 Proposal routes around Zuzu substation

(3) Other Matters

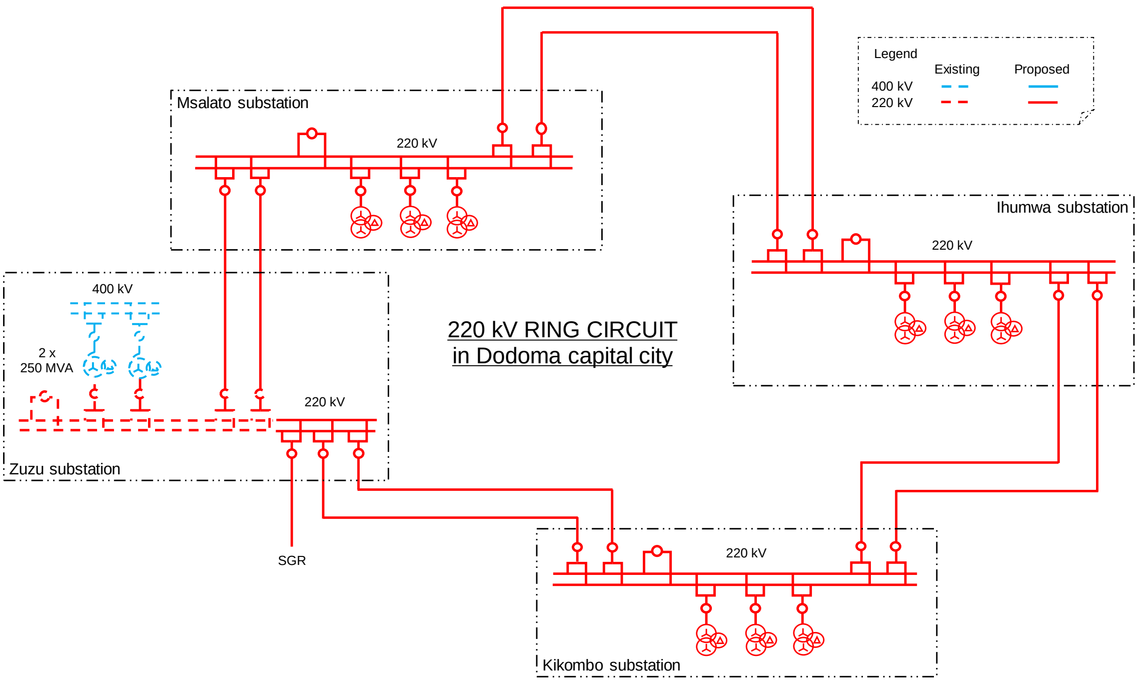
The Chalinze-Zuzu transmission line plan route, scheduled to be newly established, does not take the land development plan into consideration, and therefore must be reviewed.

The area around the Zuzu substation has transmission lines tightly packed together; therefore, it is necessary to take construction plans into consideration and think of a construction plan that does not involve mutual interference.

4-5 Substation Facility Plan

4-5-1 Outline of the Review

As mentioned in Section 4-2, a 220 kV ring circuit will be formed starting from and to Zuzu substation with 220 kV double transmission lines, as shown in Figure 4-5.1.



[Source] JICA Study Team

Figure 4-5.1 Network Diagram of 220 kV Dodoma Ring Circuit

Thus, the following new substations are to be planned;-

- Msalato substation
- Ihumwa substation
- Kikombo substation

4-5-2 Study Conditions

(1) Planning policy

For the study of Substation planning, the following policy could be applied.

- Double busbar configuration according to Grid code of Tanzania,
- The transformers should have the capacity of some load for the substations inside the ring circuit as a backup. (Backup configuration),
- Two transformers should be installed from the beginning due to N-1 criteria,
- Two each of incoming and outgoing transmission line bays to ensure reliability, and

- 220/33 kV transformers should be of double winding type to isolate 220 and 33 kV system.

(2) Power demand

According to Clause 4-2-4, the load of the power demand are allocated for each substation year by year, as shown in Table 4-5.1.

Table 4-5.1 Load Demand Forecast

Msalato

Year	2030	2035	2040	2045	2047
Load (MVA)	41.19	49.14	59.3	72.22	78.63

Ihumwa

Year	2030	2035	2040	2045	2047
Load (MVA)	100.26	119.63	144.35	175.8	191.39

Kikombo

Year	2030	2035	2040	2045	2047
Load (MVA)	16.18	19.3	23.29	28.36	30.88

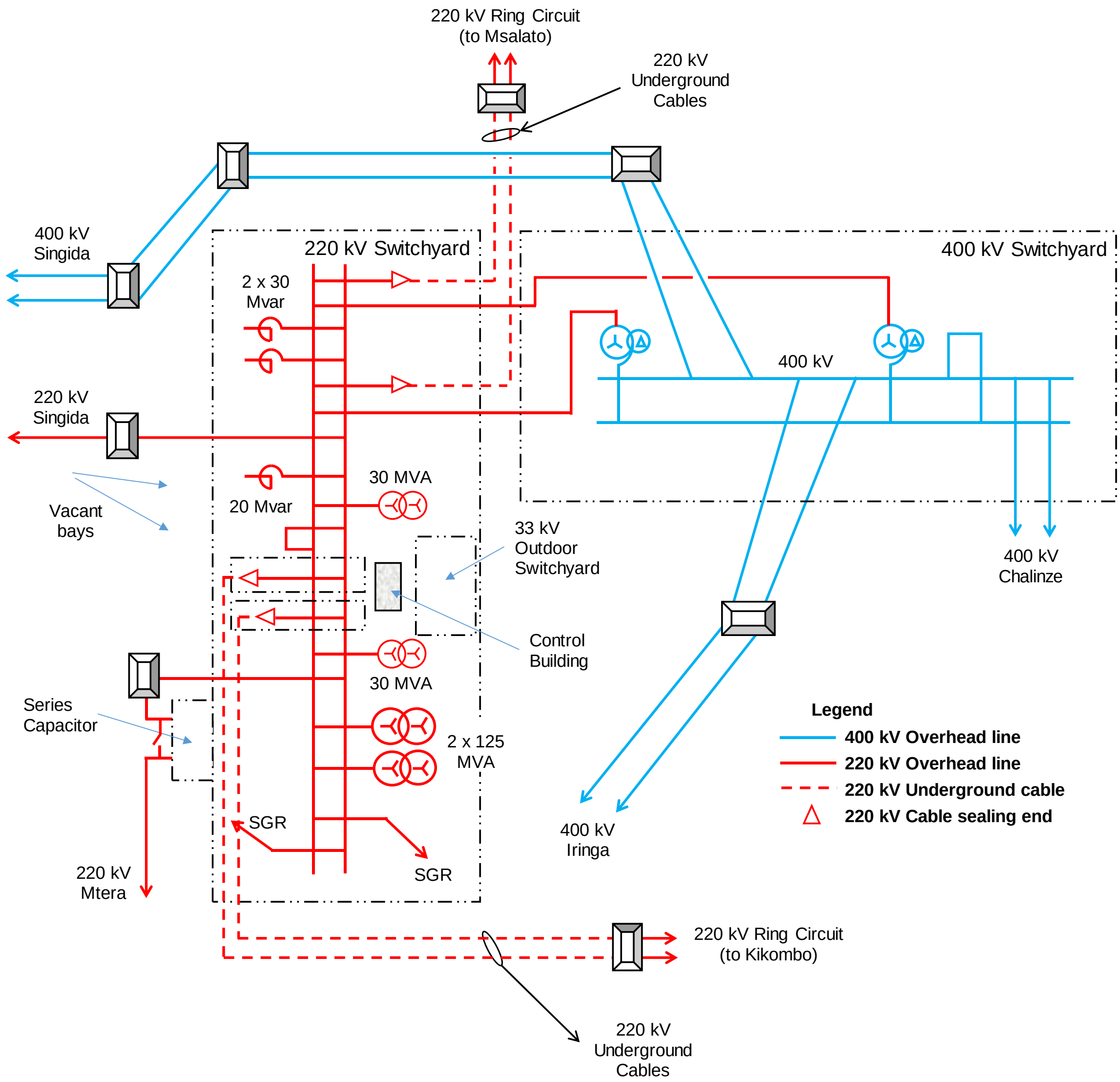
[Source] JICA Study Team

(3) Study Result and Proposed Substation Plan

1) Zuzu substation

After completion of 400 kV switchyard construction in Zuzu substation, two 220 kV spare transmission line bays will remain, as shown in Figure 3-5.7. Since four transmission line bays are necessary for the double ring circuit, two more transmission line bays should be installed. In Zuzu substation, two vacant bays on 220 kV busbar could be utilized for the transmission lines for the ring circuit. Thus, four transmission line bays are available for the 220 kV double ring circuit for Dodoma capital city at Zuzu substation. However, because the surrounding area of Zuzu substation is crowded with 400 kV and 220 kV overhead transmission lines, there is no room to install additional overhead transmission lines around Zuzu substation.

Consequently, 220 kV underground cables shall be applied for the 220 kV ring circuit. See Figure 4-5.2 “Illustrative Layout Drawing of 220 kV Ring Circuit at Zuzu Substation”. Ex-Singida 2 and ex-Iringa 2 should be changed as Msalato 1 and 2 respectively, and new transmission line bays installed in vacant bays will be for Kikombo 1 and 2.



[Source] JICA Study Team

Figure 4-5.2 Illustrative Layout Drawing of 220 kV Ring Circuit at Zuzu Substation

2) New 220 kV substations

New 220 kV substations should have "Double busbar configuration" with the following bays;-

- 4 sets of Transmission line bays
- 3 sets of Transformer bays
- 1 set of Bus coupler bay

As mentioned hereinbefore, the transformer capacity should have some backup load of the substations inside the ring circuit in case of emergency (Backup configuration). Up to or around or before the year of 2035, it should be decided whether additional transformer should be installed or not, considering the actual load growth of the area.

According to the demand forecast in this report, the following transformer capacity would be considered. See Table 4-5.2 below.

Table 4-5.2 Transformer Capacity

Msalato (MVA)

Year	2030	2035	2040	2045	2047	Remarks
Load	41.19	49.14	59.3	72.22	78.63	
Backup Load	50	59	72	87	95	Half of Ihumwa load
Transformer Capacity	2 x 50	2 x 50	3 x 50	3 x 50	3 x 50	

*Zuzu substation can backup the deficit of the capacity

Ihumwa (MVA)

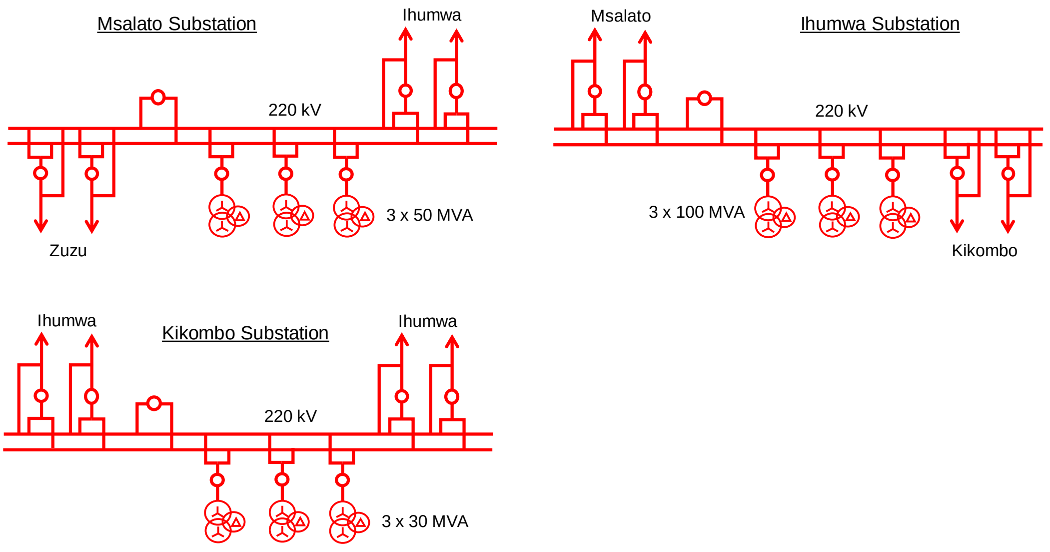
Year	2030	2035	2040	2045	2047	Remarks
Load	100.26	119.63	144.35	175.8	191.39	
Backup Load	20	24	29	36	39	Half of Msalato load
Transformer Capacity	2 x 100	2 x 100	3 x 100	3 x 100	3 x 100	

Kikombo (MVA)

Year	2030	2035	2040	2045	2047	Remarks
Load	16.18	19.3	23.29	28.36	30.88	
Backup Load	50	59	72	87	95	Half of Ihumwa load
Transformer Capacity	2 x 30	3 x 30	3 x 30	3 x 30	3 x 30	

*Zuzu substation can backup the deficit of the capacity
[Source] JICA Study Team

The simple single line diagrams of proposed three substations are shown in Figure 4-5.3, below.



[Source] JICA Study Team

Figure 4-5.3 Simple Single Line Diagram of Proposed Substations

4-6 Distribution Planning

4-6-1 Outline of the Considerations

In this chapter, based on the confirmed configuration of the existing distribution network, condition and some operation status of facilities, challenges and future expansion plans for distribution facilities, some recommendations are provided. Those recommendations should be suitable for the transmission network expansion plan proposed by the Study Team.

The target of the distribution network is within the Dodoma Capital City District, however since the existing Zuzu substation supplies through the current distribution to the suburban areas, future distribution network for those suburban areas are also considered.

4-6-2 Study Conditions

(1) Policy for the Consideration

The study of distribution facilities was conducted based on the reviewed power demand forecast and the transmission system development plan with the following basic policy.

1) To consider existing distribution plans and standard specifications

The proposal will be made based on the TANESCO plans and standard specifications provided by TANESCO.

2) To cooperate with Dodoma Capital Master Plan

The proposal will be coordinated in consideration of the distribution network development plan mentioned in the Dodoma Capital Master Plan.

3) To Relief existing distribution network

In particular, the existing distribution feeder with a long distribution line length and frequent power outages should be relieved as early as possible in order to contribute to the improvement of distribution supply reliability.

4) To facilitate distribution network development for the essential loads

Provide enough and reliable power to government offices and the Statehouse at the earliest stage.

5) Distribution system configuration

In order to minimize power outages required due to planned maintenance or unplanned (fault conditions), power distribution system that can be relieved should be adopted. Regarding two types of distribution voltages that are the issues mentioned in Chapter 3, the distribution from the new substations should be 33kV, and planned reinforcement of the existing 11kV distribution network should be upgraded to 33kV in the future.

6) Economy

Any Proposal for the facility should be considered cost effectiveness and economical in operation and maintenance

7) Low loss

Any Proposal for the facility should be considered low loss in order for the Dodoma Capital City District to become a model case of low loss distribution network for other regions.

(2) Load

The load predicted for 2025 and 2030, allocated to the supply area from each substation is as follows;

Table 4-6.1 Load Forecast at 2025 and 2030

Zuzu Supply Area	2025	2030
Town	14.8	21.6
Inter connect	11.9	17.4
Mzakwe	-	-
Mwandani	-	-
Chamwino	-	-
Mpwapwa	-	-
Bahi	1.3	2.0
Indusrial	16.2	27.0
TPDF quarters	0.9	1.5
EPZ	-	-
Airport	-	-
Dry port	-	-
Marshalling yard	-	-
State house	-	-
Butcher	-	-
Quaters 40000	-	-
Goverment City	-	-
Total Capacity(MVA)	45.2	69.4

Msalato Supply Area	2025	2030
EPZ	7.2	12.0
Airport	5.4	9.0
Mzakwe	4.4	6.4
Mwandani	9.6	14.0
Total Capacity(MVA)	26.6	41.4

Ihumwa Supply Area	2025	2030
Dry port	0.5	0.8
Marshalling yard	1.1	1.8
State house	0.5	0.8
Butcher	0.5	0.8
Quaters 40000	1.4	2.4
Goverment City	45.0	75.1
Chamwino	4.3	6.2
Mpwapwa	7.3	10.7
Total Capacity(MVA)	60.5	98.4

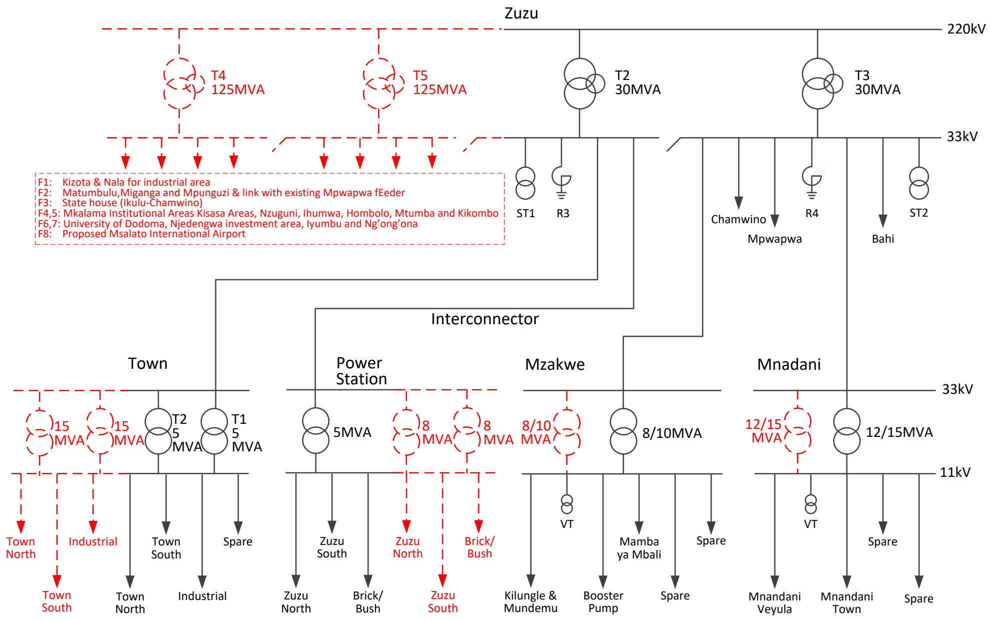
Kikombo Supply Area	2025	2030
Chamwino	4.3	6.2
Mpwapwa	7.3	10.7
Total Capacity(MVA)	11.6	16.9

[Source] JICA Study Team

4-6-3 Study results and recommendations

(1) Expansion of the existing facilities

Among the reinforcement of the existing distribution system planned by TANESCO, expansion plans related to the primary and secondary substations are as follows.



[Source] Created by JICA Study Team based on the information from TANESCO

Figure 4-6.1 Planned expansion for Distribution Network of Dodoma Capital City District

(2) Recommendation related to Distribution System

In the current Dodoma distribution system, radial distribution system supplying power from single distribution feeder has been maintained, it is recommended to consider adaption of different distribution system according to the progress of transmission system development.

As described in the power system planning and substation planning, in this grid development plan, even if an emergency situation occurs in a substation in the ring power system, backup with a capacity of approximately one power transformer from another substation to supply power to the demand area could be available. In addition, it is recommended to adopt a multi power supply system to make mutual load relief available in order to ensure high reliability by reducing the power outage area during a power outage by accident or power outage due to maintenance on the distribution lines.

(3) Expected Distribution Feeders

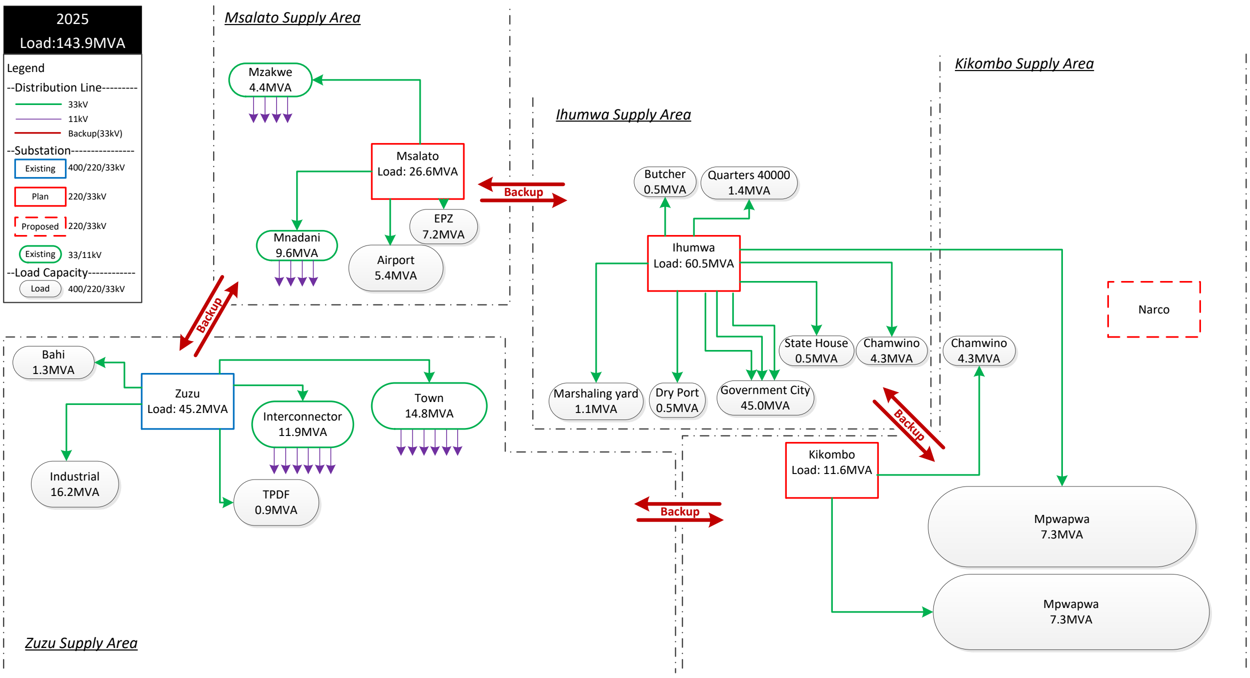
The expected distribution feeders are shown in the figures below, based on the results of power demand forecasts, power system planning, and substation planning. However the trunk lines and branch lines of the distribution lines are not considered. The 33kV distribution line of TANESCO standard specification with ACSR150mm^2 (Dingo) is considered, and a new feeder was added when the line capacity reached 80% of its rated capacity (27.03MVA).

If the expansion of the primary and secondary substations shown in Figure 4-6.1 is implemented, the substation capacity and the number of distribution feeders could be managed up to the load in 2030. However, distribution configuration with backup system should be carefully considered, depending on the concept of backup power supply system in case multi power supply system is adapted, because the number of lines might be changed and/or dedicated line might be necessary.

Figure 4-6.2 shows the distribution feeders when the capital development plan has progressed significantly and the 220kV ring transmission line and Msalato, Ihumwa and Kikombo substations are constructed in 2025. The load supplied from Zuzu Substation will be reduced, and the existing long-distance distribution feeders such as Mpwapwa feeder and Chamwino feeder will be improved. In addition, since a backup system between substations is established, the power distribution network has higher distribution reliability. However, careful planning is necessary because construction, connection switching and rehabilitation of distribution lines with a large number will be required by 2025. In addition, large-scale distribution development that considers future operation and control by DCC is also carefully planned and implemented in short-term.

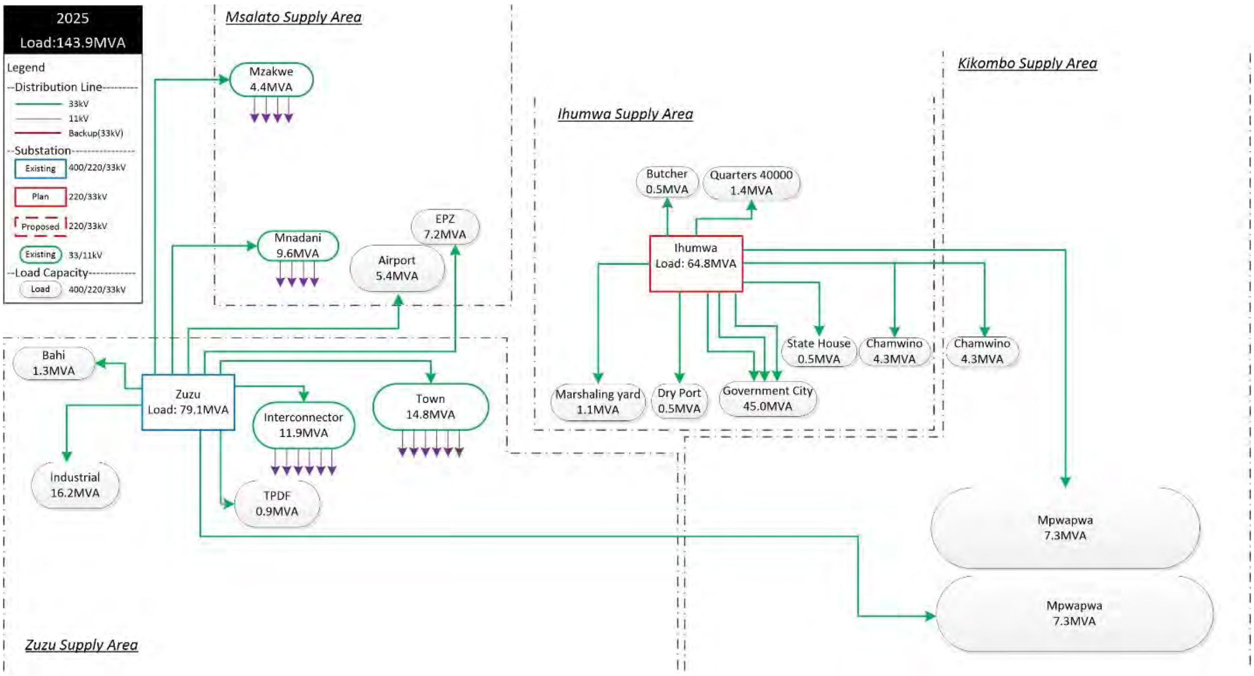
Next, Figure 4-6.3 shows the distribution feeders when the development of the capital city such as the government city has progressed and the construction of part of the 220kV ring transmission line and Ihumwa substation is completed by 2025. The supply area of Msalato substation can be handled by utilizing the distribution feeder from the existing Zuzu substation. It is assumed that it will be possible to implement in a short period because the development of distribution network could be focused on the Ihumwa government city and the existing Mpwapwa feeder and Chamwino feeders necessary to relief load urgently. However, since backup system between substations cannot be expected as much, it is necessary to take measures against power outages such as installing proper switchgear and protection devices at key locations on the distribution lines.

Finally, Figure 4-6.4 shows distribution feeders that assumes 2030 when all load, including special loads, are allocated to substations and the backup system has been established. However, it is necessary to consider distribution facilities with future load increase and secure wayleave.



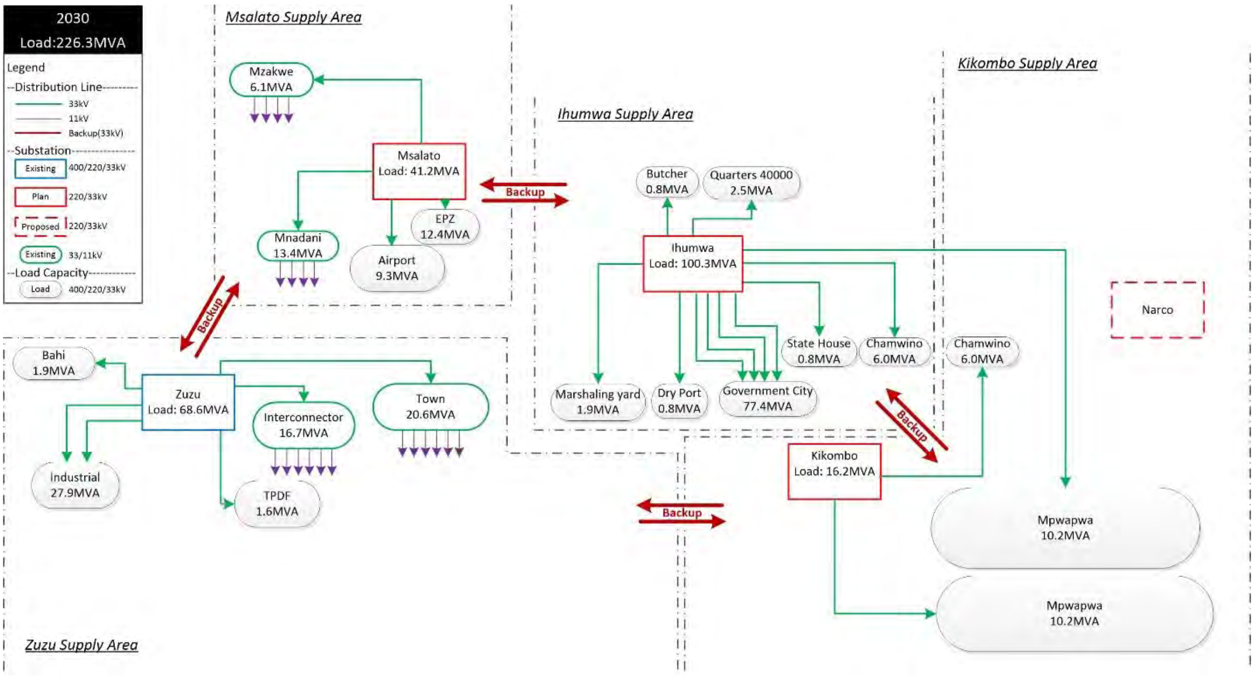
[Source] Created by JICA Study Team

Figure 4-6.2 Proposed Distribution Feeders in Dodoma Capital City District (2025)



[Source] Created by JICA Study Team

Figure 4-6.3 Proposed Distribution Feeders in Dodoma Capital City District (2025 in stepwise)



[Source] Created by JICA Study Team

Figure 4-6.4 Proposed Distribution Feeders in Dodoma Capital City District (2030)

(4) Harmonization with Dodoma Distribution Master Plan

The outline of the Distribution Master Plan Study for four regions including Dodoma Region was mentioned in Chapter 3. The Study Team received the following reports to confirm the progress of the Master Plan Study.

- Dodoma Region Load Forecast and Power System Study Report - 29/11/2019
- Dodoma Region Lines and Substation Conceptual Design Basis Report - 20/01/2020

Some parts such as load demand forecast and power system planning in the above report are different from the contents examined by the Study Team. The Distribution Master Plan study is expected to complete by July 2020, and it is necessary to discuss with the Tanzanian side how to cooperate based on the contents of the power distribution master plan final report.

Chapter 5 Consideration on Cooperation Policy in Reinforcing Dodoma Transmission and Distribution Network

Chapter 5 Consideration on Cooperation Policy in Reinforcing Dodoma Transmission and Distribution Network

5-1 Outline of Dodoma Transmission System Development Plan

The proposed Dodoma Transmission System Development Plan was considered with the development phase and coordination of the Dodoma Capital City Master Plan. Power system configuration is expected to countermeasure such as addition of transformers will be followed according to the increase in demand. Thus, number of transformers at the construction stage indicate the numbers at the initial stage of the development.

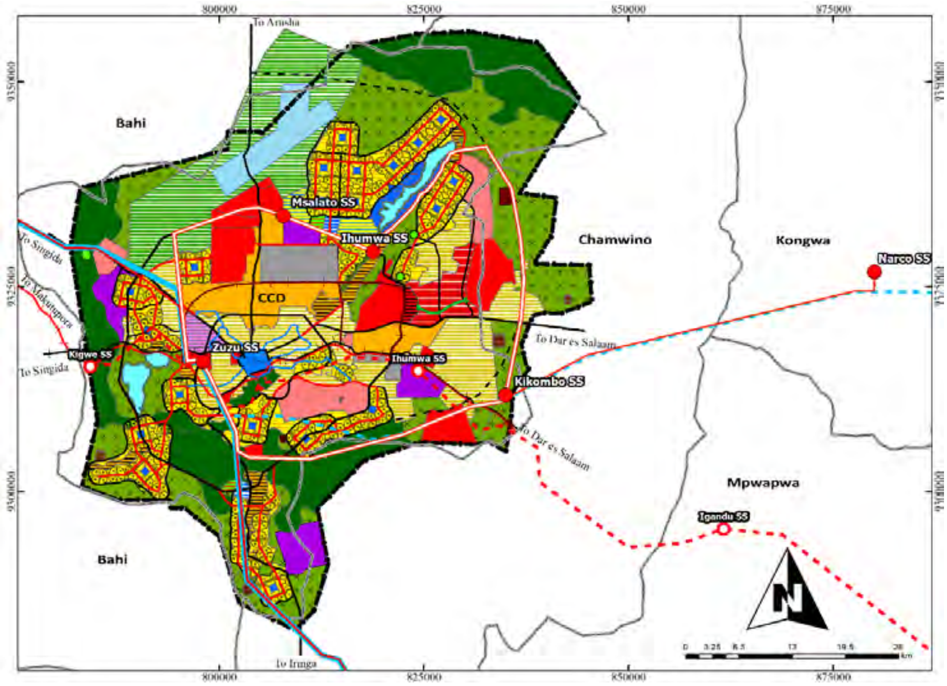
The outline of the proposed Dodoma transmission system development plan for Dodoma Capital City District is shown in Table 5-1.1. As described in the remarks, it is necessary to construct the transmission line while coordinating with the existing lines and other future planned transmission lines, particularly regarding the expropriation of the wayleave. The Study Team proposed changes to the locations of Ihumwa and Msalato substations from the location planned by TANESCO, and land acquisition process should start because locations are planned at the initial development phase of the Dodoma Capital City Master Plan. In addition, there are alternative plans to connect to Narco substation depending on the case where development is carried out, either at the same time or the case of connecting in steps (see T-5 in the table below).

Table 5-1.1 Outline of Dodoma Transmission System Development Plan

<table>
<tr><th>Facility</th><th>ID</th><th>Outline</th><th>Ramarks</th></tr>
<tr><td rowspan="6">Transmission</td><td>T-1</td><td>■ Construction of Transmission Line (Zuzu-Msalato)
· 220kV Double Circuits Approx.32km</td><td>At Zuzu substation, outgoing transmission line with Cable should be considered</td></tr>
<tr><td>T-2</td><td>■ Construction of Transmission Line (Msalato-Ihumwa)
· 220kV Double Circuits Approx.12km</td><td>-</td></tr>
<tr><td>T-3</td><td>■ Construction of Transmission Line (Ihumwa-Kikombo)
· 220kV Double Circuits Approx.52km</td><td>Outgoing transmission line to Narco from Ihumwa should be coordinated in case of stepwise development</td></tr>
<tr><td>T-4</td><td>■ Construction of Transmission Line (Kikombo-Zuzu)
· 220kV Double Circuits Approx.47km</td><td>Transmission line should be coordinated with the existing line. At Zuzu substation, outgoing transmission line with Cable should be considered</td></tr>
<tr><td rowspan="2">T-5</td><td>■ Construction of Transmission Line (Kikombo-Narco)
· 220kV Double Circuits Approx.50km (In case of one-time development)</td><td>In case of one-time development, Narco should be connected to Kikombo.</td></tr>
<tr><td>■ Construction of Transmission Line (Ihumwa-Narco)
· 220kV Double Circuits Approx.80km (In case of stepwise development)</td><td>In case of stepwise development, Narco should be connected to Ihumwa.</td></tr>
<tr><td rowspan="5">Substation</td><td>S-1</td><td>■ Construction of Msalato substation
· 2x50MVA 220/33kV Transformer
· One lot of Switching and Information facilities
· Construction of Control Building, Civil Works, etc.</td><td>Potential location should be re-considered based on the proposal by JICA Study Team</td></tr>
<tr><td>S-2</td><td>■ Construction of Ihumwa substation
· 2x100MVA 220/33kV Transformer
· One lot of Switching and Information facilities
· Construction of Control Building, Civil Works, etc.</td><td>Potential location should be re-considered based on the proposal by JICA Study Team</td></tr>
<tr><td>S-3</td><td>■ Construction of Kikombo substation
· 2x40MVA 220/33kV Transformer
· One lot of Switching and Information facilities
· Construction of Control Building, Civil Works, etc.</td><td>Potential location is confirmed by JICA Study Team, though not secured</td></tr>
<tr><td>S-4</td><td>■ Construction of Narco substation
· 1x30MVA 220/33kV Transformer
· One lot of Switching and Information facilities
· Construction of Control Building, Civil Works, etc.</td><td>Potential location is confirmed by JICA Study Team, though not secured</td></tr>
<tr><td>S-5</td><td>■ Rehabilitation of Zuzu substation
· One lot of transmission line bay facilities</td><td>Existing 4-bay space should be secured for outgoing transmission lines</td></tr>
</table>

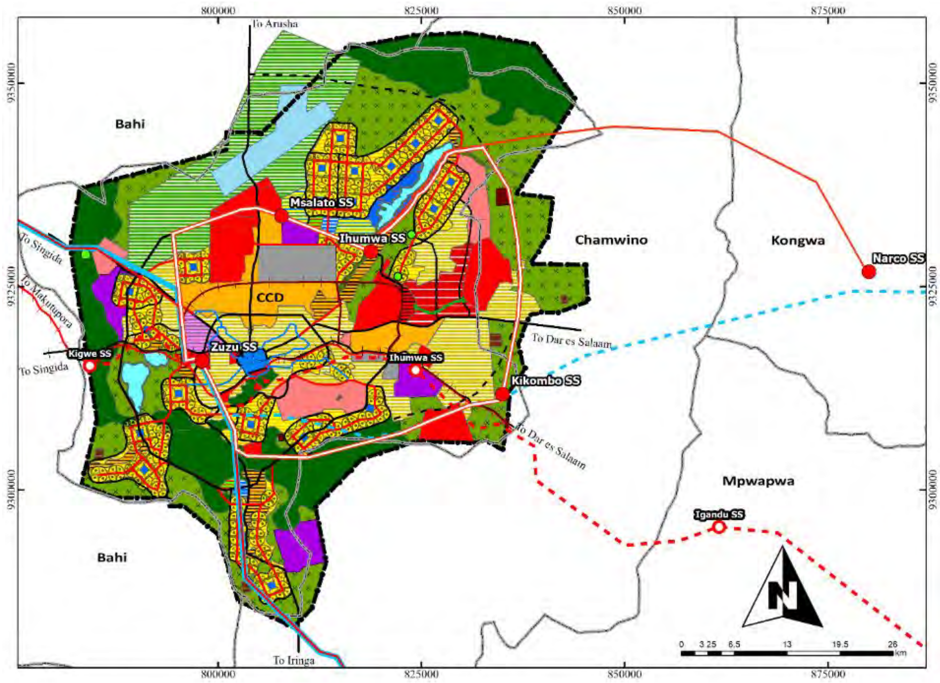
[Source] JICA Study Team

The proposed location maps for Dodoma Transmission System Development Plan are shown in Figure 5-1.1 and Figure 5-1.2.



[Source] JICA Study Team

Figure 5-1.1 Outline of Dodoma Transmission System Development Plan (In case of one-time development)



[Source] JICA Study Team

Figure 5-1.2 Outline of Dodoma Transmission System Development Plan (In case of stepwise development)

5-2 Scenario study for Transmission System Development Plan

5-2-1 Scenario Building

(1) Concept

In order to contribute to the improvement of power supply reliability in the entire Dodoma region and to improve the existing distribution network from the onset, scenario settings and evaluations are conducted based on the following concepts, in addition to the results of power demand forecast and development plans.

■ **Construction of Ihumwa substation should be completed by the end of Phase I of the Implementation Plan in Dodoma Capital City Master Plan (2024), and then immediately construction of Narco substation should be completed and should be started operation.**

- To supply reliable power to important loads such as Government City offices and Statehouse
- To increase distribution reliability by allocating approx. 50% of the load of Chamwino and Mpwapwa feeders currently supplied from Zuzu substation by long distance distribution lines.
- To enable power supply to other special loads that need to be supplied from Ihumwa substation after 2025.
- The power supply to Msalato and Kikombo supply areas could be relieved (backed up) by utilizing the existing distribution lines or from Ihumwa substation.

■ **Construction of Ihumwa substation should be completed and started operation by the end of Phase II of the Implementation Plan in Dodoma Capital City Master Plan (2029)**

- To enable power supply to other Government Buildings, Government Agencies, and other special loads by 2030.
- To complete the load transition from Zuzu substation, and to enable the capacity to withstand future demand and stable power supply under the load according to the power demand forecast.

■ **Construction of Kikombo substation should be completed and started operation with the loop transmission line is single circuit by the end of Phase III of the Implementation Plan (2034). Loop transmission line in double circuits is planned according to the progress of Phase IV of the Implementation Plan (2034).**

- To enable power supply to west and south area in Dodoma by 2034.
- To build a power supply system that takes into account unforeseen situations, such as the occurrence of system equipment accidents and maintenance shutdowns.

(2) Scenario Settings

Based on the above concepts, the following three scenarios were set up and evaluated qualitatively.

Scenario-1: **<Stepwise Development Plan 1>**

<u>Establishing a single line loop circuit as early and to secure power supply reliability</u>

Outline: Construction of Ihumwa substation with the loop transmission line in single circuit will be completed to start operation by 2025. Construction of other transmission and substation facilities will be completed to start operation by 2034, except for connection to other power systems.

Scenario-2: **<Stepwise Development Plan 2>**

<u>Ensuring power supply reliability by constructing double-circuit transmission lines on the north side with emphasis on urgency</u>

Outline: Construction of Ihumwa substation and the double-circuit transmission lines will be completed to start operation by 2025. Construction of other transmission and substation facilities will be completed to start operation by 2034, except for connection to other power systems.

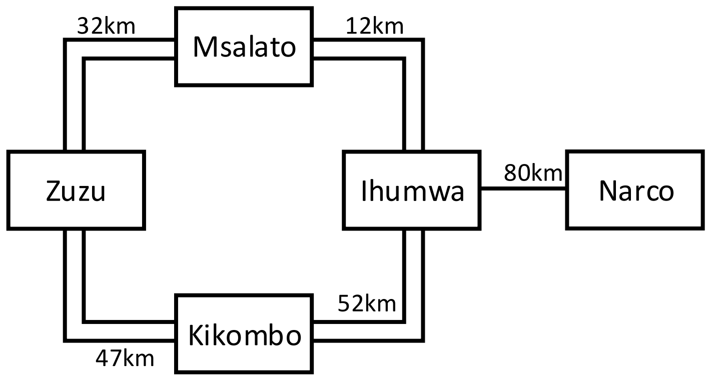
Scenario-3: **<One-time development plan>**

<u>Advanced development with double-circuit transmission loop system</u>

Outline: Construction of all substations and transmission lines in Dodoma Capital City District including Narco substation will be completed by 2025 to start operation with two-loop operation, except for connection to other power systems.

(3) Scenario Buildings

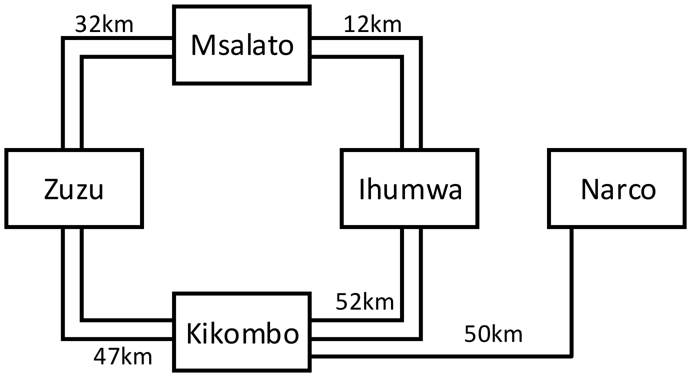
Scenario-1 and Scenario-2 are set for the stepwise development plan according to the progress of the development of Dodoma Capital City and power demand forecast. In addition, Narco substation will be connected to Ihumwa substation at the same time, or right after the construction of Ihumwa substation in order to relief load on the existing distribution network in Chamwino, Kongwe and Mpwapwa areas as early as possible. The final system configuration of Scenarios-1 and 2 is shown in Figure 5-2.1 below.



[Source] JICA Study Team

Figure 5-2.1 Final Power system Configuration (Stepwise development)

Scenario-3 is a one-time development plan, and the transmission line length will become shorter by connecting to the Kikombo substation, which is advantageous in terms of construction cost. The final system configuration of Scenarios-3 is shown in Figure 5-2.2 below.

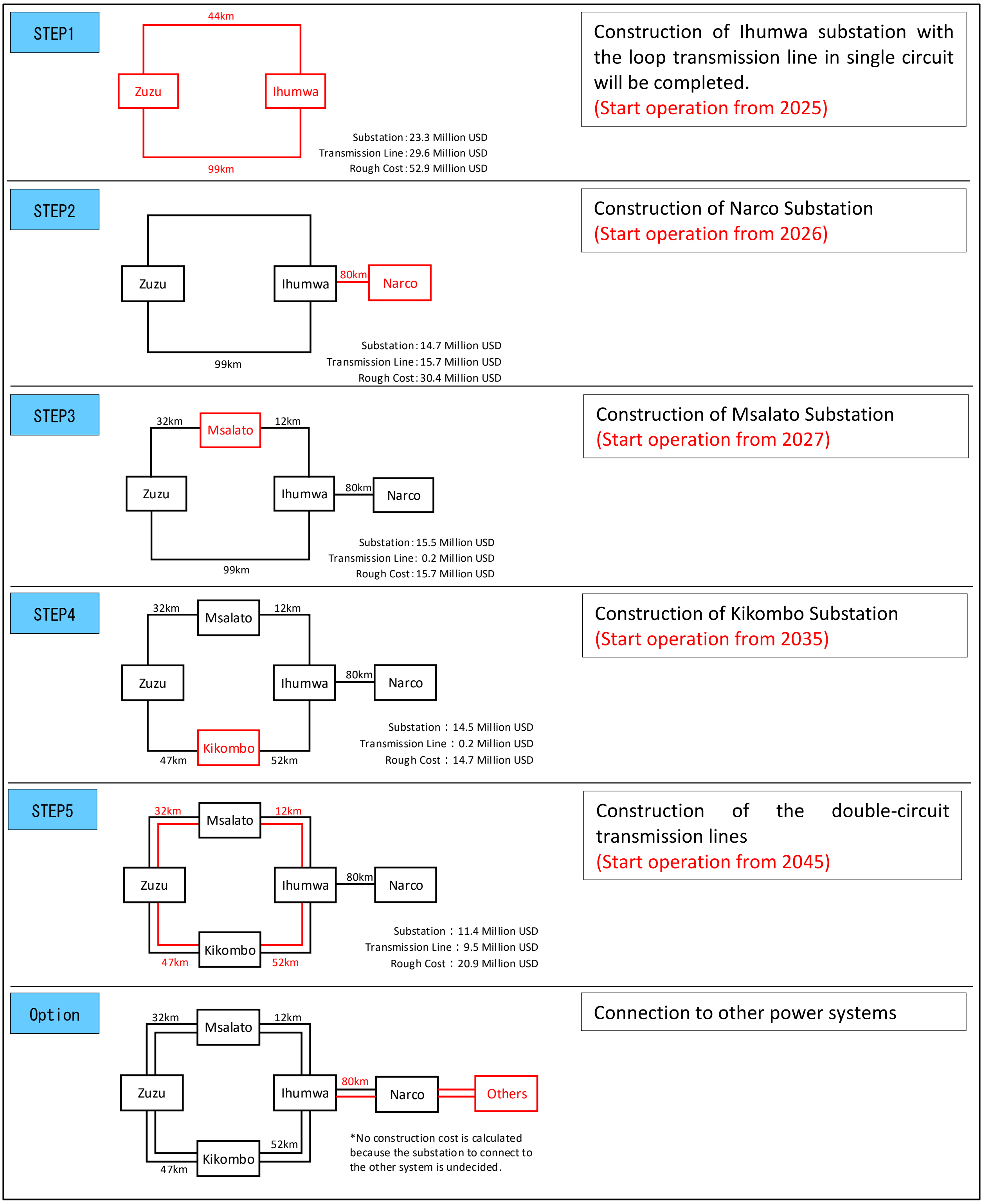


[Source] JICA Study Team

Figure 5-2.2 Final Power system Configuration (One-time development)

Scenario- 1 ：＜Stepwise Development 1＞Establishing a single line loop circuit as early and to secure power supply reliability

The stepwise development plan and reference costs for Scenario-1 are shown in Figure 5-2.3.

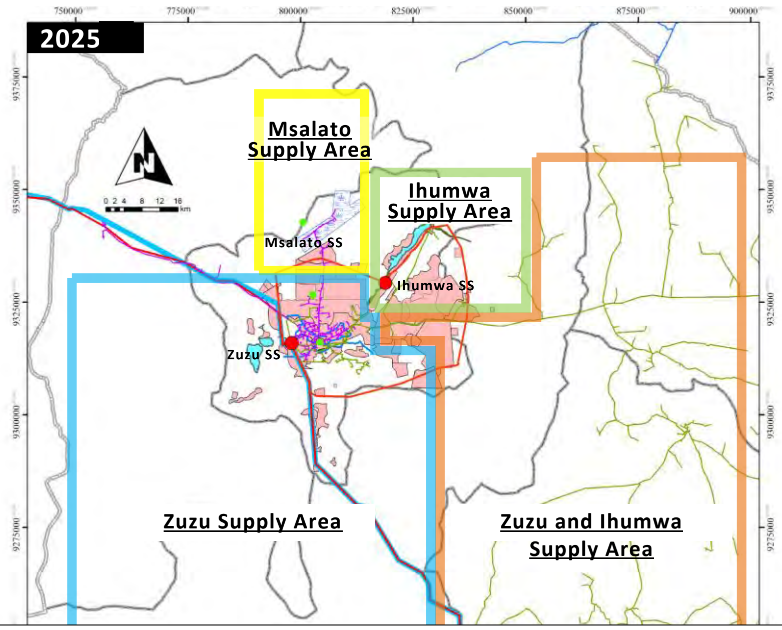


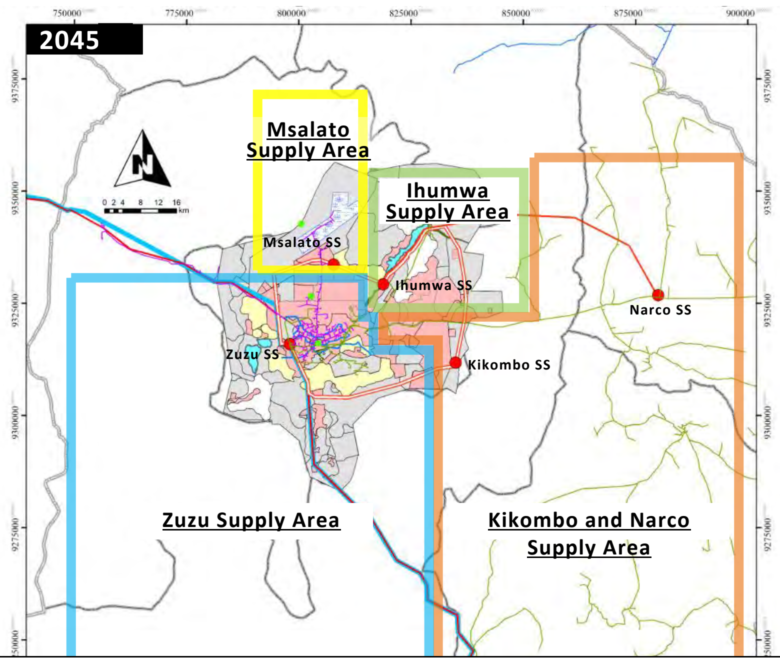
[Source] JICA Study Team [Remark] Rough Cost excludes Distribution, land preparation cost, Consultancy fee and Contingency

Figure 5-2.3 Stepwise Development Plan (Scenario-1)

Figure 5-2.4 show the site locations of scenario-1, cross section for the 2025 and 2030 with expected load.

Load allocation for each substation [MVA]	Substation	2025-year	2026-year	2027-year	2035-year	2045-year
	ZuZu Substation	71.75	80.00	55.44	81.81	120.23
	Ihumwa Substation	72.09	57.81	66.02	100.33	147.44
	Narco Substation	-	24.25	26.15	24.70	36.31
	Msalato Substation	-	-	33.07	49.14	72.22
	Kikombo Substation	-	-	-	13.90	20.42





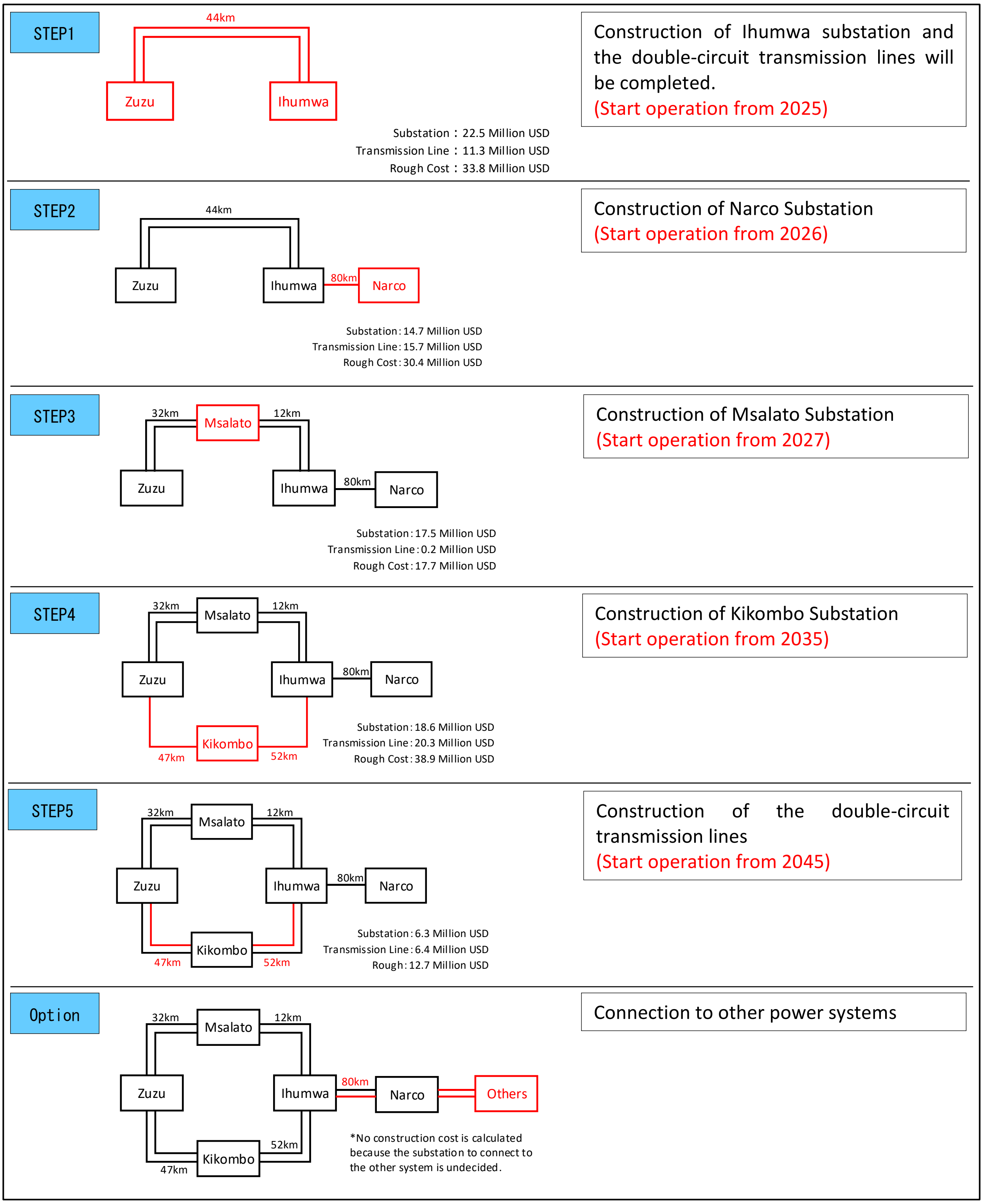
n were omitted.

[Source] JICA Study Team

Figure 5-2.4 Site Location of Scenario-1

Scenario-2 : ＜Stepwise Development 2＞ Ensuring power supply reliability by constructing north side double-circuit transmission lines with emphasis on urgency

The stepwise development plan and reference costs for Scenario-2 are shown in Figure 5-2.5.

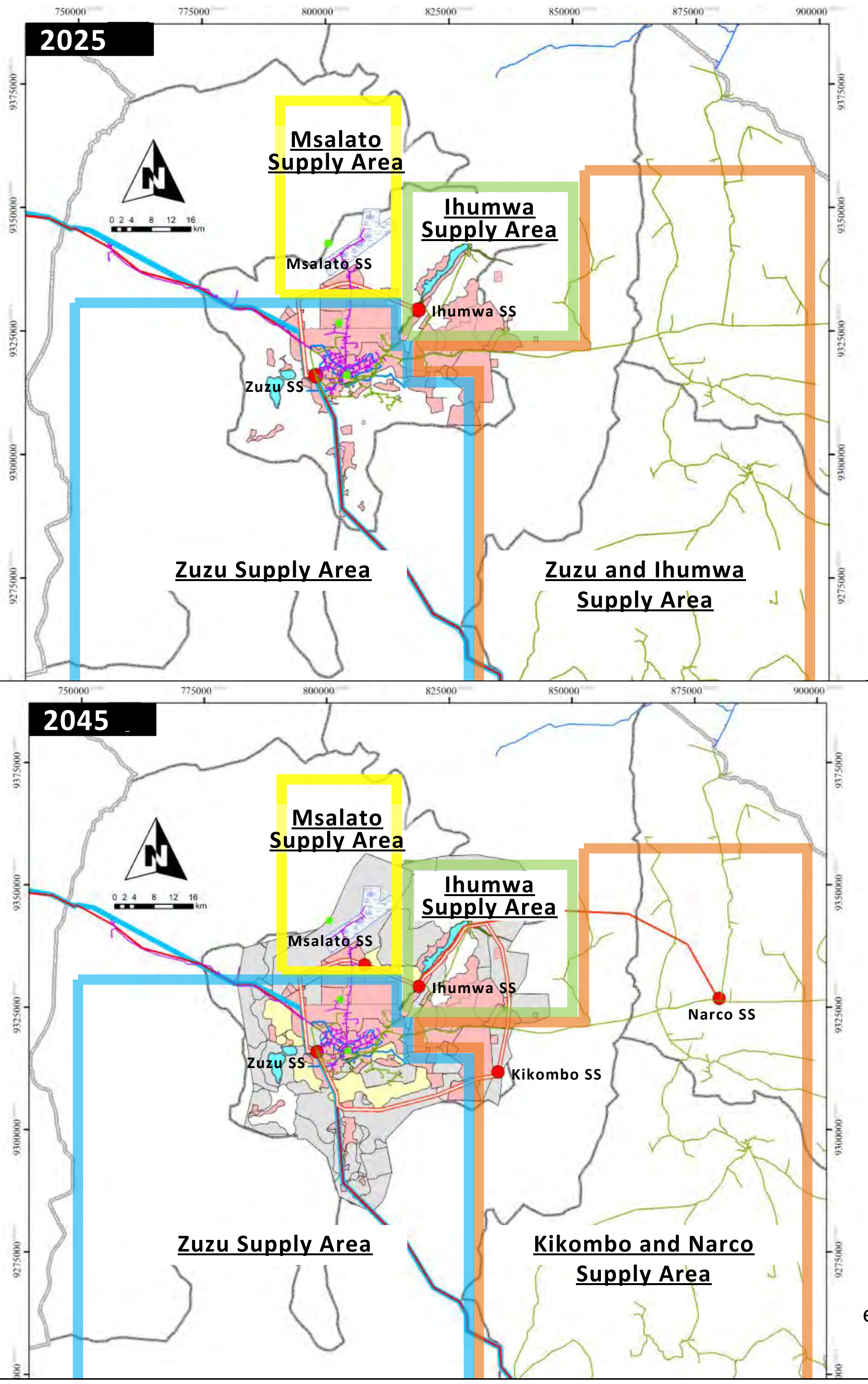


[Source] JICA Study Team [Remark] Rough Cost excludes Distribution, land preparation cost, Consultancy fee and Contingency

Figure 5-2.5 Stepwise Development Plan (Scenario-2)

Figure 5-2.6 show the site locations of scenario-2 cross section for 2025 and 2030.

Load allocation for each substation [MVA]	Substation	2025-year	2026-year	2027-year	2035-year	2045-year
	ZuZu Substation	71.75	80.00	55.44	81.81	120.23
	Ihumwa Substation	72.09	57.81	66.02	100.33	147.44
	Narco Substation	-	24.25	26.15	24.70	36.31
	Msalato Substation	-	-	33.07	49.14	72.22
	Kikombo Substation	-	-	-	13.90	20.42



ere omitted.

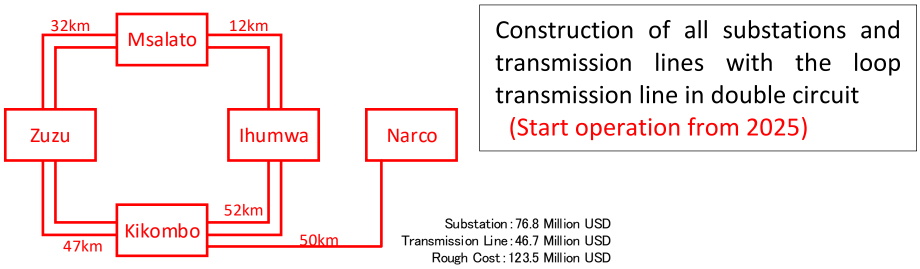
[Source] JICA Study Team

Figure 5-2.6 Site Location of Scenario-2

Scenario-3 : <One-time Development> Advanced development with double-circuit transmission loop system

The One-time Development Plan and reference costs for Senario-3 shown in Figure 5-2.7.

Figure 5-2.8 shows the Site location of scenario-3.

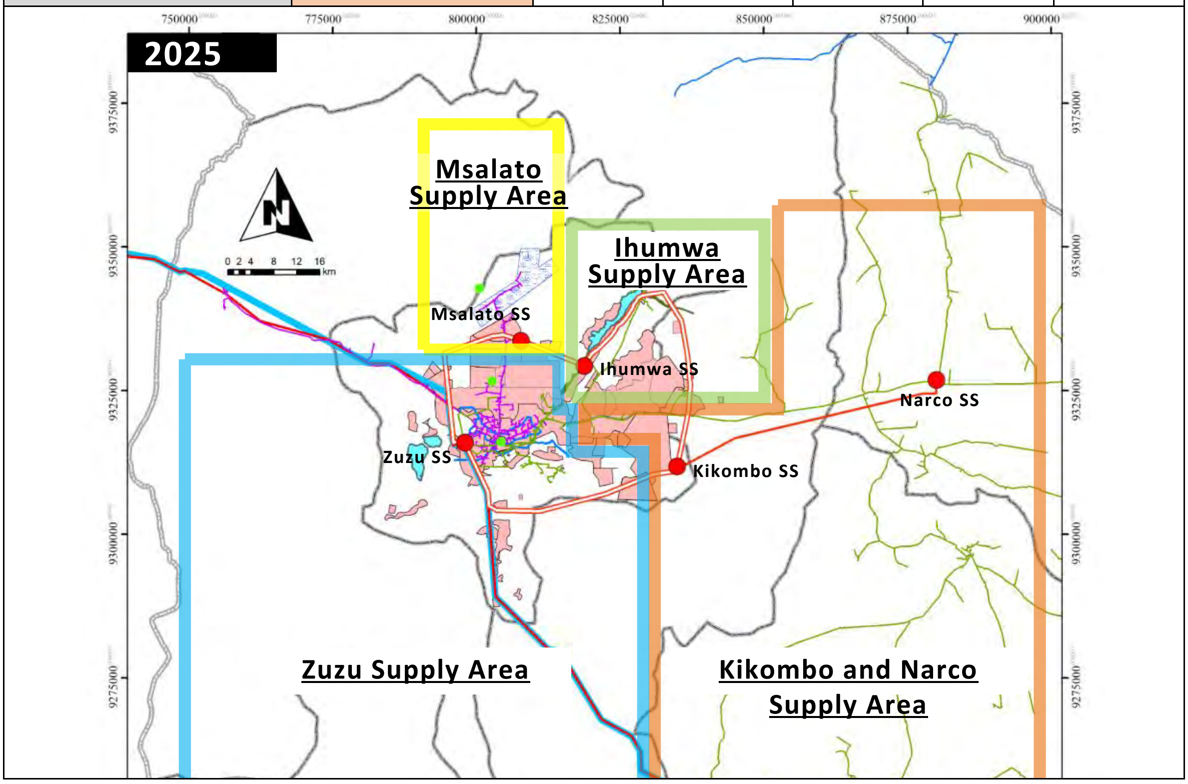


[Remark] Estimated project costs include transmission and substation equipment construction costs, but do not include land reclamation costs, consultant costs, and contingency costs. In addition, the cost of the third transformer at each substation (Msalato substation, Ihumwa substation, Kikombo substation) and associated switching equipment is not included.

[Source] JICA Study Team

Figure 5-2.7 One-time Development Plan (Scenario-3)

Load allocation for each substation [MVA]	Substation	2025-year	2026-year	2027-year	2035-year	2045-year
	ZuZu Substation	45.16	50.21	55.44	81.81	120.23
	Ihumwa Substation	48.61	57.06	65.21	100.33	147.44
	Narco Substation	14.84	16.00	17.26	24.70	36.31
	Msalato Substation	26.59	29.79	33.07	49.14	72.22
	Kikombo Substation	8.35	9.00	9.71	13.90	20.42



[Source] JICA Study Team

Figure 5-2.8 Site Location of Scenario-3

5-2-2 Consideration of Implementation Schedule

Table 5-2.1 shows implementation schedule for the scenario examined in the previous section with reference to the priority step of the development case, scale of construction, estimated costs, etc.

This implementation schedule has been prepared assuming that the substation and transmission facilities (part or all) will start operation in 2025, when the main development of the Dodoma Capital MP will be completed in Phase I.

Therefore, the detailed schedule needs to be considered in the future in consideration of feasibility.

Table 5-2.1 Proposed Implementation Schedule

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
■ **Dodoma National Capital City Master Plan**																					
- Completion of ongoing development - Development of 12 communities	Phase I																				
- Land acquisition and planning for development of 52 communities						Phase IA															
- Development of 13 communities						Phase II															
- Development of 16 communities											Phase III										
- Development of 21 communities															Phase IV						
■ **Scenario and Scheme for consdierations**																					
Scenerio1					STEP1	STEP2	STEP3								STEP4				STEP5(~2045)		
Scenerio2					STEP1	STEP2	STEP3								STEP4				STEP5(~2045)		
Scenerio3					ALL																

5-3 Scenario Evaluation

Table 5-3.1 shows the result of evaluation for three scenarios assessed in terms of qualitative viewpoint.

Table 5-3.1 Preliminary Evaluation for the proposed Scenarios

Scenario	Feature	Challenge	Cost: Cost by Scenario	Cost: For Influence on Cost (For Fundability)	Technical: High reliability of power supply at the end of Capital MP Phase I	Technical: Considerations items for cooperative development with distribution systems	Implementation: Coordination with demand forecast	Implementation: Development delay risk (Project scale)	Implementation: To secure Wayleave	Max Score 18
1	1. Lower initial costs than One--time development. Therefore, development according to the increase in demand becomes possible. 2. Since the construction of the Nalco substation will be completed by 2025, the distribution of power to Kongwa and Mpwapwa areas can be achieved quickly. 3. Construction of a loop transmission line having high reliability is quickly realized	Since the project scale in STEP1 is rather large, It is necessary to make a business plan and carry out an environmental and social considerations survey in a short period.	Initial cost :52.9 Million USD Total : 134.6 Million USD	Standard 2	Better 3	Standard 2	Better 3	Standard 2	Better 3	**More Better** **15**
			By establishing early system reliability and carrying out Stepwise Development, the total cost is maximized in all scenario, but the initial cost can be suppressed.		Although the project scale of STEP1 is large, it can be expected to respond to urgency because it is Stepwise Development. Since the loop transmission line in single circuits is constructed quickly, power supply reliability can be secured the fastest.		Since the scenario is based on the development plan of Dodoma MP, Coordination with demand forecast is the highest.			◎
2	1. Lower initial costs than One-time development. Therefore, development according to the increase in demand becomes possible. 2. Since the construction of the Nalco substation will be completed by 2025, the distribution of power to Kongwa and Mpwapwa areas can be achieved quickly. 3. By constructing of north side Double Circuit transmission lines, it becomes possible to transmit power in the event of a one-circuit outage.	In the construction of transmission lines in STEP 4, it may be difficult to secure Wayleave in Dodoma urban area.	Initial cost :33.8 Million USD Total : 133.5 Million USD	Better 3	Standard 2	Standard 2	Better 3	Better 3	Standard 2	**More Better** **15**
			Although the total cost is slightly higher than in the scenario-3, the initial investment cost can be suppressed as compared with the scenario-1.		Since the initial project scale is the smallest, it can be expected to respond to urgency.		Since STEP1 has a small project scale, it is easiest to secure Wayleave. However, when constructing the transmission line in STEP 4, there is a possibility that it is necessary to secure a wayleave while Dodoma Capital Development is progressing.			◎
3	Since the development of the transmission system prior to the capital development plan becomes possible, it has an advantage in terms of Wayleave and environmental and social considerations. Since the operation will start as the loop transmission line with double circuits from 2025, A highly reliable system can be constructed at an early stage.	Since the project scale is large due to one-time development, it is necessary to make a project plan and conduct an environmental and social considerations survey in a short period.	Initial cost :123.5 Million USD Total : 123.5 Million USD	Worse 1	Better 3	Worse 1	Worse 1	Worse 1	Better 3	**Average** **10**
			Although the overall cost can be suppressed as compared with the scenarios-1 and 2, the initial cost may be large and fund procurement may be difficult.		There are many considerations for coordination with distribution system construction. For example, it is necessary to consider a change in the power distribution system, a switching work in consideration of the power outage time and the number of power outages, and so it is difficult to make a plan in a short time.		Since the project scale is large due to one-time development, the risk of development delay is high. In order to switch or expand the distribution system according to the scenario, it is necessary to concentrate resources (human and economic), which may increase the risk of development delay.			△

Evaluation : ◎ (More Better:15~18), ○ (Better:11~14), △ (Average:6~10)

5-4 Applicability of quality Infrastructure

Based on the results of field surveys, confirmation of development status, and discussions with TANESCO, it was examined whether Japanese technology along with the development of high-quality infrastructure promoted by the Japanese government could be introduced in the development of the Dodoma transmission and distribution network.

5-4-1 Latest Technologies for Transmission and Distribution

A transmission and distribution network ensures that the quality and reliability are considered as Quality Infrastructure, which has following features.

a) To improve power quality
b) To improve reliability
c) To reduce costs in consideration of running costs
d) To reduce environmental impact
e) To improve maintenance and inspection activities

Table 5-4.1 shows the Japanese technologies that can achieve the effects of the above five items in the Dodoma transmission and distribution network.

Table 5-4.1 Applicable Latest technology

No.	Applied technology	Application fields	Effect				
			High quality	High reliability	Cost reduction in consideration of running costs	Reduced environmental Impact	Improved maintenance and inspection
1	Low-loss distribution transformer	Distribution Facility	-	-	○	-	-
2	Low-loss conductor	Transmission facilities	-	-	○	-	-
3	External Gapped transmission Line Arresters		○	-	-	-	-
4	Low-loss transformer	Substation facilities	-	-	○	-	-
5	Special three phase transformer		-	-	○	○	-
6	Low SF6 gas leakage rate		-	-	-	○	-
7	Gas insulated transformer		-	○	○	-	○
8	High seismic resistance of substation equipment		-	○	-	-	-
9	Special protection system		-	○	-	-	-
10	Spring operation mechanism for Gas circuit breaker		○	○	-	-	○
11	Compact type GIS		-	○	○	-	-

The outline of each technology is shown below.

(1) Low-loss distribution transformer (Amorphous transformer)

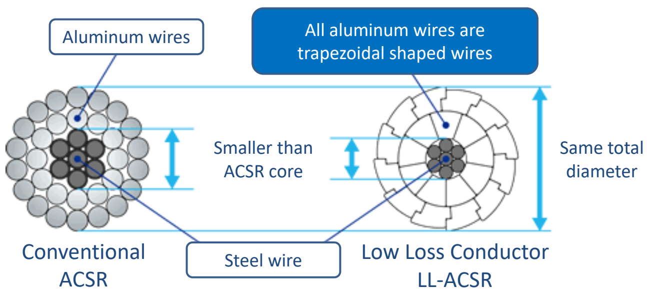
[Source] Prepared by Study Team based on manufacturer

Figure 5-4.1 Amorphous transformer

The amorphous transformer shown in Figure 5-4.1 is a transformer in which an amorphous alloy is applied to the iron core. Although the crystal structure of a normal metal or alloy has regularly arranged atoms, the crystal structure of an amorphous alloy has a random atomic arrangement. Therefore, when amorphous metal is applied to the iron core of the transformer, the hysteresis loss and eddy current loss of the transformer are extremely small. That is, if an amorphous transformer is applied, no-load loss can be suppressed, so that it is possible to reduce the loss of the transformer for a long time. However, amorphous alloys have a lower hardness than ordinary metals and alloys and have a limited mechanical resistance to the short-circuit electromagnetic force of transformers, so they can be used in transformers with a capacity of about 1000 kVA or less.

(2) Low-loss conductor

Low-loss conductor has achieved a reduction in diameter by adopting high-strength materials in the steel core, and improved aluminum occupancy by adopting trapezoidal aluminum conductors. As a result, by adopting low-loss conductor, compared to existing steel core aluminum conductor of the same diameter, the outer shape and tensile strength of the conductor can be maintained at the same level as conventional wires, and transmission loss can be reduced by approximately 20%.



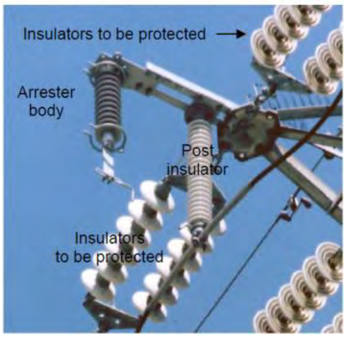
[Source] Prepared by Study Team based on manufacturer catalog

Figure 5-4.2 Comparison between conventional conductor and Low-loss Conductor

(3) External Gapped Transmission Line Arresters (EGLA)

EGLA, consisting of arrester body and series air gap, is installed in parallel with the insulator to be protected. When lightning strikes a transmission tower and power line conductor, a gap connected in series with the lightning arrester body discharges, protecting the insulator from overvoltage. When arcing horns are installed at both ends of the insulator, the arcing horn can be prevented from discharging during the lightning strike on the transmission tower and power line conductor, and a circuit breaker can suppress the operation. It then becomes possible to protect an instantaneous power outage.

In this way, by applying lightning arresters on power transmission lines, it becomes possible to protect the insulation support such as insulators from lightning strikes on transmission tower and power line conductors, and also to protect an instantaneous power outage due to arc horn flashover. EGLA is a device that has been widely used in Japan, and has recently been standardized by IEC (International Electrotechnical Commission). Application of EGLA is expanding overseas.



[Source] Prepared by JICA Study Team based on technical paper

Figure 5-4.3 Application examples of EGLA

(4) Low-loss transformer

It is possible to reduce iron loss by applying a low-loss silicon steel sheet to the core material of a large-capacity power transformer. Reduction of iron loss can reduce no-load loss and contributes to long-term economic improvement.

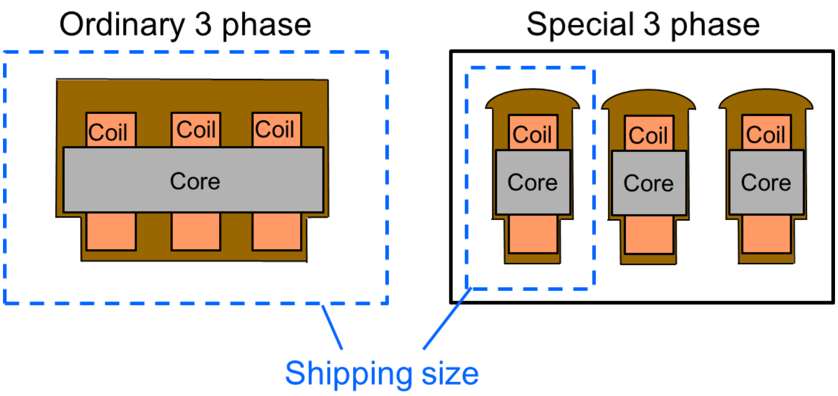
[Source] Prepared by JICA Study Team based on technical paper

Figure 5-4.4 765 kV Class Power Transformer

(5) Special three phase transformer

As shown in Figure 5-4.5, the special three-phase transformer can divide the three-phase transformer into single-phase transformers to reduce the transportation weight compared to ordinary three-phase transformers. It becomes possible to alleviate the transportation problem. Therefore, when there are narrow roads and bridges on the transformer transportation route, special three-phase transformers may be applied instead of ordinary three-phase transformers.

When a transformer is installed in the Dodoma region, it is assumed that it will be transported by sea to Dar es Salaam Port and land transport from Dar es Salaam to Dodoma region, depending on the transformer manufacturer. From Dar es Salaam to the Dodoma area, there are no mountainous areas, so it seems that there are no narrow roads or bridges. However, in Tanzania, when heavy equipment are transported, tax is imposed according to their weight, so the special three-phase transformer is less taxable than the ordinary three-phase transformer for land transportation. Therefore, it is necessary to evaluate the total cost.



[Source] Prepared by JICA Study Team

Figure 5-4.5 Conceptual diagram of a special three-phase transformer

(6) Low SF6 gas leakage rate

SF6 gas used in gas insulation equipment such as gas insulated switchgear and gas insulated circuit breakers is a global warming gas. Therefore, it is desirable to reduce the release of SF6 gas to the atmosphere as much as possible from the viewpoint of reduced environmental impact. In addition, the achievement of a low gas leakage rate is very important in maintaining the long-term reliability of the equipment because it can prevent the deterioration of the insulation performance of the device and rust on the flange surface. Japanese manufacturers have been working on improving the tightness of gas insulation equipment for a long time, and many Japanese manufacturers have achieved a gas leakage rate of 0.1% / year or less as shown in Table 5-4.2. On the other hand, IEC has recently been studied to change the gas leakage rate, which requires performance verification in the type test, from 0.5% / year to 0.1% / year. In order to reduce the environmental impact, the application of equipment that has achieved a low gas leakage rate is considered to be very effective. On the other hand, in the IEC standards in recent years, it is considered to change the gas leakage rate, which currently requires performance verification in type tests, from 0.5% / year to 0.1% / year. In order to reduce the environmental load, it is very effective to apply an equipment that achieves a low gas leakage rate.

Table 5-4.2 Gas leak rate specified in IEC standards and provided by Japanese manufacture

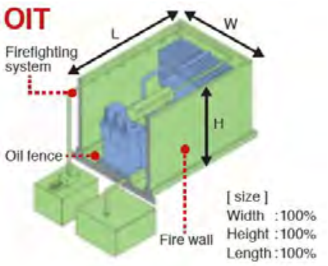
	Factory Test	Site Test
Provided by many Japanese manufacture	< 0.1 % / year	< 0.1 % / year
IEC standard	< 0.5 % / year	< 0.5 % / year

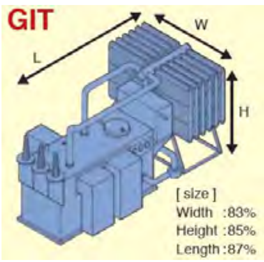
(7) Gas-insulated transformer

Gas-insulated transformers are widely used not only in Japan but also in many countries such as Hong Kong, China, and Australia, for the purpose of disaster prevention measures and compactness in underground substations in urban areas. Gas-insulated transformers are used not only in underground substations but also in areas that take into consideration the natural environment because they do not use oil and are free from oil leakage.

Table 5-4.3 Features of GIT compared to Oil-Immersed Transformers

	Contents
Features of GIT	✓ Non-Flammable, Non-Explosive ✓ Non fire-fighting system requirement ✓ Flexible arrangement ✓ Easy Maintenance ✓ Reduction of installation period





[Source] Prepared by JICA Study Team based on Manufacturer's website

Figure 5-4.6 Comparison of GIT and oil-Immersed Transformers (OIT)

(a) 110kV-50MVA GIT(Low-pressure type)

(b) 275kV-300MVA GIT(High-pressure type)

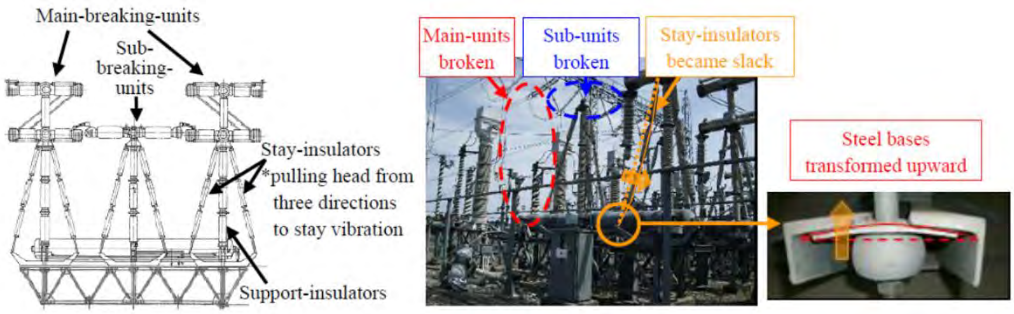
[Source] Prepared by JICA Study Team based on technical paper

Figure 5-4.7 Application examples of GIT

(8) High seismic resistance of substation equipment

Earthquakes frequently occur in Japan, and the JEC (Japanese Electrotechnical Committee) standard describes a verification test for seismic performance as a reference test for switchgears. In recent years, the Great East Japan Earthquake of magnitude 9.0 occurred on March 11, 2011, the largest in Japan's observation history, but there was no significant supply disruption due to the damage of substation equipment. Therefore, the validity of the current seismic guidelines for substation equipment in Japan is recognized. On the other hand, the seismic motion exceeding the assumptions of this guideline has caused partial damage to substation equipment designed based on this guideline. In Japan, this experience is analyzed and the optimization of the design method is examined.

In Tanzania, a magnitude 5.7 earthquake occurred in September 2016. Therefore, it is important to apply substation equipment that reflects the knowledge of many earthquakes in the construction of the infrastructure of the area with the capital function.

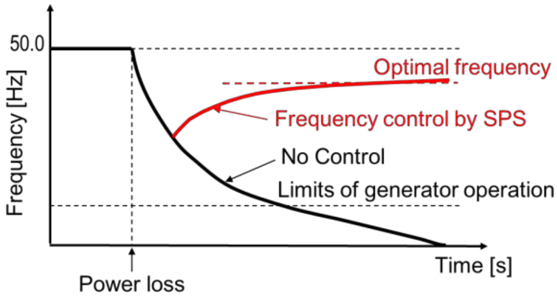


[Source] Prepared by JICA Study Team based on technical paper

Figure 5-4.8 Damages to 275kV air circuit breaker by the Great East Japan Earthquake

(9) Special protection system

By installing Special protection system, it is possible to monitor system information over a wide area and control the frequency appropriately. Therefore, it is possible to prevent a large-scale power outage when an accident occurs and to minimize the influence of the power outage. Figure 5-4.9 shows Conceptual diagram of Special protection system. If the frequency is not controlled by the special protection system, the frequency gradually decreases after the power loss, and eventually goes below the operating limit of the generator, which may cause a large-scale power outage. On the other hand, if the frequency is controlled by special protection system, it can be confirmed that the frequency is close to the optimum frequency after power loss. Although special protection system is not a device that operates frequently, it is a system that contributes to improving the reliability of the system because it can prevent a large-scale power outage during operation. Since special protection system can prevent a large-scale power failure, it contributes to improving the reliability of power system.

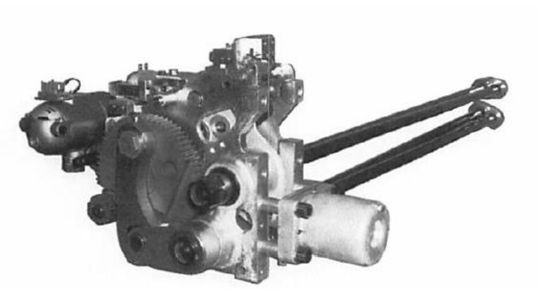


[Source] Prepared by JICA Study Team

Figure 5-4.9 Conceptual diagram of Special Protection System

(10) Spring operation mechanism for Gas circuit breaker

Compared with the hydraulic operation mechanism, the spring operation mechanism has fewer parts and less failure frequency because there are no auxiliary devices such as a hydraulic pressure switch and an oil pressure gauge. In addition, maintenance and inspection can be labor-saving because the number of inspection items, test items, and replacement parts during regular inspections can be reduced. Since the spring operating mechanism does not cause oil leakage unlike the hydraulic operating mechanism, the circuit breaker to which the spring operating mechanism is applied can maintain high reliability.



[Source] Prepared by JICA Study Team based on technical paper

Figure 5-4.10 300kV Torsion bar Spring Mechanism

(11) Compact GIS

The Compact GIS can minimize the installation area compared to the air substation equipment. Recently, many manufacturers are transporting LCP (local Control Panel) and GIS unit as one unit, saving labor in local connection work and shortening the installation period. In Tanzania, GIS is adopted at two locations (Dar es Salaam and Kilimanjaro) for indoor substations.

(a) 145 kV GIS for City Center Substation in Dar es Salaam

(b) 330 kV GIS

[Source] Prepared by JICA Study Team

Figure 5-4.11 Application examples of Compact GIS

5-4-2 Application of Latest technology to Dodoma transmission and distribution network development

As a result of discussions with TANESCO based on the field survey results, the possibility of specific application of the following four Japanese technologies, which are expected to reduce costs including running costs, was examined.

(1) Low-loss distribution transformer (Amorphous transformer)

Amorphous transformers have a slightly higher initial investment than conventional transformers (about 1.2 times depending on the manufacturer), but have less power loss. Therefore, the application of the amorphous transformer makes it possible to reduce the power generation cost, and the initial investment amount higher than that of a conventional transformer can be recovered in a few years, and the economic introduction effect is high.

When applying the amorphous transformer to the Dodoma metropolitan area, the cost effectiveness will be examined with reference to specification shown in Table 5-4.4.

Table 5-4.4 Specification of amorphous transformer

Outline specification	Condition (Number)
Voltage:33kV/400V, 11kV/400V Capacity:1250kVA(Ground mounted installation) 500kVA(pole mounted)	1000/3000/5000

(2) Low-loss conductor

Based on the scenario of Dodoma's transmission system development plan, the effects of applying low-loss transmission lines were examined. The study conditions, patterns and results are shown below.

1) Specification

Table 5-4.5 shows the specifications of ordinary and low-loss transmission lines. The conventional ACSR was Blue Jay widely used for 220 kV transmission lines in Tanzania.

Table 5-4.5 Specifications of Transmission line (example)

Item	Unit	220 kV		
		Conventional ACSR (BlueJay)	LL-ACSR/AS (719mm^2)	LL-ACSR/AS (600/29mm^2)
Overall diameter	mm	31.96	31.96	31.96
Weight	kg/km	1,868	2,154	1,860
Nominal cross section	mm^2	603.3	741.2	624.6
Current Capacity (75℃)	A	773 at 75℃	870 at 75℃	796 at 75℃
AC Resistance	Ω/km	0.0652	0.0516	0.0616

2) Transmission line cost

The unit price of transmission line is shown in Table 5-4.6. The transmission line cost (initial value) was estimated by multiplying the transmission line unit price and transmission line distance shown in Table 5-4.6.

Table 5-4.6 Unit price of transmission line

1USD=120JPY

Transmission line Type	Cost
Conventional ACSR (BlueJay)	9.1 USD/m
LL-ACSR/AS(719mm^2)	10.8 USD/m
LL-ACSR/AS(600/29mm^2)	9.4 USD/m

3) Consideration Step of recovery year

a) The power flow was calculated based on the results of each substation load distribution described in Chapter 4-2.

b) The transmission line loss was calculated based on the power flow results, and the loss cost due to the transmission line loss was obtained by multiplying the TANESCO power selling unit price by 0.1 USD / kWh.

c) The power generation cost corresponding to the loss amount of each year was added to the transmission line cost (initial cost), and the recovery year was examined.

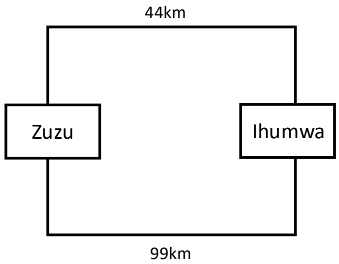
4) Cost of construction for transmission equipment and recovery year

The initial cost and the cost recovery year when applying low-loss transmission lines in Scenario 1, Scenario 2, and Scenario 3 described in Chapter 5-2 were examined.

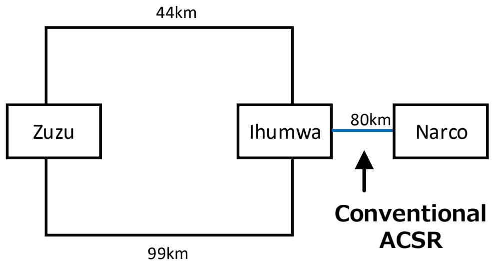
Figure 5-4.12 to Figure 5-4.14 show the study patterns. As shown in the figure, the transmission line between Ihumwa-Narco uses a conventional ACSR because the load current is not large. The low-loss ACSR was studied in two cases, a low-loss line (719 mm^2) and a low-loss line (600/29 mm^2). Table 5-4.7 and Figure 5-4.15 show the results of the study.

Table 5-4.7 Recovery year of low-loss conductor

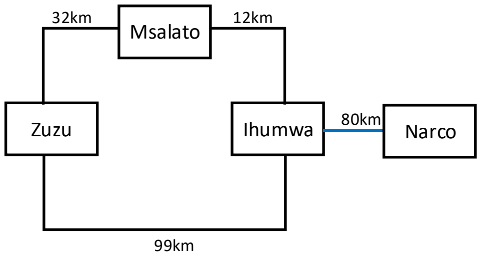
Scenario	LL-ACSR/AS(719mm^2)	LL-ACSR/AS(600/29mm^2)
Scenario-1	2032	2031
Scenario-2	2032	2030
Scenario-3	2046	2043



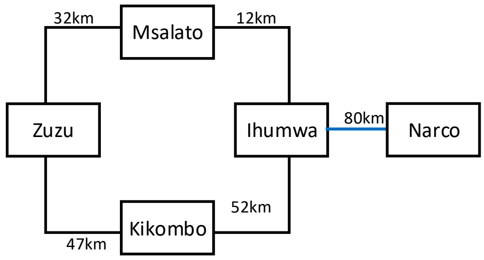
(a) STEP 1(From 2025 -)
Construction of Ihumwa substation with the loop transmission line in single circuit



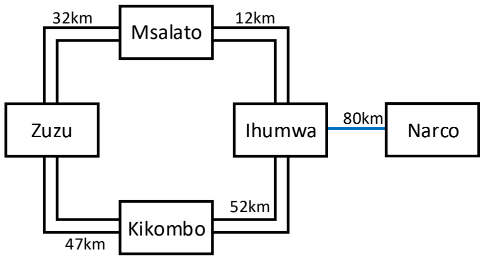
(b) STEP 2(From 2026 -)
Construction of Narco substation
(Using conventional ACSR for connection)



(c) STEP 3(From 2027 -)
Construction of Msalato substation

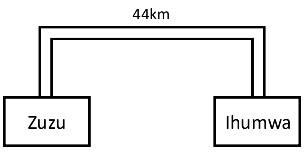


(d) STEP 4(From 2035 -)
Construction of Kikombo substation

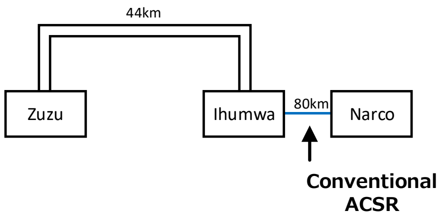


(e) STEP 5(From 2045 -)
Construction of the double-circuit transmission lines

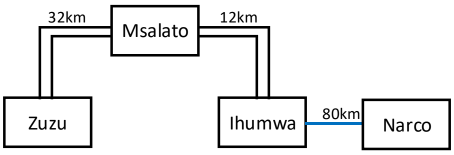
Figure 5-4.12 Application pattern of low-loss conductor (Scenario 1)



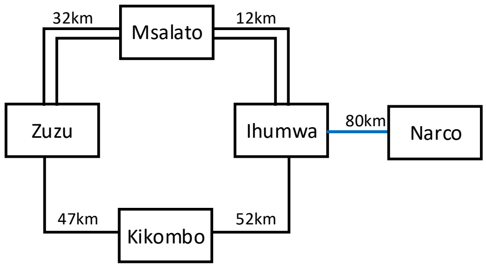
(a) STEP 1(From 2025 -)
Construction of Ihumwa substation and the double-circuit transmission lines



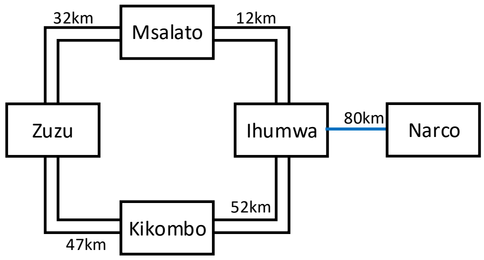
(b) STEP 2(From 2026 -)
Construction of Narco substation
(Using conventional ACSR for connection)



(c) STEP 3(From 2027 -)
Construction of Msalato substation



(d) STEP 4(From 2035 -)
Construction of Kikombo substation



(e) STEP 5(From 2045 -)
Construction of the double-circuit transmission lines

Figure 5-4.13 Application pattern of low-loss conductor (Scenario 2)

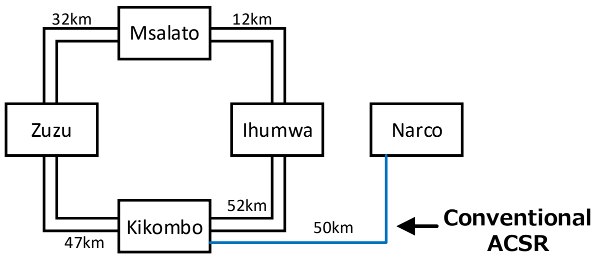
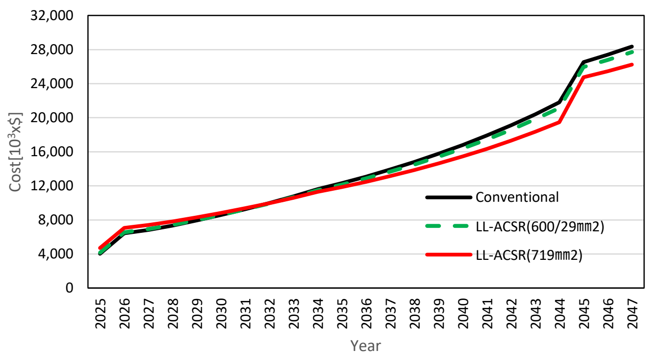
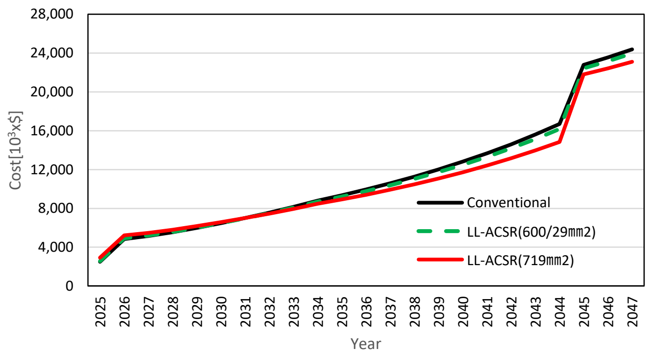


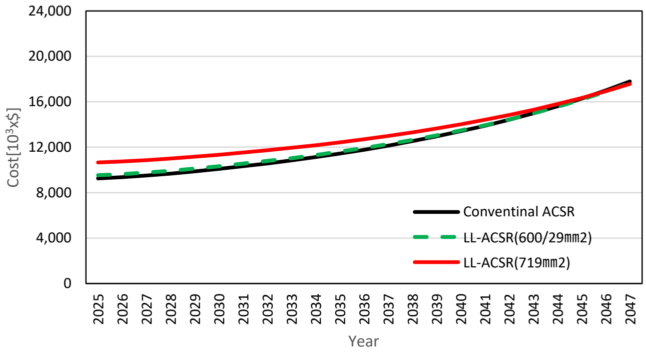
Figure 5-4.14 Application pattern of low-loss conductor (Scenario 3)



(a) Scenario 1



(b) Scenario 2



(c) Scenario 3

Figure 5-4.15 Cost of construction for transmission equipment and recovery year

As a result of trial calculations in Scenario 1 to Scenario 3, it was confirmed that the recovery year of the low-loss conductor was superior to 719mm^2(LL-ACSR) as shown in Table 5-4.7, and that it could be recovered by 2046. The estimation results are affected by the price of conventional ACSR, the price of electric power, so it is necessary to scrutinize the numerical values used in the study.

(3) Special three phase transformer

As described in the substation plan, a 220kV, 100MVA transformer are planned to install in Ihumwa substation.

The candidate site of the substation where the development of the Dodoma urban Metropolitan Network, including Ihumwa substation, is planned to develop roads around the substation in the future, so that there are no major restrictions on transportation.

However, Tanzania is taxed according to the weight and volume of the equipment, therefore, the application merit of applying special three-phase transformer will be examined.

The transport dimensions and weight of normal three-phase transformer and special three-phase transformer were estimated under the conditions shown in Table 5-4.8. The examination results are shown in Table 5-4.9.

Table 5-4.8 Specification of Transformer

Item	Specification
Voltage	220kV
Capacity	100MVA
Cooling system	ONAN/ONAF
Primary voltage	220kV±10×1.25%
Secondary voltage	33kV
Tertiary voltage	6.9kV(arbitrarily)
Vector group	YNyn0(d)
LIWV	HV：1050kV HVN：95kV LV：170kV
AC	HV：460kVrms HVN：38kVrms LV：70kVrms
%Z	13%
Elevation	1200m

*: Assumes transformer planned to be installed in Ihumwa substation

Table 5-4.9 Approximate dimensions and weights of ordinary three-phase transformer and special three-phase transformer (example)

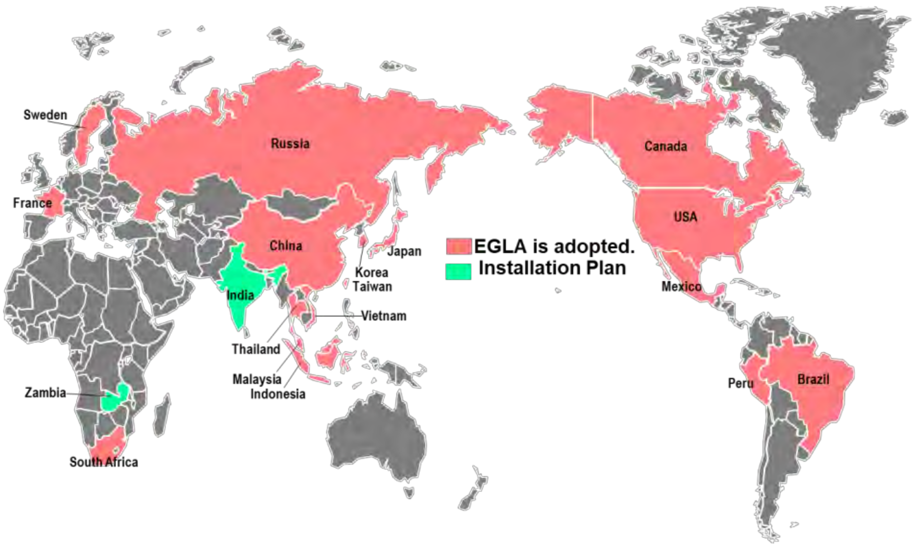
		Ordinary	Special three phase	
			Phase V (with OLTC)	Phase U, W
Transport dimensions (mm)	W	3,000	3,000	3,000
	L	8,200	4,800	3,700
	H	4,200	3,700	3,700
Transport mass (ton)		88	50	47
Number of tank divisions		1		3

*: Varies by manufacturer

As shown in Table 5-4.9, it can be confirmed that the ordinary transformer has a transport mass of 88 tons, and the special three-phase transformer has a maximum transport mass of 50 tons. In Tanzania, there is a regulation on the loading weight for each transportation vehicle, and a overload tax is imposed if the regulation is exceeded. In addition, if the weight including the transportation vehicle exceeds 56 tons, some places have restricted traffic. When examining a specific development plan, it is necessary to evaluate the cost of each transformer, the tax amount for each transformer division, and evaluate the economic efficiency.

(4) External Gapped Transmission Line arresters (EGLA)

External Gapped Transmission Line Arresters are currently used in over 20 countries in the world as shown in Figure 5-4.16. As described in Chapter 5-3-1, by applying EGLA, it is possible to protect insulators during lightning strikes on power transmission towers and transmission lines, and to prevent instantaneous power failure due to arc horn flashover. An example of the economic effect by applying EGLA is introduced.



[Source] Prepared by JICA Study Team

Figure 5-4.16 Applicable situation of EGLA

Since the lightning arrester for power transmission can suppress instantaneous power failure and destruction of insulators, the following effects can be expected.

- ✓ Improving power reliability (reducing economic losses) by preventing power outages and securing sales for electric utilities.
- ✓ Reduce maintenance costs by preventing damage to transmission line equipment

1) Improve power reliability by preventing power outages (reducing economic losses)

Economic loss reduction by preventing power outage was estimated under the following conditions.

[Conditions]

Supply Capacity: 100MVA
Number of customers and power outage costs: As shown in Table 5-4.10
Annual Power outage time (C) : 0.33hr(20min.)※1
Failure rate due to lightning (D): 42.7%※2
Operation period (E): 20years
*1 Annual Power outage time: Data quote from SAIDI (System Average Interruption Duration Index)
*2 Failure rate due to lightning (D): Report of Central Research Institute of Electric Power Industry in Japan, T72, and Guide to Lightning Protection Design for Transmission lines (2003)

Table 5-4.10 Number of customers supplying 100MVA and the amount of damage per customer for one hour of power outage

Consumer	Number of customers(A)*3	Impact of power outage (B)*4
General(2kW)	10,000(95.6%)	1,700JPY(16USD)
Low voltage (50kW)	400(3.8%)	220,000JPY(2000USD)
High Voltage(500kW)	40(0.38%)	1,100,000JPY(10,000USD)
Extra High Voltage(2000kW)	20(0.19%)	7,600,000JPY(69,091USD)

1USD : 110JPY

*3: Number of customers: Assumed based on cases of Japanese electric power companies
*4: Impact of power outage (B) : Report of Central Research Institute of Electric Power Industry in Japan, (2007), Impact of Supply Reliability and Blackout on Residential and Business Customers of Electric Power Companies in Japan

[Economic loss estimation]

Economic loss was estimated by the following formula;
Number of customers (A) x Impact of power outage (B) x Annual power outage time (C) x Failure rate (D) x Operation period (E)
In the above case, it was estimated that an economic loss of about 850 million JPY (7.7 million USD) would occur.

2) Securing sales for electric utilities by preventing power outages

The loss of the electric utility due to power outage was estimated under the following conditions.

[Conditions]

Supply Capacity (A): 100MVA

Average load (B)：70%
Annual Power outage time (C)：0.33hr(20min.)
Failure rate due to lightning (D): 42.7%
Electricity charge (E)：30JPY/kWh(0.3 USD/kWh)
Operation period (F): 20years

[Loss estimation due to power failure]

Loss due to power outage was estimated by the following formula;
Supply Capacity (A) x Average load (B) x Annual Power outage time (C) x Failure rate due to lightning (D) x Electricity charge (E) x Operation period (F)
In the above case, it was estimated that the electric utility would lose 6 million JPY (50 thousand USD) yen due to a power outage

3) Reduce maintenance costs by preventing damage to transmission line equipment

The maintenance costs due to power line equipment damage were estimated under the following conditions.

[Conditions]

Number of accidents (A): 2 times / year
Maintenance worker (B): 7people
Labor costs (C): 50,000 yen / person day
Repair days (D): 3 days
Operation period (E): 20 years

[Estimation of maintenance costs]

The maintenance cost due to the damage to the transmission line facilities was estimated by the following formula;
Number of accidents (A) x Maintenance worker (B) x Labor costs (C) x Repair days (D) x Operation period (E)
From the above case, it was calculated that maintenance cost of about 40 million JPY (364 thousand USD) would be incurred.

4) Application cost of EGLA

The application cost of EGLA was estimated under the following conditions.

[Conditions]

Voltage: 220kV
Transmission line length: 44km (assumed between Zuzu and Ihumwa substations)
Number of Transmission tower: 130
Number of installed EGLA: 390 phases (installed EGLA for one line)

Specification for EGLA: IEC60099-8, Class Y2, with external gap

[Application cost]

If the unit price of EGLA is assumed to be from 360,000 JPY (3,273 USD) to 400,000 JPY (3,636 USD) (depending on the manufacturer), the cost of applying EGLA will be about 140 JPY million (1.3 million USD) to about JPY160 million (1.5 million USD).

5) Investment effect

Loss reduction cost by applying EGLA: Approximately 900 million JPY (8.2 million USD)

Applicable cost of EGLA: Approximately 140 million JPY (1.3 million USD) to 160 million JPY (1.5 million USD)

As a result of the trial calculation, it was confirmed that the application of EGLA improves the power quality and reduces the maintenance cost, so the economic effect is great.

In the future, necessary constants will be obtained and estimated for economic losses when applied to the Dodoma urban area.

Chapter 6 Discussion of development scenario and study of implementation scheme

Chapter 6 Discussion of development scenario and study of implementation scheme

6-1 Discussion of development scenario

In Dodoma, the Study Team reported to TANESCO, the Ministry of Energy, and the Ministry of Finance and Planning for a draft final report covering the contents of Chapters 1 to 5 of this report for four days from January 28 to 31, 2020. Then, the contents were discussed and a site survey was carried out.

In the presentation given by the Study Team, the results of the review of demand forecasts and the concept of load distribution to substations were explained, and a plan to expand the Dodoma urban area transmission and distribution network was proposed. In addition, three development scenarios were presented, and discussions were held with the Tanzania side.

<Recommended scenarios of the Study Team>

The Study Team explained the details of scenario study and evaluation, and recommended the development of Scenario 1 or Scenario 2 mainly for the following reasons.

- Stepwise Development is a plan that meets the demand based on the power demand forecast for about 30 years.
- One-time Development is an excessive upfront investment.
- In One-time Development, maintenance of equipment is concentrated at the same time, so the time and cost spent on maintenance are inclined.

<Recommended scenarios for TANESCO and MoE>

However, TANESCO and the Ministry of Energy recommended Scenario 3, which would be One-time under for the following main reasons:

- Saves time and effort.
- It can cope with a sudden increase in demand over a long period.
- Overall investment costs can be reduced.

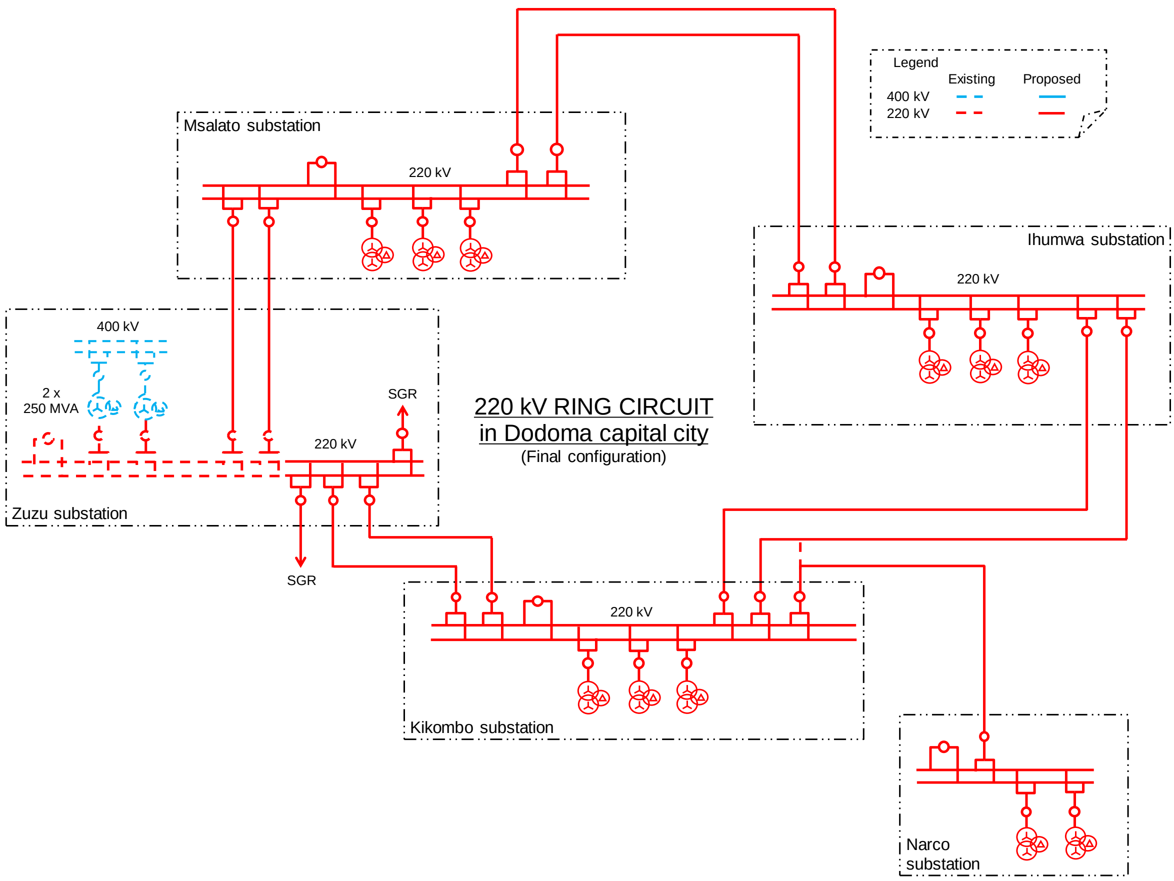
In addition, TANESCO has requested that Double circuit design with multiple conductors be finalized, including the connection to Narco substation.

6-2 Outline of Dodoma Transmission System Development Plan Considering the Discussion Results

6-2-1 Changes in transmission and substation facilities plan

(1) Final Configuration of 220kV Dodoma Ring Circuit

Since the route of 220 kV transmission line between Ihumwa and Kikombo substations (S/S) has been changed, the transmission line for Narco S/S will be turn-in to Kikombo S/S and turn-out to Narco S/S at the time of the construction of second circuit between Ihumwa and Kikombo S/S. Thus, Kikombo S/S will finally deliver the power to Narco S/S in every scenario. The final configuration of 220 kV Dodoma ring circuit is shown in Figure 6-2.1 below.



[Source] JICA Study Team

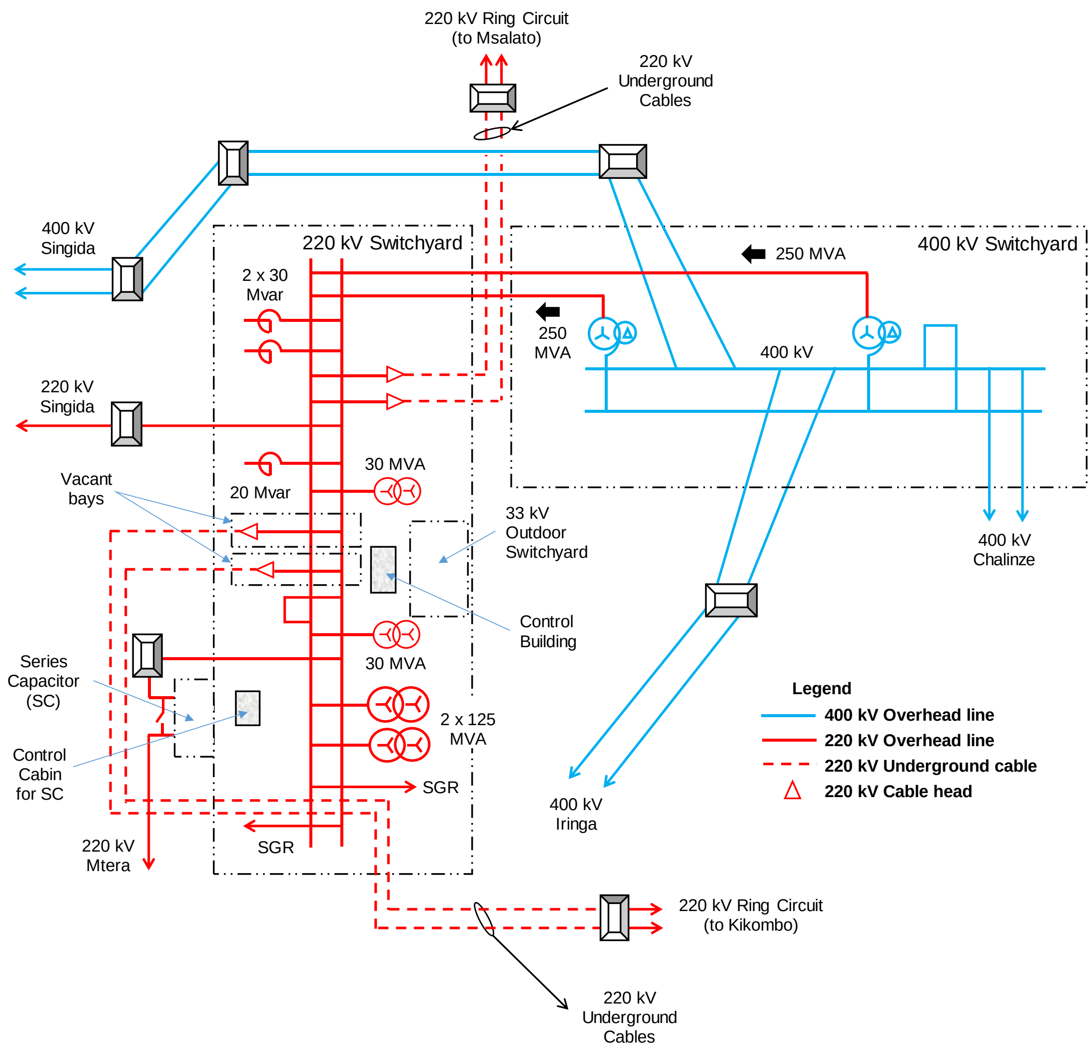
Figure 6-2.1 Network Diagram of 220 kV Dodoma Ring Circuit

(2) Substation Location

TANESCO has already started investigating the location of the substations at Msalato, Ihumwa and Kikombo for land acquisition. In addition, it was confirmed that there was no resettlement, and TANESCO requested that the study be carried out at the substation location originally planned.

(3) 220kV underground cable route for Kikombo substation at Zuzu substation

220kV cable route for Kikombo substation should be passed between two 220kV SGR bays. However, it was found that there is no such a route inside the substation. Thus, the cables should be routed at outside the substation, as shown in Figure 6-2.2 below. According to TANESCO, this route is within their property.



[Source] JICA Study Team

Figure 6-2.2 Illustrative Layout Drawing of 400 kV Zuzu Substation

(4) Transmission line route between Zuzu substation and Msalato substation

Considering the location of the originally planned Msalato substation, the TANESCO original plan was adopted for the transmission line route between Zuzu substation and Msalato substation except for the area near Zuzu substation that crosses the existing line.

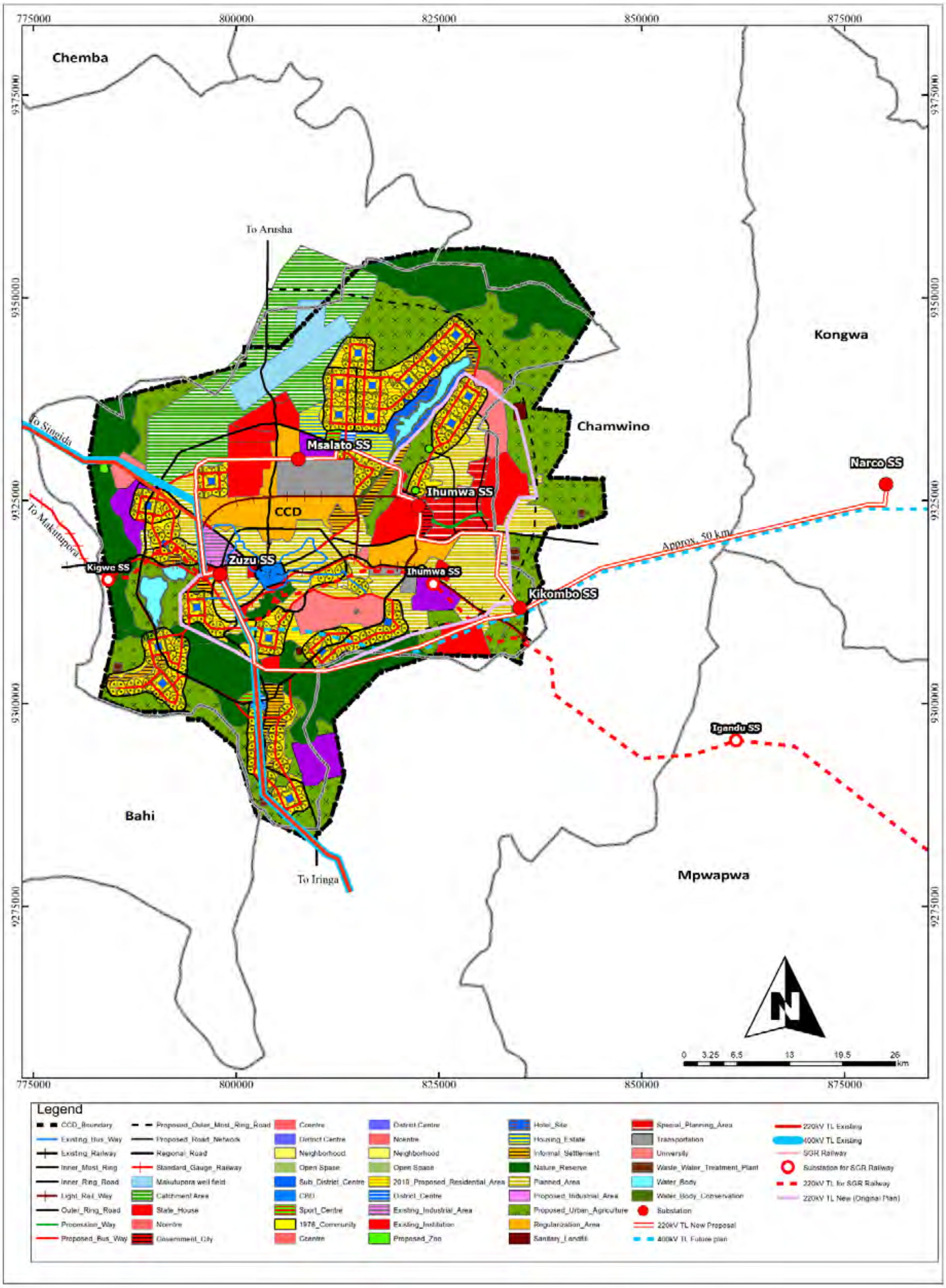
(5) Transmission line route between Ihumwa substation and Kikombo substation

After discussions between Dodoma City and TANESCO, the transmission lines had to be re-routed to avoid interfering with the Statehouse. TANESCO was considering two plans: a short pass around the government office and a major detour. As a result of discussion with TANESCO, if a detour route is selected, the length of the transmission line will be longer and the cost will increase, so TANESCO will negotiate with Dodoma City on a short route. The final route (draft) and specifications agreed with TANESCO are shown in Figure 6-2.3 and Table 6-2.1.

The location of the substation has been modified slightly based on the coordinates received from TANESCO on the second survey. However, the final route (draft) is under discussion by TANESCO with Dodoma City and may change in the future.

Table 6-2.1 Specifications of Final route (draft)

Voltage level	Number of lines	Transmission line section	Distance
220kV	2	Zuzu-Msalato	28km
220kV	2	Msalato-Ihumwa	21km
220kV	2	Ihumwa-Kikombo	26km
220kV	2	Kikombo-Zuzu	47km
220kV	1	Kikombo-Narco	50km



[Source] JICA Study Team

Figure 6-2.3 Final route of transmission line (draft)

6-2-2 Study Team's Opinions and Recommendations

(1) Views on proposed double conductors per phase for 220kV Dodoma City ring circuit system

TANESCO proposes that the design of the 220kV Dodoma City ring circuit system should be double circuits with twin conductors per phase to accommodate the long term power system planning and consider other loads beyond Dodoma City, however, JICA Study Team does not recommend this idea be applied because of the reason mentioned below.

In the system configuration described in the report, the conductor of the 220kV transmission lines for the ring circuit system is planned to be the single Bluejay that is a standard conductor of TANESCO for 220kV and is able to deliver over 300MVA. It can accommodate the demand of 2047 forecasted by TANESCO supplying from Zuzu substation with a single conductor of 220kV transmission line without the ring configuration. By using the ring configuration, the supply capacity and reliability (N-1) are improved, and the double circuits are also adopted in consideration of the power supply to government offices. The system configuration is to ensure higher supply capability and reliability (N-2 in transmission system) and that can accommodate over 500 MVA even in the state of securing N-1 reliability, it is assumed that supplying power to the reginal demand areas beyond Dodoma City will not have a significant adverse effect. If the demand exceeds the forecasted demand of TANESCO greatly, it is possible to stop operation line by line in this system configuration and the replacement of conductors will be easily performed.

Due to recent advances in technology, several types of conductors having the same or smaller diameter, lighter weight, small sag, and nearly twice the current capacity have been introduced to practical use, and utilization in developing countries has been reported.

In addition, in the case where only one circuit is strung on the two-circuit tower on one side with the proposed two conductors per phase adoption, a large unbalanced load is applied, so that the towers and foundations need to be strengthened. Thus, it is not recommended because it is predicted to be more expensive than the cost of transmission line with two circuits strung.

As described in the basic policy on the power system plan in 4-3-2, economically cost effectiveness is one of the important considerations, the Study Team believe that conducting capital expenditures of the appropriate scale at the appropriate time while keeping the initial investment low as much as possible will reduce the burden on the operation of the power company and lead to the continuation of sound management. (Unnecessary investment costs when the demand growth is within the forecasted range can be avoided.)

(2) Opinions and recommendations on pending points for transmission equipment planning

The pending points in Table 6-2.2 are shown.

Table 6-2.2 Concerns about final route plan

Transmission line section	Concerned points	Pending Contents
Zuzu-Msalato	About 3km from Msalato substation	・Residential area passage (near intersection with A104 road)
	Near Msalato substation	・Because it is adjacent to the new airport, it may be affected by the airport construction plan. ・It may be interfering with the EPZ planning area.
Msalato-Ihumwa	Msalato substation exit	・It may be interfering with planned bus road maintenance areas.
	About 5km from Msalato substation	・There is a high possibility to be detoured because the route is along the EPZ section.
	About 7km from Ihumwa substation	・Densely populated areas passage.
Ihumwa-Kikombo	Within 5km from Ihumwa substation	・As it passes through the area where government offices are built, it may be affected by government office development plans. ・Maintenance work may be restricted due to passing near government offices
	Within 10km from Kikombo substation	・Pass through the planned residential area.
Kikombo-Zuzu	Around Kikombo substation	・Crossing the new Chalinze - Zuzu transmission line
	About 2km from Kikombo substation	・Pass through the planned residential area.
	About 7km from Kikombo substation	・Intersection with the new SGR transmission line
	About 11km from Kikombo substation	・Pass through the planned residential area.

1) Transmission line route between Msalato substation and Ihumwa substation

Since the route passes around the New International Airport, it is necessary to confirm the height restrictions. In case of height restrictions, it is necessary to use underground cables in some sections. In addition, the area that interferes with the bus road maintenance area needs to be examined.

2) Transmission line route between Ihumwa substation and Kikombo substation

The vicinity of the Ihumwa substation is not only a government district but also a military site, so it is necessary to discuss it as soon as possible. In addition, when using an underground cable, it is necessary to avoid interference with a distribution line to be underground. The transmission line between Ihumwa-Kikombo is selected to be a short-distance route, so it will not only pass around government offices, but will also pass through residential areas in the future. Therefore, it is necessary to secure the wayleave, the site for the tower, and the access road to the tower site as soon as possible.

3) Transmission line route between Kikombo substation and Zuzu substation

The transmission line between Kikombo substation and Zuzu substation may interfere with the transmission line between the new Chalinze substation and Zuzu substation that is planned on almost the same route. If possible, they should be used jointly from the viewpoint of Wayleave.

(3) Opinions and recommendations on pending points for substation equipment planning

1) 220kV Busbars at Zuzu substation

According to the information from TANESCO at site, two bays for present Singida substation (400 kV designed transmission lines connected) will be used for 400/220 kV transformers as shown in Figure 6-2.1. In this connection, we would like to point out that the 220 kV busbar might be overloaded since the rated capacity of each transformer is 250 MVA.

220 kV busbar rating: 1 x Bluejay = **333 MVA < 500 MVA** (= 2 x 250 MVA)

2) 220kV Vacant bays

It was found that there is a cable duct (almost 2 m width) running at the one of the vacant bay. Therefore, same type of equipment used for other bays may not be installed. The other type of equipment or new additional bay should be considered at the implementation stage.

6-2-3 Outline of Dodoma Transmission System Development Plan

The Outline of Dodoma Transmission System Development Plan taking into account the discussion results is shown in Table 6-2.3. Transmission lines must be constructed in coordination with existing and other future transmission and distribution lines.

Table 6-2.3 Outline of Dodoma Transmission System Development Plan

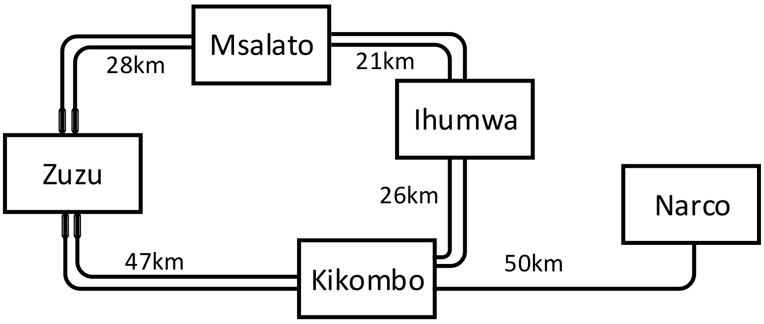
Facility	ID	Outline	Ramarks
Transmission	T-1	■ Construction of Transmission Line (Zuzu-Msalato) ・ 220kV Double Circuits Approx.28km	At Zuzu substation, outgoing transmission line with Cable should be considered.
	T-2	■ Construction of Transmission Line (Msalato-Ihumwa) ・ 220kV Double Circuits Approx.21km	-
	T-3	■ Construction of Transmission Line (Ihumwa-Kikombo) ・ 220kV Double Circuits Approx.26km	Transmission line route is changed to avoid interfering with the Statehouse.
	T-4	■ Construction of Transmission Line (Kikombo-Zuzu) ・ 220kV Double Circuits Approx.47km	Transmission line should be coordinated with the existing line. At Zuzu substation, outgoing transmission line with Cable should be considered.
	T-5	■ Construction of Transmission Line (Kikombo-Narco) ・ 220kV Single Circuits Approx.50km	Both Stepwise Development and One-time development, Narco should be finally connected to Kikombo.
Substation	S-1	■ Construction of Msalato substation ・ 2x50MVA 220/33kV Transformer ・ One lot of Switching and Information facilities ・ Construction of Control Building, Civil Works, etc.	Since the survey for land acquisition has already been started and it has been confirmed that resettlement is not necessary, the location of the substation has been decided based on the original plan of TANESCO.
	S-2	■ Construction of Ihumwa substation ・ 2x100MVA 220/33kV Transformer ・ One lot of Switching and Information facilities ・ Construction of Control Building, Civil Works, etc.	Same as above
	S-3	■ Construction of Kikombo substation ・ 2x40MVA 220/33kV Transformer ・ One lot of Switching and Information facilities ・ Construction of Control Building, Civil Works, etc.	Same as above
	S-4	■ Construction of Narco substation ・ 2x40MVA 220/33kV Transformer ・ One lot of Switching and Information facilities ・ Construction of Control Building, Civil Works, etc.	Same as above
	S-5	■ Rehabilitation of Zuzu substation ・ One lot of transmission line bay facilities	Existing 4-bay space should be secured for outgoing transmission lines

[Source] JICA Study Team

6-3 Proposal of cooperation policy

6-3-1 Scenario for Transmission System Development Plan (revised version)

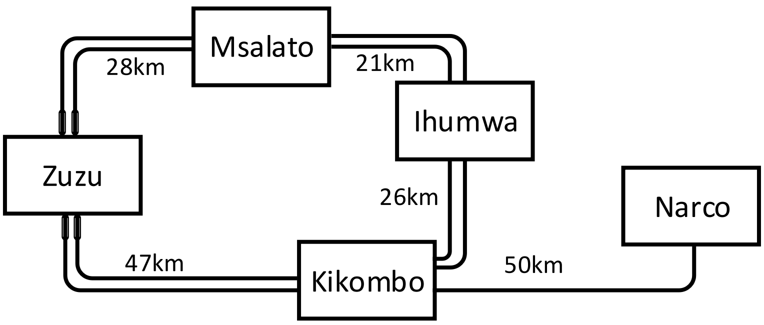
Following the concept of 5-2-1 Scenario Building, the scenario was revised based on the discussion results. In accordance with the scenario Building described in 5-2-1, Scenarios 1 and 2 are stepwise development plans in accordance with power demand assumptions and Dodoma Urban Area Development Plan. In the revised version of the scenario, Narco substation is connected from Kikombo substation even in the stepwise development, considering the transmission line length and construction cost as in the case of the batch development. Figure 6-3.1 shows Final Power system Configuration of Scenario 1 and Scenario 2.



[Source] JICA Study Team

Figure 6-3.1 Final Power system Configuration (Revised Stepwise development)

Figure 6-3.2 shows Final Power system Configuration of Scenario 3, which is One-time Development. In scenario 1 and scenario 2, which are the Stepwise development, Narco substation is connected to Kikombo substation as the final configuration. Therefore, the final configuration of the one-time development and the stepwise development is the same.

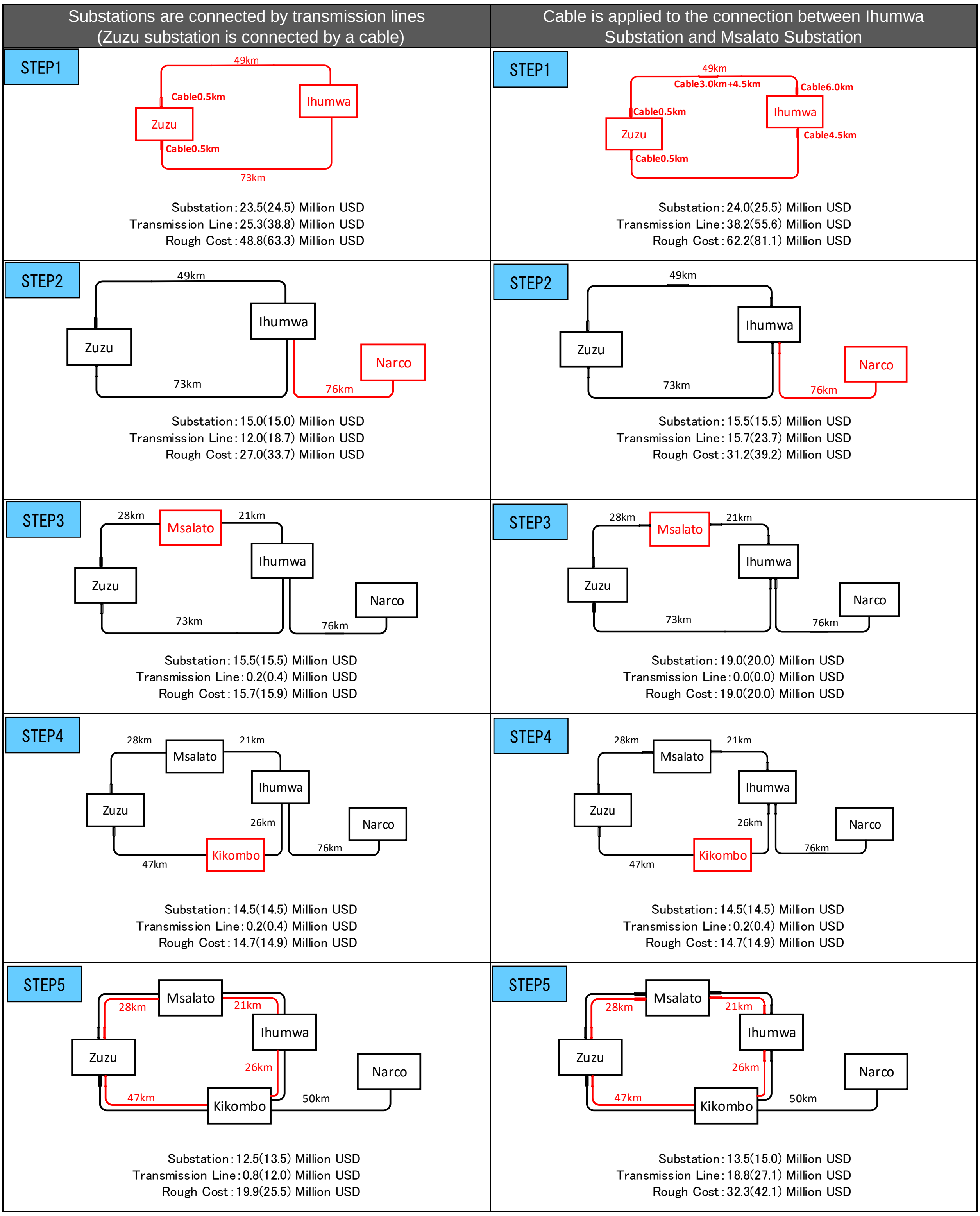


[Source] JICA Study Team

Figure 6-3.2 Final Power system Configuration (Revised Stepwise development)

Scenario- 1 ：＜Stepwise Development 1＞Establishing a single line loop circuit as early and to secure power supply reliability

The stepwise development plan and reference costs for Scenario-1 are shown in Figure 6-3.3.



[Source] JICA Study Team

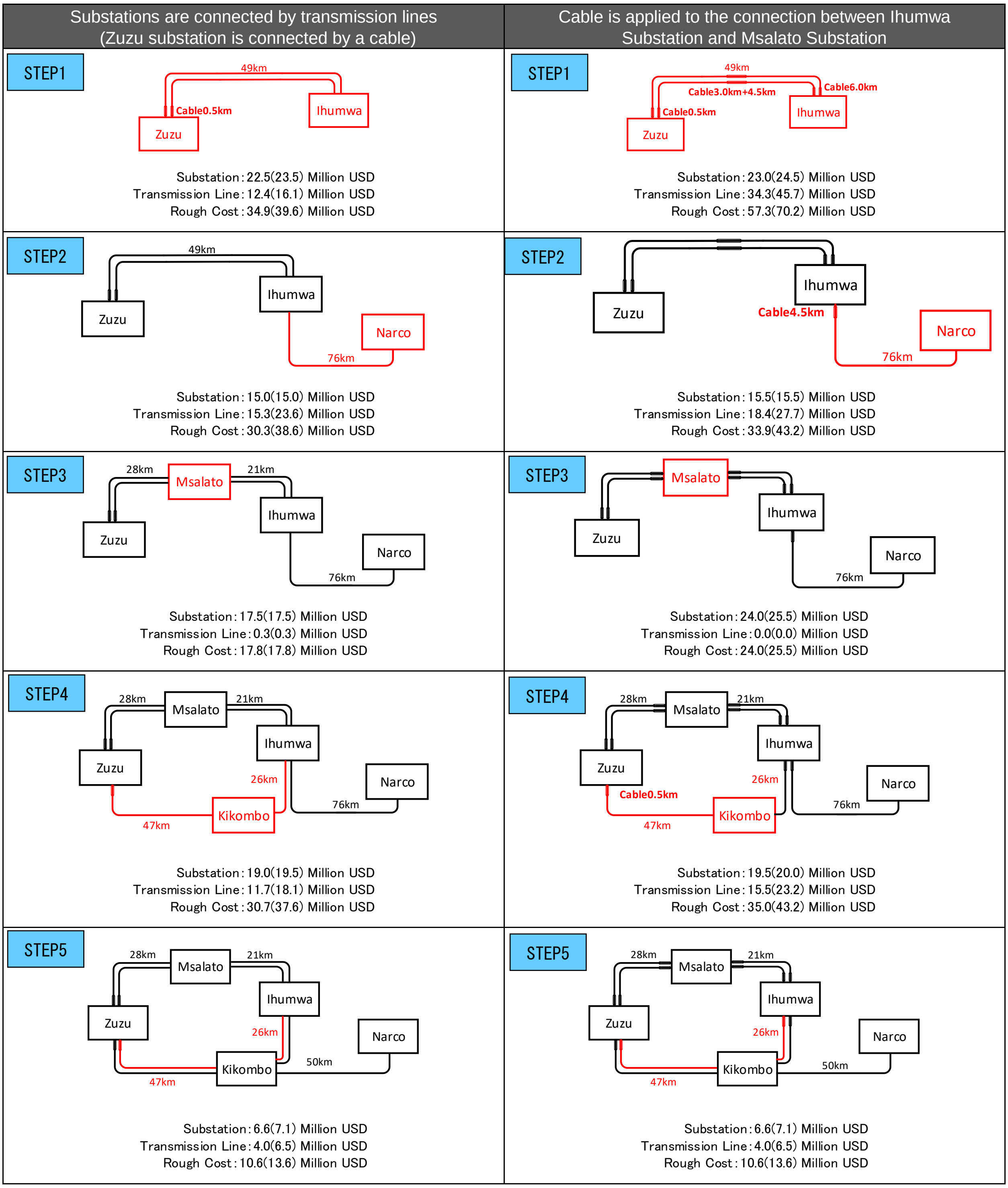
[Remark] Rough Cost excludes Distribution Cost, land preparation cost, Consultancy fee and Contingency.

( ) Shows the cost when applying multiple conductors to the transmission line.

Figure 6-3.3 Stepwise Development Plan (Scenario-1): Draft

Scenario-2 : ＜Stepwise Development 2＞ Ensuring power supply reliability by constructing north side double-circuit transmission lines with emphasis on urgency

The stepwise development plan and reference costs for Scenario-2 are shown in Figure 6-3.4.



[Source] JICA Study Team

[Remark] Rough Cost excludes Distribution Cost, land preparation cost, Consultancy fee and Contingency.

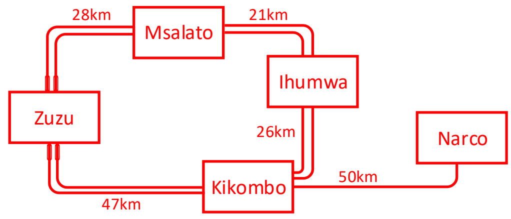
( ) Shows the cost when applying multiple conductors to the transmission line.

Figure 6-3.4 Stepwise Development Plan (Scenario-2): Draft

Scenario-3 : <One-time Development> Advanced development with double-circuit transmission loop system

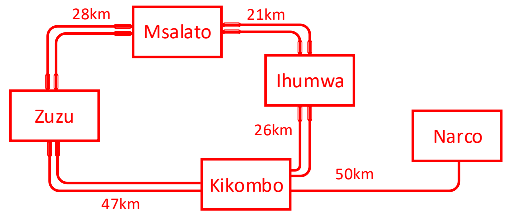
The one-time development plan and reference costs for Scenario-3 are shown in Figure 6-3.5.

Substations are connected by transmission lines (Zuzu substation is connected by a cable)



Substation : 77.5(79.5) Million USD
Transmission Line : 40.4(54.9) Million USD
Rough Cost : 117.9(134.4) Million USD

Cable is applied to the connection between Ihumwa Substation and Msalato Substation



Substation : 80.0(83.0) Million USD
Transmission Line : 68.6(93.3) Million USD
Rough Cost : 148.6(176.3) Million USD

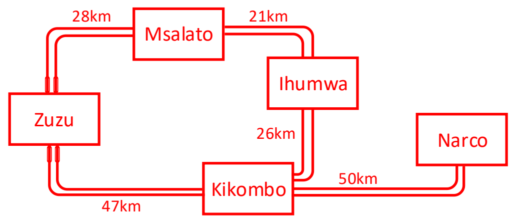
[Source] JICA Study Team
[Remark] Rough Cost excludes Distribution Cost, land preparation cost, Consultancy fee and Contingency.
( ) Shows the cost when applying multiple conductors to the transmission line.

Figure 6-3.5 One-Time Development Plan (Scenario-3): Draft

Option : <One-time Development>

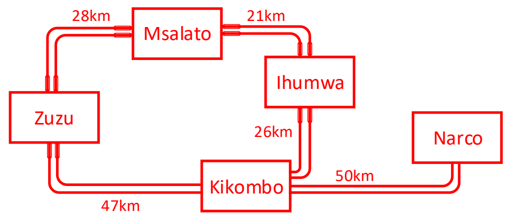
The one-time development plan and reference costs discussed with the Tanzania side are shown in Figure 6-3.6.

Substations are connected by transmission lines (Zuzu substation is connected by a cable) [Narco Substation and Kikombo Substation are connected to two circuits.]



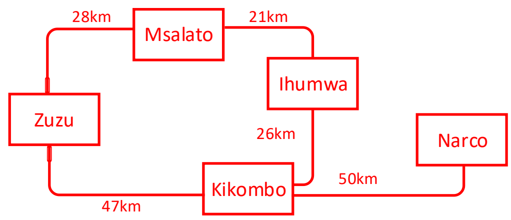
Substation : 79.5(81.5) Million USD
Transmission Line : 42.2(54.6) Million USD
Rough Cost : 121.7(136.1) Million USD

Cable is applied to the connection between Ihumwa Substation and Msalato Substation [Narco Substation and Kikombo Substation are connected to two circuits.]



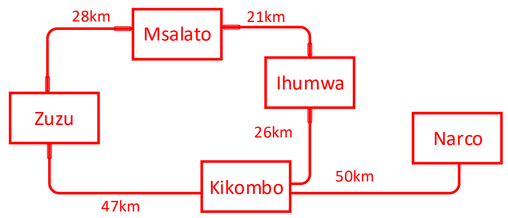
Substation : 82.0(85.0) Million USD
Transmission Line : 70.3(93.1) Million USD
Rough Cost : 152.3(178.3) Million USD

Substations are connected by transmission lines (Zuzu substation is connected by a cable) [1 line loop + 1 line connection of Narco-Kikombo substation]



Substation : 68.0(69.0) Million USD
Transmission Line : 35.3(54.2) Million USD
Rough Cost : 103.3(123.3) Million USD

Cable is applied to the connection between Ihumwa Substation and Msalato Substation [1 line loop + 1 line connection of Narco-Kikombo substation]



Substation : 69.5(71.0) Million USD
Transmission Line : 47.9(70.7) Million USD
Rough Cost : 117.4(141.7) Million USD

[Source] JICA Study Team
[Remark] Rough Cost excludes Distribution Cost, land preparation cost, Consultancy fee and Contingency.
( ) Shows the cost when applying multiple conductors to the transmission line.

Figure 6-3.6 One-Time Development Plan (Scenario-3): Option

Figure 6-3.3 to Figure 6-3.5 show the rough cost for each scenario. Table 6-3.1 shows the rough cost of connecting each substation with a transmission line (single conductor) (Zuzu substation is connected with a cable).

Table 6-3.1 Rough Cost for each scenario
Each substation is connected by a transmission line (single conductor)
(Zuzu substation is connected by a cable)

Scenario	STEP1	STEP2	STEP3	STEP4	STEP5	Total
1	48.8Million USD	27.0Million USD	15.7Million USD	14.7Million USD	19.9Million USD	126.1Million USD
2	34.9Million USD	30.3Million USD	17.8Million USD	30.7Million USD	10.6Million USD	124.3 Million USD
3	117.9 Million USD	-	-	-	-	-

[Source] JICA Study Team

6-3-2 Consideration of Implementation Schedule

As described in Chapter 5, Scenario Formation, the Study Team reviewed the demand forecast and constructed an economic development scenario with high supply reliability, taking into account the Dodoma National Capital City Master Plan. In addition, a qualitative evaluation of the scenario was conducted by the Study Team.

In this section, implementation scheme plans for each development will be examined based on the above viewpoints and future cooperation policies is proposed.

(1) Stepwise Development

Scenario-1: Establishing a single line loop circuit as early and to secure power supply reliability

Scenario-2: Ensuring power supply reliability by constructing double-circuit transmission lines on the north side with emphasis on urgency

Scenarios 1 and 2 of the stepwise development plan differ in development order to achieve different goals. On the other hand, the common points of both scenarios are as follows;

- ✓ To develop economically according to demand and progress of development
- ✓ To supply power to government offices such as the Statehouse preferentially
- ✓ To build a distribution network in the southeastern area where power outages often occur at an early stage.

Table 6-3.2 shows the applicability and concerns of grant aid and ODA loan.

Table 6-3.2 Features and concerns by implementation scheme of the stepwise development plan

	Applicability / features	Concerns
Grant aid	✓ Partial stage application is possible. ✓ The procedure is simpler than ODA loan. ✓ It is implemented in a short time from request to delivery. ✓ Construction quality, safety and process management are ensured. ✓ The power supply situation is urgently improved.	✓ The development scale becomes smaller. ✓ Tanzania's burden is required. ✓ High benefits are required.
ODA loan	✓ The development scale increases. ✓ International competitive bidding may reduce overall project costs.	✓ The procedure is more complicated than with grant aid. ✓ Widespread distribution system reinforcement is required. ✓ The bidding process up to the contract is long. ✓ Construction quality, safety and process management may not be performed reliably.

(2) One-time Development

Scenario-3: Advanced development with double-circuit transmission loop system

Scenario 3 of the collective development plan can satisfy all the important points described in the stage development plan.

On the other hand, there are many concerns that need to be carefully considered.

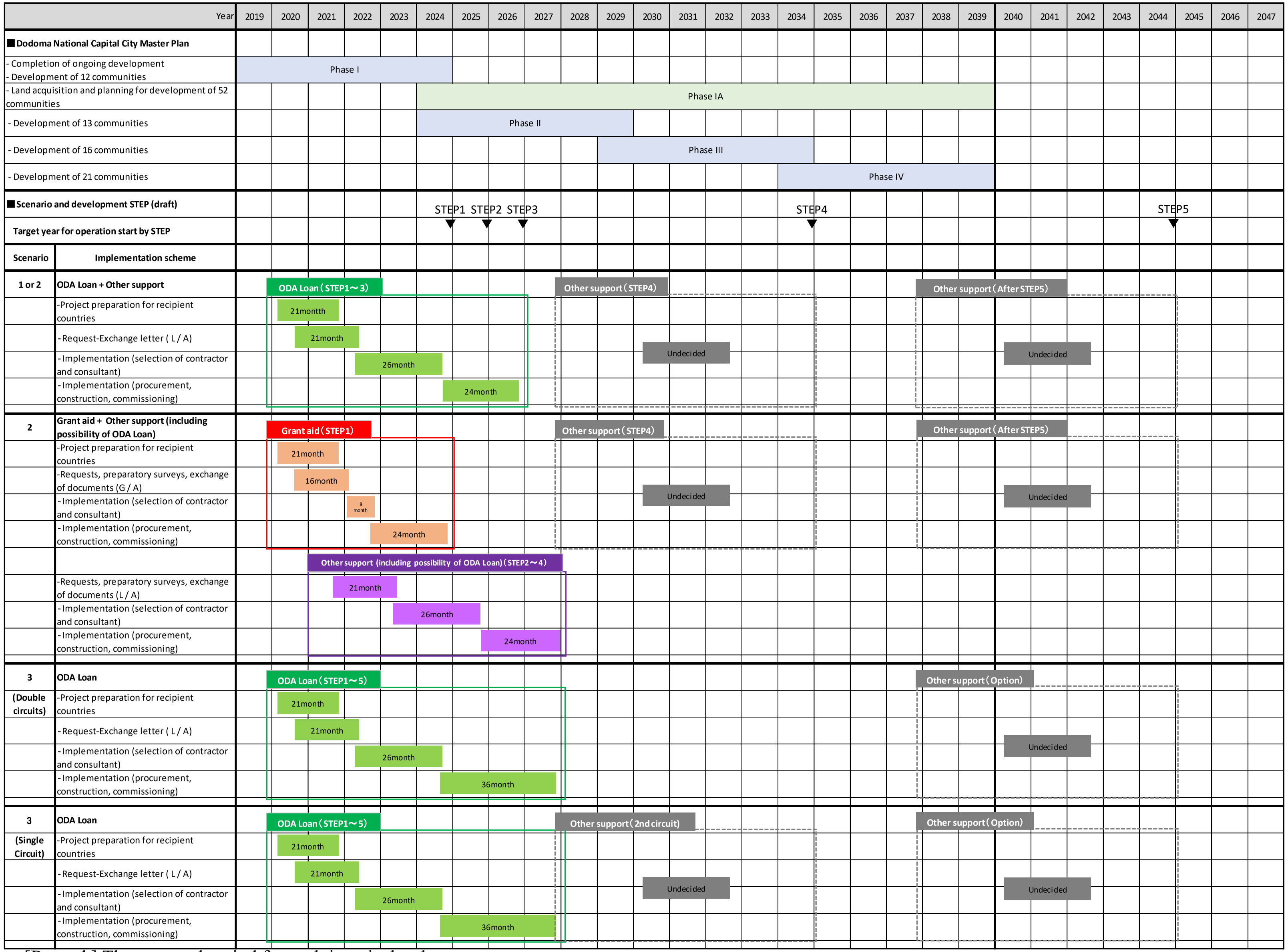
Since there is no possibility of grant aid due to the scale of the project, the applicability and concerns of ODA loan are shown in Table 6-3.3.

Table 6-3.3 Features and concerns by implementation scheme of the one-time development plan

	Applicability / features	Concerns
ODA loan	✓ One-time development is possible from the viewpoint of the project scale. ✓ International competitive bidding may reduce overall project costs. ✓ The power supply capability can be improved at an early stage. ✓ It is possible to respond to unexpected sudden increase in demand.	✓ The procedure is more complicated than with grant aid. ✓ Large-scale land acquisition and compensation will be implemented by the recipient country in a short period of time. ✓ Widespread distribution system reinforcement is required. ✓ The bidding process up to the contract is long. ✓ Construction quality, safety and process management may not be performed reliably. ✓ Excessive upfront investment (non-economic). ✓ Maintenance of equipment is concentrated at the same time, so the time and cost spent on maintenance are inclined. ✓ Although the load factor of the equipment is low, the time to replace the equipment comes soon

(3) Proposal of implementation scheme

Figure 6-3.7 shows the results of a study of the implementation schedule considering the expected period of each stage for each scheme.



[Remark] The assumed period for each item is the shortest.

Figure 6-3.7 Each scenario and proposed implementation scheme

Option (Minimize initial costs)

1) Response to urgency

Considering the power supply situation in the urban area of Dodoma and the future demand, it is proposed to implement the combined support of the Grant Aid that can be implemented in a short period of time and ODA loan in Scenario 2 of the stepwise development plan shown in the proposed implementation scheme.

Scenario 2 of the stepwise development plan can be the following items:

- ✓ The first step of development will be completed in 2024, and it will be possible to respond to increased demand from the target of operation start in 2025.
- ✓ A supply system to government offices has been established, and it is possible to respond to emergencies, such as supplying power to southeastern Dodoma Province where serious power outages often occur.

<Emergency perspective>

- ✓ The power demand in the Dodoma urban area in 2025 is expected to be 115.1MW, which is about 3.8 times the actual value of 30.6MW in 2018. The Dodoma National Capital City Master Plan Phase 1 completion target is 2024. Phase 1 includes development of international logistics and transportation, such as the construction of international airport, outer ring roads, and bus terminals. Substations are needed to supply power to these important loads and government offices.
- ✓ Currently, long-distance distribution is being carried out from the existing Zuzu substation to the southeastern part of the Dodoma urban area. More than 900 power outages have occurred in the Dodoma urban area over the past three years (More than 50% of outages occur on distribution lines to supply power to the southeast district). One of the major reasons is that the distribution loss is 10% or more, and urgent action is required.

2) Minimization options

In consideration of the Grant Aid that can be implemented in a short time, Figure 6-3.8 shows the proposed system configuration of initial development aiming to minimize the initial cost and the approximate cost. With options that minimize the initial cost, it will not be possible to provide “rescuable configuration (considering N-1)” and “high-quality power supply (outage time)” at the initial stage. Therefore, it is necessary to proceed with the system configuration of scenario 2 STEP1 at an early stage.

Initial development (plan)	Initial development option 1	Initial development option 2
<Scenario 2 : STEP1>	<Difference from Scenario 2 : STEP1> Transmission: 2 circuits ⇒ 1 circuit	<Difference from Scenario 2 : STEP1> Transmission: 2 circuits ⇒ 1 circuit Substation: 220kV double bus ⇒ 220kV single bus 2 transformers ⇒ 1 transformer 33kVSWGR feeder 8 lines ⇒ 4 lines
 Substation : 22.5 Million USD Transmission Line : 12.4 Million USD Rough Cost : 34.9 Million USD	 Substation : 20.0 Million USD Transmission Line : 10.2 Million USD Rough Cost : 30.2 Million USD	 Substation : 14.5 Million USD Transmission Line : 10.2 Million USD Rough Cost : 24.7 Million USD
-	[issue] (1) N-1 cannot be rescued (Options 1 and 2 are not available for transmission line failures, others are only Option 2) In case of transmission line accident, substation bus accident, substation transformer accident, power supply failure occurs. (2) Power outage is required when substations are added(Option 2 only) Long-term power outages are required when buses are duplicated or transformers are added. (3) Increase in total substation construction costs(Options 1 and 2) As development stages increase, the total cost of development increases.	

[Source] JICA Study Team
[Remark] Rough Cost excludes land preparation cost, Consultancy fee and Contingency.
[Note] The transmission line in the figure is composed of a single conductor.

Figure 6-3.8 Options (minimize initial costs)

3) Expected benefits

In addition to Emergency Perspective, the following benefits can be expected by constructing the Ihumwa Substation as described in “Scenario Building” in section 5-2-1.

< Expected benefits of construction of Ihumwa substation >

✓ In addition to securing power supply to government offices, it will be possible to supply power to the existing distribution network and supply areas from the Msalato Substation and Kikombo Substation.

In order to obtain the expected benefits from the initial development of the transmission and distribution network in the Dodoma urban area, the following developments need to be carried out in parallel with the construction of Ihumwa Substation.

✓ Expansion of distribution network (new construction / extension)

✓ Repairing of distribution network (switch-over, improvement)

[Note] In case of development option 1 and 2 : Due to the issues (1) and (2) in Figure 6-3.8, it is necessary to implement measures to improve the supply reliability from the Zuzu substation for the 33 kV distribution network supplied from the Ihumwa substation (Double conductor, Changing to large diameter conductor, etc.).

【Attachment】

Attachment 1.   Itinerary for the Field Survey

Attachment-1. Itinerary for the Field Survey

DAY	DATE		CONSULTANT: Chief Consultant / Substation Planning (2) / Distribution Planning	Substation Planning (1)	Transmission Planning	Assistant of Substation and Transmission Planning	Power Demand Forecast and Power System Planning	Assistant of Demand Forecast and Power System Planning	Coordinator
1	2019.9.21	SAT	22:20-03:50 [QR807] Narita/Tokyo - Doha	20:00-21:40 [JL330] Fukuoka - Haneda/Tokyo	19:50-21:10 [QR6036] Hiroshima - Haneda/Tokyo	22:20-03:50 [QR807] Narita/Tokyo - Doha		20:00-21:40 [JL330] Fukuoka - Haneda/Tokyo	22:20-03:50 [QR807] Narita/Tokyo -Doha
2	2019.9.22	SUN	08:45-16:55 [QR1357] Doha - Dar es Salaam	00:30-06:15 [EK313] Haneda/Tokyo - Dubai 10:15-14:40 [EK725] Dubai - Dar es Salaam	00:01-06:00 [QR813] Haneda/Tokyo - Doha 08:45-16:55 [QR813] Doha - Dar es Salaam	08:45-16:55 [QR1357] Doha - Dar es Salaam		00:01-06:00 [QR813] Haneda/Tokyo - Doha 08:45-16:55 [QR813] Doha - Dar es Salaam	08:45-16:55 [QR1357] Doha - Dar es Salaam
3	2019.9.23	MON	09:30~ Courtesy call to JICA Tanzania Office - Explanation and discussion of inception report and site survey schedule 11:00~ Courtesy call to TANESCO (Eng. Theodory Bayona, Eng. Amos Kaihula, Eng. Mahende M. Mugaya) at TANESCO Ubungo - Explanation of inception report, site survey schedule and questionnaire 14:30~ Meeting with TANESCO at TANESCO Ubungo - Power Demand Forecast and Dodoma MP						
4	2019.9.24	TUE	10:00~ Meeting with TANESCO at TANESCO Ubungo - Power Demand Forecast, Dodoma MP and Distribution 12:00~ Meeting with TANESCO at TANESCO Ubungo - Transmission Planning 14:00~ Meeting with African Development Bank (AfDB) at AfDB office - The progress of Dodoma City Outer Ring Road Upgrading Project - Information exchange of current and future projects 15:00~ Meeting with World Bank (WB) at WB office - Information exchange of current and future projects						
5	2019.9.25	WED	10:00~ Meeting with TANESCO at TANESCO Ubungo - Distribution and Transmission 10:30~ Meeting with TANESCO at TANESCO Ubungo - Investment and Planning						
6	2019.9.26	THU	09:15-10:30 [PW600] Dar es Salaam - Dodoma (Terminal 2) 13:00~ Team Meeting, Data Analysis, Preparing meeting materials						
8	2019.9.28	SAT	09:00~ Site Survey - Existing 33/11kV Town Substation - Existing 400/220/33kV Zuzu Substation - Site for new Distribution Control Center (DCC) - Site for new Grid Control Center (GCC)						
9	2019.9.29	SUN	- Preparing meeting materials - Drafting the technical memorandum - Team Meeting						
10	2019.9.30	MON	08:00~ Meeting with TANESCO at TANESCO Dodoma 09:00~ Courtesy call to Ministry of Energy (MoE) with TANESCO and JICA Tanzania Office at MoE - Explanation of inception report and site survey schedule - Reporting of the discussion with TANESCO						
			15:00- Meeting with Ministry of Lands, Housing and Human Settlements Development (MLHHSD) and TANESCO at MLHHSD - The progress of Dodoma National Capital City Master Plan (2019-2039)	14:00~ Meeting with City Council Dodoma (CCD), SMEC and TANESCO at TANESCO Dodoma - The progress of development based on Dodoma National Capital City Master Plan (2019-2039) - Discussion on the development plan of transmission and distribution line in Dodoma with SMEC - Data Correction from Dodoma Municipality and SMEC				14:00~Meeting with CCD and TANESCO at TANESCO Dodoma	15:00- Meeting with MLHHSD and TANESCO at MLHHSD
11	2019.10.1	TUE	08:00~ Meeting with Tanzania National Roads Agency (TANROADS) and TANESCO at TANROADS - Dodoma ring roads - Acts and Regulations	08:00~ Data Analysis				08:00~Data Analysis	08:00~ Meeting with TANROADS and TANESCO at TANROADS
			09:00~ Team Meeting and Data Analysis						
12	2019.10.2	WED	08:00~ Skype Meeting with JICA HQ						
			10:00~ Meeting with MLHHSD and CCD at Capital Development Authority (CDA) - The progress of Dodoma National Capital City Master Plan (2019-2039)	09:00~ Data Analysis				09:00~ Data Analysis	10:00~ Meeting with MLHHSD and CCD at CDA
			14:00~ Site Survey with TANESCO - Existing 33/11kV Mnadano Substation - Existing 33/11kV Mzakwe Substation						
13	2019.10.3	THU	09:00~ Data Analysis 11:00~ Data Collection from MoE at TANESCO Dodoma	09:00~ Site Survey with TANESCO - Existing 400/220/33kV Zuzu Substation				09:00~ Data Analysis	09:00~ Data Analysis 11:00~ Data Collection from MoE at TANESCO Dodoma
			14:00~ Site Survey with TANESCO - Site for new Msalato Substation - Site for new Ihumwa Substation						
14	2019.10.4	FRI	09:00~ Meeting with TANESCO at TANESCO Dodoma - Data Analysis - Preparing meeting materials - Drafting the technical memorandum and draft final report - Team Meeting						09:00~ Data Collection at MLHHSD 11:00~ Data Collection at MWTC 14:00~ Data Collection at Regional Commissioner 16:00~ Data Analysis

Attachment-1. Itinerary for the Field Survey

DAY	DATE		Chief Consultant / Substation Planning (2) / Distribution Planning	Substation Planning (1)	Transmission Planning	Assistant of Substation and Transmission Planning	Power Demand Forecast and Power System Planning	Assistant of Demand Forecast and Power System Planning	Coordinator
			CONSULTANT						
15	2019.10.5	SAT	10:00~ Meeting with TANESCO at TANESCO Dodoma - Preparing meeting materials - Drafting the technical memorandum and draft final report - Team Meeting				20:00-21:35 [JL330] Fukuoka - Haneda/Tokyo	10:00~ Meeting with TANESCO at TANESCO Dodoma - Preparing meeting materials - Drafting the technical memorandum and draft final report - Team Meeting	
16	2019.10.6	SUN	- Preparing meeting materials - Drafting the technical memorandum and draft final report - Team Meeting				00:30-06:45 [EK313] Haneda/Tokyo - Dubai 10:15-14:40 [EK725] Dubai - Dar es Salaam 16:25-17:40 [PW600] Dar es Salaam - Dodoma	- Preparing meeting materials - Drafting the technical memorandum, technical memorandum and draft final report - Team Meeting	
17	2019.10.7	MON	- Meeting with TANESCO - Data Analysis						
			16:00~ Explanation to MoE and TANESCO at TANESCO Dodoma - Power Demand Forecast & Allocation of the load for substations						
18	2019.10.8	TUE	09:00~ Site Survey - Kikombo Substation Site 13:00~ Data Analysis						
			16:00~ Explanation to TANESCO at TANESCO Dodoma - Power System Configuration						
19	2019.10.9	WED	09:30~ Meeting with TANESCO at TANESCO Dodoma 11:00~ Data Analysis	09:00~ Data Analysis					09:30~ Meeting with TANESCO at TANESCO Dodoma
			11:00~ Meeting with JICA HQ at TANESCO Dodoma - Data Analysis 16:00~ Meeting with JICA HQ at TANESCO Dodoma						
20	2019.10.10	THU	- Meeting with TANESCO at TANESCO Dodoma - Meeting with JICA HQ at TANESCO Dodoma - Data Analysis						
			15:00 Explanation to TANESCO at TANESCO Dodoma - Findings of the Power System Planning, Transmission Planning, Substation and Distribution Planning - Introduction of applicable quality infrastructure for Dodoma Capital City District						
21	2019.10.11	FRI	12:00~ Finalization of the Technical Memorandum at TANESCO Dodoma 18:00-19:15 [PW603] Dodoma - Dar es Salaam						
22	2019.10.12	SAT	- Preparing meeting materials - Drafting the draft final report - Team Meeting						
23	2019.10.13	SUN	- Preparing meeting materials - Drafting the draft final report - Team Meeting			18:05-00:10 [QR1357] Dar es Salaam - Doha		18:05-00:10 [QR1357] Dar es Salaam - Doha	
24	2019.10.14 Nyerere Day	MON	- Preparing meeting materials - Drafting the draft final report - Team Meeting			02:10-18:40 [QR806] Doha - Narita/Tokyo		02:10-18:40 [QR806] Doha - Narita/Tokyo	
25	2019.10.15	TUE	09:00~ Meeting with TANESCO at TANESO Ubungo	- Preparing meeting materials - Drafting the draft final report - Team Meeting			- Preparing meeting materials - Drafting the draft final report - Team Meeting	08:05-10:00 [JL307] Haneda/Tokyo - Fukuoka	09:00~ Meeting with TANESCO at TANESO Ubungo
26	2019.10.16	WED	10:00~ Meeting with AFD at AFD office 15:30~ Meeting with SMEC and TANESCO at SMEC office						
27	2019.10.17	THU	09:00~ Report to JICA Tanzania Office 10:30~ Report to Embassy of Japan						
			18:05-00:10 [QR1357] Dar es Salaam - Doha	16:45-23:20 [EK726] Dar es Salaam - Dubai	18:05-00:10 [QR1357] Dar es Salaam - Doha		16:45-23:20 [EK726] Dar es Salaam - Dubai		18:05-00:10 [QR1357] Dar es Salaam - Doha
28	2019.10.18	FRI	06:45-22:40 [QR812] Doha - Haneda/Tokyo	02:40-17:35 [EK318] Dubai - Narita/Tokyo	06:45-22:40 [QR812] Doha - Haneda/Tokyo		02:40-17:35 [EK318] Dubai - Narita/Tokyo		02:55-18:40 [QR806] Doha - Narita/Tokyo
-	2019.10.19	SAT		08:05-10:00 [JL307] Haneda/Tokyo - Fukuoka	06:55-08:20 [QR6025] Haneda/Tokyo - Hiroshima		08:05-10:00 [JL3057] Haneda/Tokyo - Fukuoka		

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Attachment-1. Itinerary for the Field Survey

DAY	DATE		Chief Consultant / Substation Planning (2) / Distribution Planning	Substation Planning (1)	Transmission Planning	Power Demand Forecast and Power System Planning
1	2020.1.25	SAT	16:30(Lilongwe)-20:40(Dar es Salaam) by ET42	20:35(Fukuoka)-22:00(Seoul/Incheon) by OZ135 23:50(Seoul/Incheon)-05:05+1(Dubai) by EK323	10:35(Fukuoka)-11:55(Tokyo) by LH4915 15:20(Tokyo)-19:10(Frankfurt) by LH717 21:35(Frankfurt)-06:25+1(Addis Ababa) by LH9694	20:35(Fukuoka)-22:00(Seoul/Incheon) by OZ135 23:50(Seoul/Incheon)-05:05+1(Dubai) by EK323
2	2020.1.26	SUN	Team Meeting	10:30(Dubai)-15:00(Dar es Salaam) by EK725 Team Meeting	09:45(Addis Ababa)-12:35(Dar es Salaam) by LH9665	10:30(Dubai)-15:00(Dar es Salaam) by EK725 Team Meeting
3	2020.1.27	MON	09:30~ Courtesy call to JICA Tanzania Office - Explanation and discussion of draft final report and survey schedule 16:00-17:00 [Air Tanzania] Dar es Salaam - Dodoma			
4	2020.1.28	TUE	08:30~ Meeting with TANESCO at Dodoma Regional Office - Courtesy call and Explanation of objectives, Schedule 10:00~ Courtesy call to TANESCO Management at Dodoma Regional Office - Courtesy call and Explanation of objectives, Schedule 14:00~ Courtesy call to Ministry of Energy (MoE) with TANESCO at MoE - Courtesy call and Explanation of the Proposed Dodoma Power System Planning			
5	2020.1.29	WED	08:30~ Meeting with TANESCO at Dodoma Regional Office 10:00~ Presentation-1 of Draft Final Report by JICA Study Team 11:00~ Presentation-2 of Draft Final Report by JICA Study Team 15:00~Meeting with Ministry of Finance and Planning (MFP)			
6	2020.1.30	THU	09:00~ Site Survey with TANESCO - New candidate site for Msalato Substation - New candidate site for Ihumwa Substation			
7	2020.1.31	FRI	10:00~ Conclusion of the Technical Memorandum at TANESCO Dodoma 17:30-18:30 [Air Tanzania] Dodoma - Dar es Salaam			
8	2020.2.1	SAT	- Preparing meeting materials - Drafting the Final report - Team Meeting			16:30(Dar es Salaam)-23:05(Dubai) by EK726
9	2020.2.2	SUN	- Preparing meeting materials - Drafting the Final report - Team Meeting			03:30(Dubai)-16:50(Seoul/Incheon) by EK322 18:15(Seoul/Incheon)-19:35(Fukuoka) by OZ136
10	2020.2.3	MON	11:00~ Meeting with TANESCO at Ubungo 14:00~ Meeting with SMEC and TANESCO at SMEC office			
11	2020.2.4	TUE	10:00~ Meeting with the AfDB at AfDB office			
12	2020.2.5	WED	09:00~ Meeting with the AFD at AFD office 11:00~ Meeting with the World Bank at WB office 14:00~ Report to JICA Tanzania Office			
13	2020.2.6	THU	15:35(Dar es Salaam)-18:05(Johannesburg) by SA187	Stay in Dar es Salaam	23:20(Dar es Salaam)-06:15+1(Zurich) by LH5889	
14	2020.2.7	FRI	13:45(Johannesburg)-06:10+1(Singapore) by SQ479	Stay in Dar es Salaam	09:25(Zurich)-10:20(Munich) by LH2367 15:30(Munich)-	
15	2020.2.8	Sat	08:05(Singapore)-15:35(Haneda) by SQ632	Stay in Dar es Salaam	10:55(Haneda) by LH714 13:20(Haneda)-14:50(Hiroshima) by LH4886	

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Attachment 2. List of Meetings

Organization and Name	Title
Ministry of Energy (MoE)	
Mr. Leonard R. MASANJA	Commissioner for Electricity and Renewable energy Division
Eng. Innocent G. Luoga	Assistant Commissioner for Electricity
Mr. Juma Mkobya	Acting Assistant Commissioner for Electricity Development
Eng. Christopher Nyondo	Acting Assistant Commissioner for Electricity
Eng. Salum Inegeja	Professional Engineer
Eng. Dauson Kamaka	Engineer
Eng. Christopher Bitesigirwe	Energy Engineer
Ministry of Lands, Housing and Human Settlements Development (MLHHSD)	
Prof. John Lupala	Chair-team of Dodoma city Master Plan
	Director for Rural and Town Planning
Mr. Alfred Luaudo	Principal Town Planner
Ministry of Works, Transport and Communications (MoWTC)	
Eng. Emmanuel Wansibho Raphael	Director of Airports Construction
Ms. Mkude Kibode	Overload Surcharge
City Council Dodoma (CCD)	
Mr. William Alfayo	Town Planner
Mr. Azor Willcom	Town Planner
Mr. Tegemea Mgalamge	Town Planner
Tanzania Electric Supply Company Ltd. (TANESCO)	
Eng. Khalid James	Deputy Managing Director, Investment
Eng. Raymond Seya	Deputy Managing Director, Distribution and Customer Services
Eng. Costa L. Rubagumya	Senior Manager Strategic Planning
Eng. Fokas Daniel	Manager, Strategic Planning
Ms. Amtha Tehengone	Manager of Investment
Eng. Theodory Bayona	Senior Manager, Sales & Marketing

Eng. Peter Kigadye	Project Coordinator (ZTIC)
Eng. Athanasius Nangali	Senior Zonal Manager (Central Zone)
Eng. Clara Simbila	Manager, Planning and Design
Eng. Leo Mwakatobe	Principal Engineer, Planning and Design
Eng. Mahende M. Mugaya	Senior Manager, Distribution
Eng. Joseph Mongi	Principal Engineer, Substation
Eng. Issac A. Chanji	Ag. Deputy Managing Director, Transmission
Eng. Amos J. Kaihula	Ag. Senior Manager, Transmission
Eng. Neema Mushi	Principal Engineer, Transmission
Eng. John Nkomola	Engineer, Transmission
Eng. Evodius Rweyemamu	Planning Engineer (Light Current)
Eng. Peter Lucas	Planning Engineer (Heavy Current)
Eng. Frank Mayila	Planning Engineer of Dodoma Regional Office
Mr. Amiri Tabu	Surveyor
Eng. Tumaini Nyari	Ag. Regional Manager Dodoma
Eng. Saigu Mguwami	Ag. Regional Transmission Engineer Dodoma
Ms. Leila Muhein	Ag. Manager of Public Relations
Ms. Luey Benju	Secretary
Ms. Frida Mkumbo	Ag. Manager of Communication System
Eng. Kmrwa Nangari	Zonal Distribution Engineer

Tanzania National Roads Agency (TANROADS)

Mr. Leonard Chimagu	Regional Manager -Dodoma

Tanzania Rural and Urban Road Agency (TARURA)

Mr. Noel Cheti	Road Engineer

African Development Bank (AfDB)

Ms. Minja Marie Hellen (Ms.)	Principal Transmission Engineer

World Bank (WB)

Mr. Mbuso Gwafila (Mr.)	Senior Energy Specialist

Agence Francise de Dévelopment (AFD)

Mr. Vincent Joguet	Programme Officer Energy Sector

SMEC

Mr. Felicien Hakizimana	Distribution Engineer
Mr. Berekate Mamo	Substation Engineer
Mr. Maruf Khan	Operations Manager – Ethiopia and Tanzania

Embassy of Japan in Tanzania

Mr. Shinichi Goto	Ambassador Extraordinary and Plenipotentiary
Mr. Shintaro Hayashi	First Secretary
Ms. Emi Mashiko	First Secretary

JICA Tanzania Office

Mr. Naofumi Yamamura	Chief Representative
Mr. Satoru Matsuyama	Senior Representative
Mr. Kentaro Akutsu	Senior Representative
Mr. Hayakazu Yoshida	Representative
Ms. Apolei Rosina	Assistant Program Officer

Attachment 3. Technical Memorandum

TECHNICAL MEMORANDUM
FOR
DATA COLLECTION SURVEY
ON
DODOMA TRANSMISSION AND DISTRIBUTION SYSTEM
IN THE REPUBLIC OF TANZANIA
AGREED BETWEEN
MINISTRY OF ENERGY (MOE),
TANZANIA ELECTRIC SUPPLY COMPANY LIMITED (TANESCO)
AND
JICA STUDY TEAM

Dodoma, October 11th, 2019

阿部 真

Mr. Makoto Abe
Chief Consultant
JICA Study Team
Yachiyo Engineering Co., Ltd.

Eng. Raymond Seya
Ag. Managing Director
Tanzania Electric Supply Company Ltd. (TANESCO)

Ministry of Energy (hereinafter referred to as MOE), Tanzania Electric Supply Company Ltd. (hereinafter referred to as "TANESCO") and JICA Study Team for the Data Collection Survey on Dodoma Transmission and Distribution System in the United Republic of Tanzania (hereinafter referred to as "the Team") had series of technical discussions to form a mutual understandings of the findings from the First Field Survey and the parties agreed to record the following points as a conclusion of the discussions.

1. **Main objectives of the Survey**

   The team explained that the main objectives of the Survey are as follows:

   (1) To confirm progress and details of the Dodoma National Capital City Master Plan,

   (2) To conduct a survey to investigate and analyze the current and future power demand, facilities, system and applicable quality infrastructure for Dodoma Capital City District, and

   (3) To contribute to JICA's cooperation policy consideration for Dodoma Transmission and Distribution network expansion.

2. **Scope of the Survey**

   The team explained that the scope of the Survey is as follows:

   (1) Power Demand Forecast
   - Review the existing power demand forecast predicted by TANESCO and propose updated power demand forecast.
   - Allocate the updated power demand to proposed substations.

   (2) Power System Planning
   - Review the existing power system and expansion plan.
   - Propose power system configuration for Dodoma Urban area with recommended voltage level.

   (3) Transmission Planning
   - Review the existing transmission plan.
   - Propose transmission plan and alternatives (if any).

   (4) Substation Planning
   - Review the existing substation plan.
   - Propose substation plan based on the discussion with TANESCO, result of power demand forecast for substations and power system plan.

   (5) Distribution Planning
   - Review the existing distribution plan.
   - Propose distribution plan based on the discussion with TANESCO, result of power demand forecast for substations and power system plan.

3. **Expected Output**

   The team explained that the expected output of the Survey is as follows:

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- Updated transmission and distribution development plan for Dodoma urban area proposed by the Team

4. Findings of the First Field Survey

(1) Issues discussed and/or agreed among the parties

- The Team explained the above objectives, scope of the survey and expected output.
- The Team had a presentation on the proposed power demand forecast on 7th October, 2019 and TANESCO basically agreed with the proposal though TANESCO required to refer to "Tanzania National Bureau of Statistics" for Population and GDP comparison.
- Based on the result of the power demand forecast and load allocation for the existing and expected substations, the Team had a presentation on the proposed power system configuration by showing the Base-case with 4 options (See Attachment) on 8th October, 2019.

  During the discussion, the Team highly recommended to keep the proposed ring circuit within the Dodoma Capital City in order to secure reliabilities, quality by limiting the risk of faults and transmission losses.

  After the presentation, TANESCO had an internal consideration about the Base-case and Option1, and requested the Team to consider additional transmission line from proposed Kikombo substation to Narco in order to secure power supply for the 5 districts.
- Based on the above discussion and comments from TANESCO, the Team had a presentation on the "Findings of the First Field Survey in Dodoma" with additional option (Option5 – see attachment) on 10th October 2019.

  During the discussion, the team explained that the power system configuration shown by the Team was an ideal idea for the final shape of 2047 in case of the Dodoma City development and power demand forecast are realized properly.

  The team also explained that the stepwise transmission and distribution power system development for Dodoma Capital City shall be proposed by the Draft Final report.

  Finally, the Team explained that the Team shall have furtherer analysis in Japan and the Draft Final Report incorporated with the comments and the result of the analysis will be submitted to Ministry of Energy and TANESCO.

  The team explained outline of the quality infrastructure technology that may be applicable in Dodoma City Transmission and Distribution Network.

(2) Pending issues

- Since forecasted power demand is limited in Narco, the Team emphasized to construct the additional transmission line from Kikombo to Narco in 132kV.

  However, TANESCO requested to plan the line in 220kV in order to maintain the same voltage level with the existing 220kV line and avoiding voltage transformation in proposed Kikombo Substation and challenge during Operation and Maintenance of the line after

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being commissioned.

5. Tentative Schedule

- Analysis in Japan: November, 2019
- Second Field Work (Submission & Explanation of Draft Final Report): December, 2019
- Submission of Final Report: February, 2020
- However TANESCO request to complete this study early January, 2020

Attachment

Attachment-1: Findings of the First Field Survey in Dodoma

Attachment-2: Applicable Quality Infrastructure Technology Presentation

DATA COLLECTION SURVEY ON DODOMA TRANSMISSION AND DISTRIBUTION SYSTEM IN THE UNITED REPUBLIC OF TANZANIA

Findings of the First Field Survey in Dodoma

OCTOBER 10TH, 2019
JICA STUDY TEAM

Contents

1. Objectives & Expected output of the Survey

<Main Objectives>

- To confirm progress and details of the Dodoma National Capital City Master Plan,
- To conduct a survey to investigate and analyze the current and future power demand, facilities, system and applicable quality infrastructure for Dodoma Capital City District, and
- To contribute to JICA's cooperation policy consideration for Dodoma Transmission and Distribution network expansion.

<Expected Output>

- Updated transmission and distribution development plan for Dodoma urban area proposed by JICA Study Team

2. Scope of the Survey

Power Demand Forecast

- Review the existing power demand forecast predicted by TANESCO and propose updated power demand forecast.

Power System Planning

- Allocate the updated power demand to proposed substations.
- Review the existing power system and expansion plan.
- Propose power system configuration for Dodoma Urban area with recommended voltage level.

2. Scope of the Survey

◆ Transmission Planning

- Review the existing transmission plan.
- Propose transmission plan and alternatives (if any).

◆ Substation Planning

- Review the existing substation plan.
- Propose substation plan based on the discussion with TANESCO, result of power demand forecast for substations and power system plan.

◆ Distribution Planning

- Review the existing distribution plan.
- Propose distribution plan based on the discussion with TANESCO, result of power demand forecast for substations and power system plan.

3. Power Demand Forecast

A) Scope of the survey

In order to analyze and investigate the current and future

Plan for Dodoma capital city area, to establish load forecast for 30 year

→Target year 2047

B) Reference documents

- Power System Master Plan (2016): prepared by JICA
- Establishment of power demand forecast (2018)
  : Prepared by TANESCO
- Dodoma National capital city master plan(2019) :Prepared by Ministry of Lands, Housing and Human settlement Development

3. Power Demand Forecast

C) Precondition of demand forecast

◆ The forecast period

→Short term 2019 to 2022

→Medium term 2023 to 2037

→long term 2038 to 2047

◆ Total anticipated load for specific loads for movement of capital city function to Dodoma)

→104.8MW (the load will come in 2020-2029)

3. Power Demand Forecast

D) Current Dodoma situation

◆ The current peak demand for Dodoma region

→30.6MW (28th November 2018 recorded)

◆ Population growth in Dodoma region

→Compared numbers described in Dodoma MP with expected ones in PSMP2016

【population growth in Dodoma region】 (thousand)

	2012	2015	2016	2017	2017/12
PSMP2016(expected)	2,083	2,234	2,281	2,329	2.3%
Dodoma MP(Actual)	2,083	—	2,265	2,312	2.1%

◆ GDP growth

→Compared actual value with expected values in PSMP2016

	Senerio setting in PSMP 2016						Actual	
	2013-15	2015-20	2020-25	2025-30	2030-35	2035-40	2011-2015	2013-2018
HIGH	7%	8%	8%	8~10%	8~10%	8~10%	Average	Average
BASE	7%	7%	7%	6%	6%	5%	6.4%	6.7%
LOW	7%	6%	6%	5%	5%	4%	(*1)	(*2)

*1 AFDB

*2 National bureau statistics in Dodoma

3. Power Demand Forecast

E) Precondition of demand forecast

◆ Electricity demand growth rate

Since actual GDP growth rate is less 7%, Scenario Low case of PSMP is selected

Year	Low Case of PSMP*	TANESCO Assumption
2019-2022	8%	9%
2023-2037	7.8%	7%
2038-2047	6.4%	5%

*Average value for corresponding period from the growth rates forecasted in PSMP 2016

3. Power Demand Forecast

F) Result of demand forecast

(MW)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
JICA survey team	30.6	33.04	46.16	59.49	73.04	86.79	100.8	115.1	129.6	144.5	159.8	175.4
TANESCO 2018	31.4	34.2	48.1	62.2	76.6	90.6	104.7	119	133.6	148.5	163.6	179.1

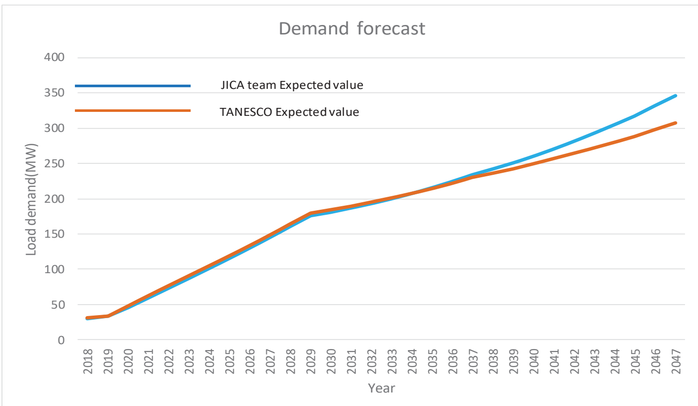
(MW)	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
JICA survey team	181	186.9	193.4	200.3	207.8	215.9	224.6	234	242.3	251.1	260.5	270.5
TANESCO 2018	184.1	189.4	195.1	201.2	207.7	214.7	222.2	230.2	236.3	242.7	249.5	256.5

(MW)	2042	2043	2044	2045	2046	2047
JICA survey team	281.1	292.5	304.5	317.3	330.9	345.4
TANESCO 2018	264	271.8	280	288.6	297.6	307.1

Necessity capacity in 2047

JICA: 432MVA

TANESCO: 384MVA



4.Power System Planning

Basic planning policy

- ✓ High reliability electricity supply to Government city (Ihumwa S/S)
- ✓ High quality electricity supply (maintain voltage level, low interruption rate, etc.)
- ✓ Backup configuration
- ✓ Long Project Life (approximately 30years)
- ✓ Appropriate specification of facilities (capacity, voltage level, etc.)
- ✓ Cost Effectiveness
- ✓ Low loss

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4.Power System Planning

Purpose of New substations

Power supply for

Ihumwa S/S	◆ Government city ◆ Other specific load in government city
Zuzu S/S	◆ New industrial zone (western area) ◆ Dodoma central area
Msalato S/S	◆ New airport and EPZ ◆ Dodoma north area
Kikombo S/S	◆ Dodoma east & south area

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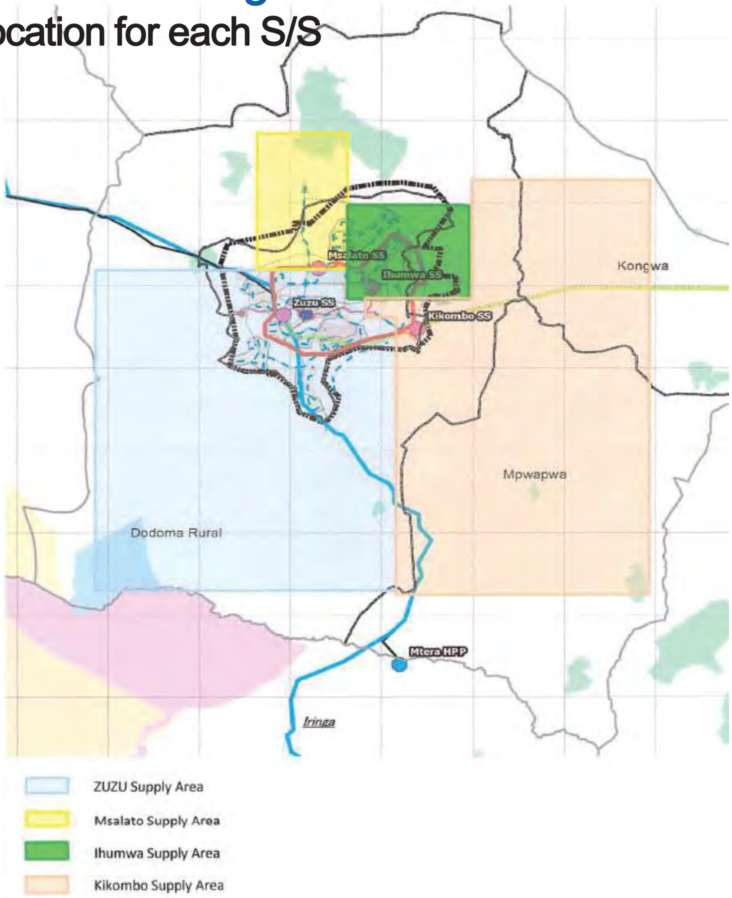
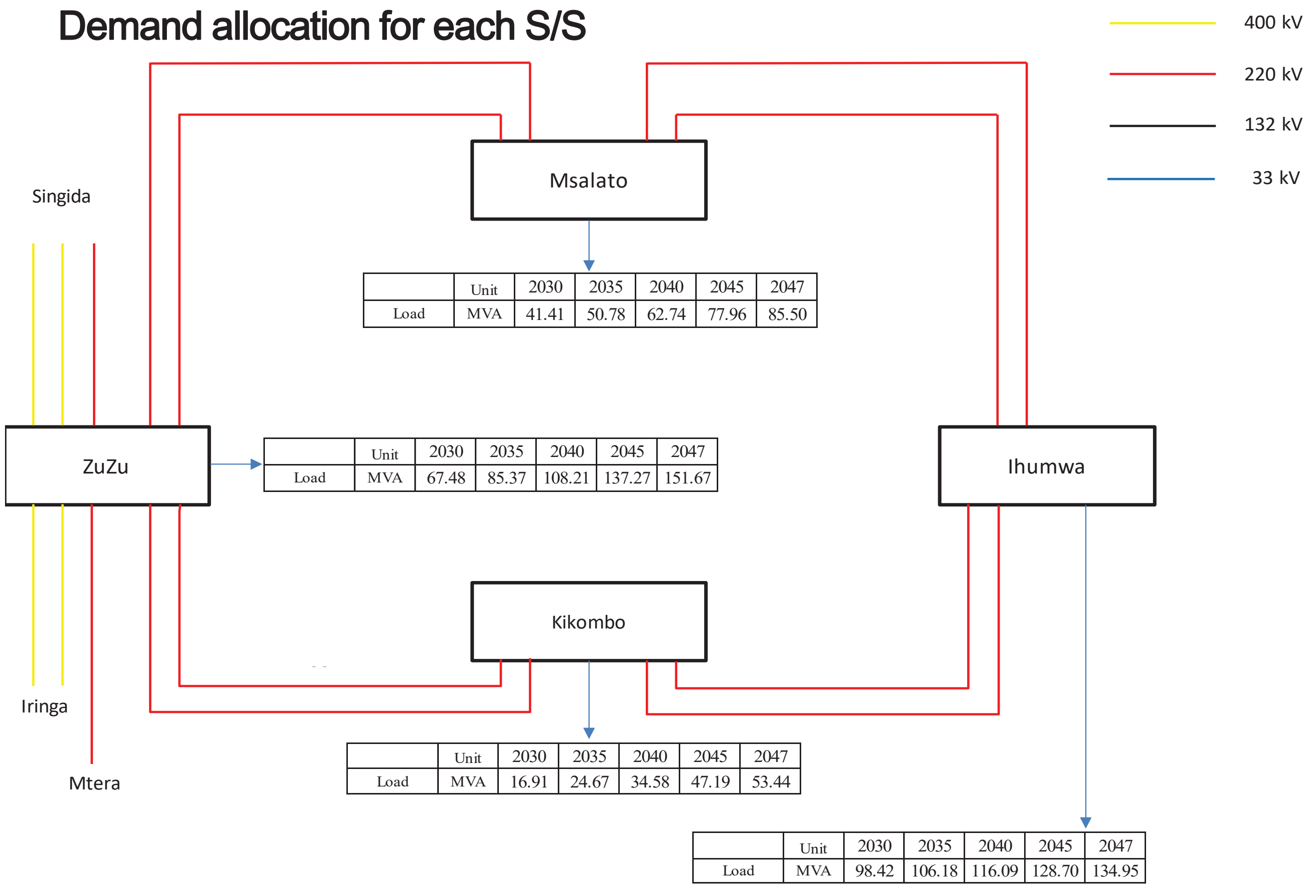
4.Power System Planning

Demand allocation for each S/S



4.Power System Planning

Demand allocation for each S/S



Msalato:

	Unit	2030	2035	2040	2045	2047
Load	MVA	41.41	50.78	62.74	77.96	85.50

ZuZu:

	Unit	2030	2035	2040	2045	2047
Load	MVA	67.48	85.37	108.21	137.27	151.67

Kikombo:

	Unit	2030	2035	2040	2045	2047
Load	MVA	16.91	24.67	34.58	47.19	53.44

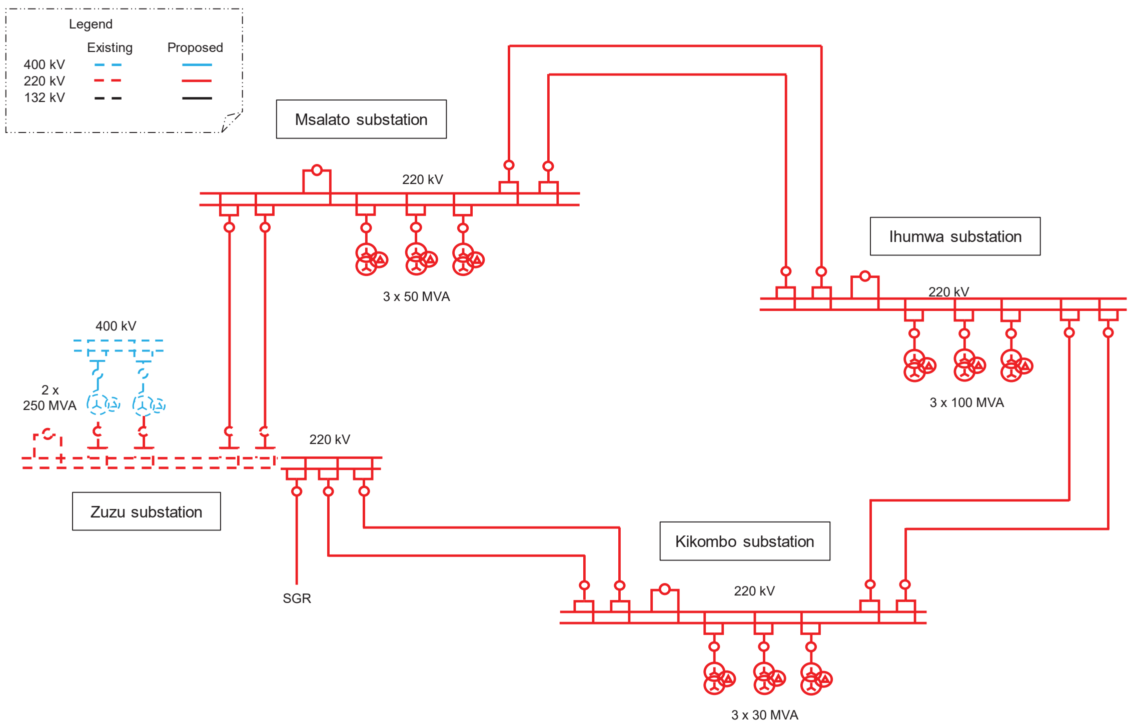
Ihumwa:

	Unit	2030	2035	2040	2045	2047
Load	MVA	98.42	106.18	116.09	128.70	134.95

4.Power System Planning

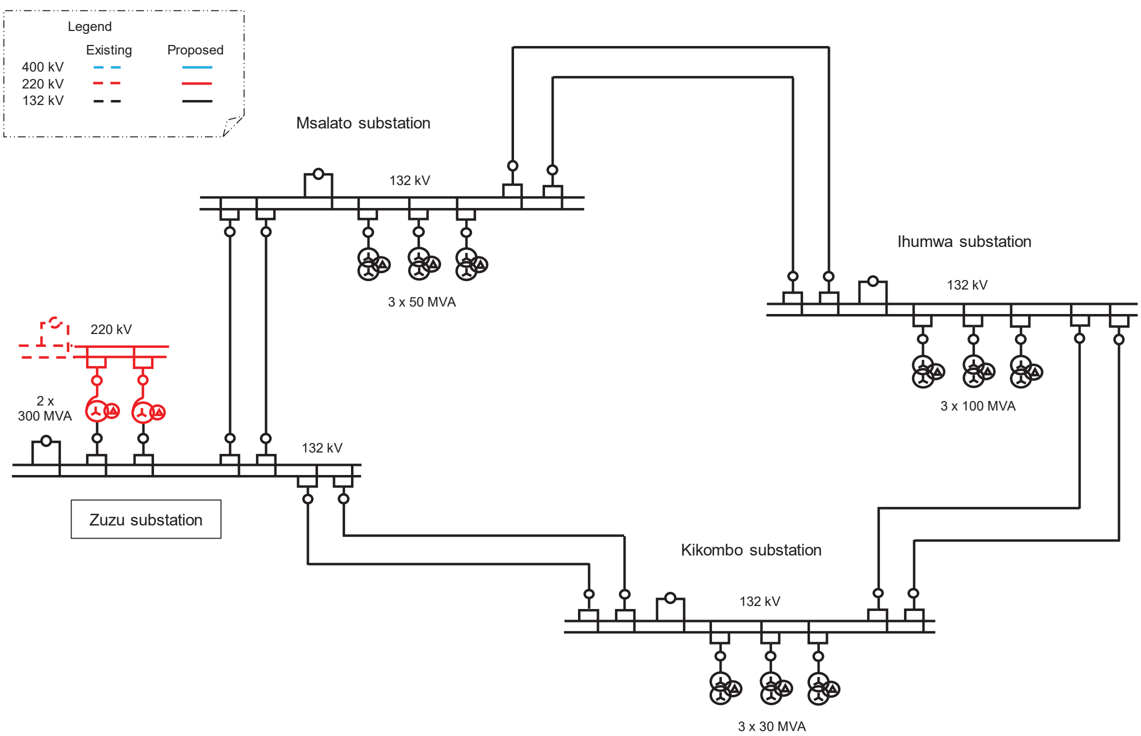
Voltage level comparison at base case(220kV & 132kV)

Simple Single Line Diagram with 220kV



4.Power System Planning

Voltage level comparison at base case(220kV & 132kV)
Simple Single Line Diagram with 132kV



4.Power system planning

Voltage level comparison at base case(220kV & 132kV)

Result of comparison

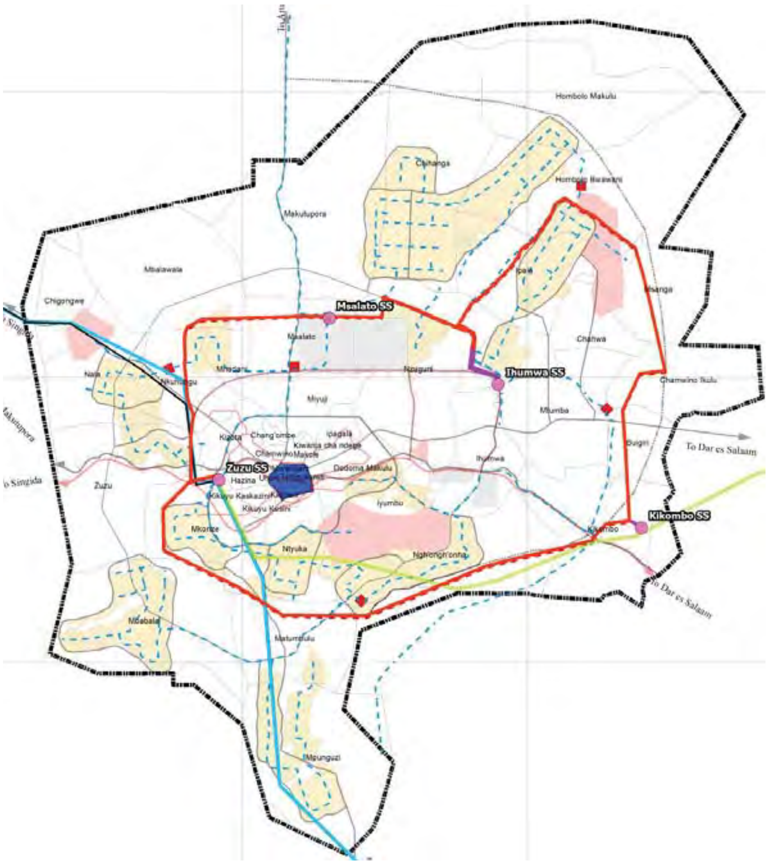
Items	220kV		132kV	
T/L conductor	Single Blue jay		Twin Hawk	
Substation	Ihumwa	220 kV/33 kV	Ihumwa	132 kV/33 kV
	Msalato	220 kV/33 kV	Msalato	132 kV/33 kV
	kikombo	220 kV/33 kV	kikombo	132 kV/33 kV
	Zuzu	-	Zuzu	220 kV/132kV 300 MVA x 2 Additional 132kV Switch yard
Cost	Equivalent (because of additional transformers and 132kV switchyard in Zuzu S/S)			
System loss	1 (base)		apprx. 5	
Result	○		Δ	

5. Transmission Planning

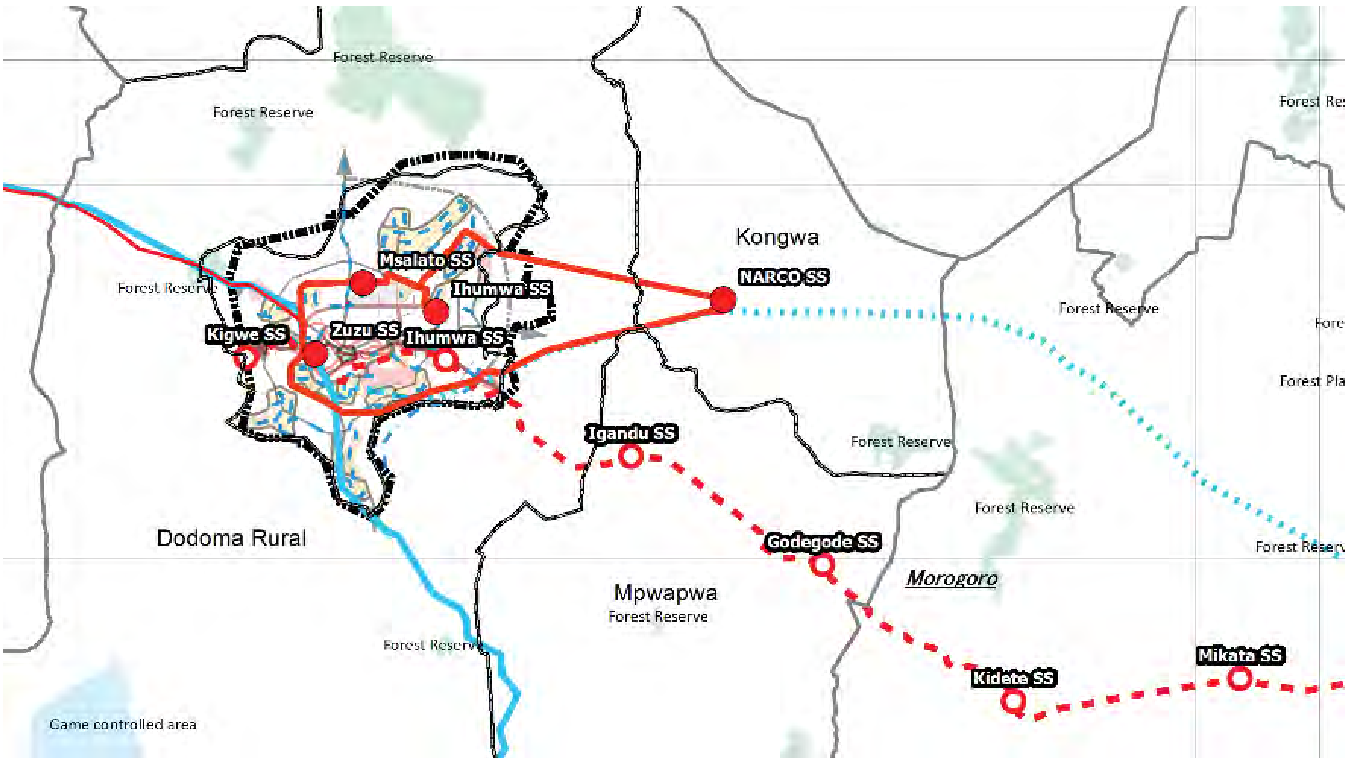
A) Proposed Ring transmission lines

Base case	･Zuzu →Msalato→Ihumwa→Kikombo→Zuzu (165km)
Option 1	･Zuzu →Msalato→Ihumwa→Narco→Zuzu(235km)
Option 2	･Zuzu →Msalato→Ihumwa→Narco→Chitope →Zuzu(355km) *Including existing transmission line from Chitope to Zuzu(110km)
Option 3	･Zuzu→Haneti→Msalato→Ihumwa→Narco →Zuzu(390km)
Option 4	･Zuzu →Msalato→Ihumwa→Narco→MteraHPP →Zuzu(390km) *Including existing transmission line from Mtera HPP to Zuzu(130km)
Option 5	･Zuzu →Msalato→Ihumwa→Kikombo→Zuzu (165km) ･Kikombo→Narco(50km)

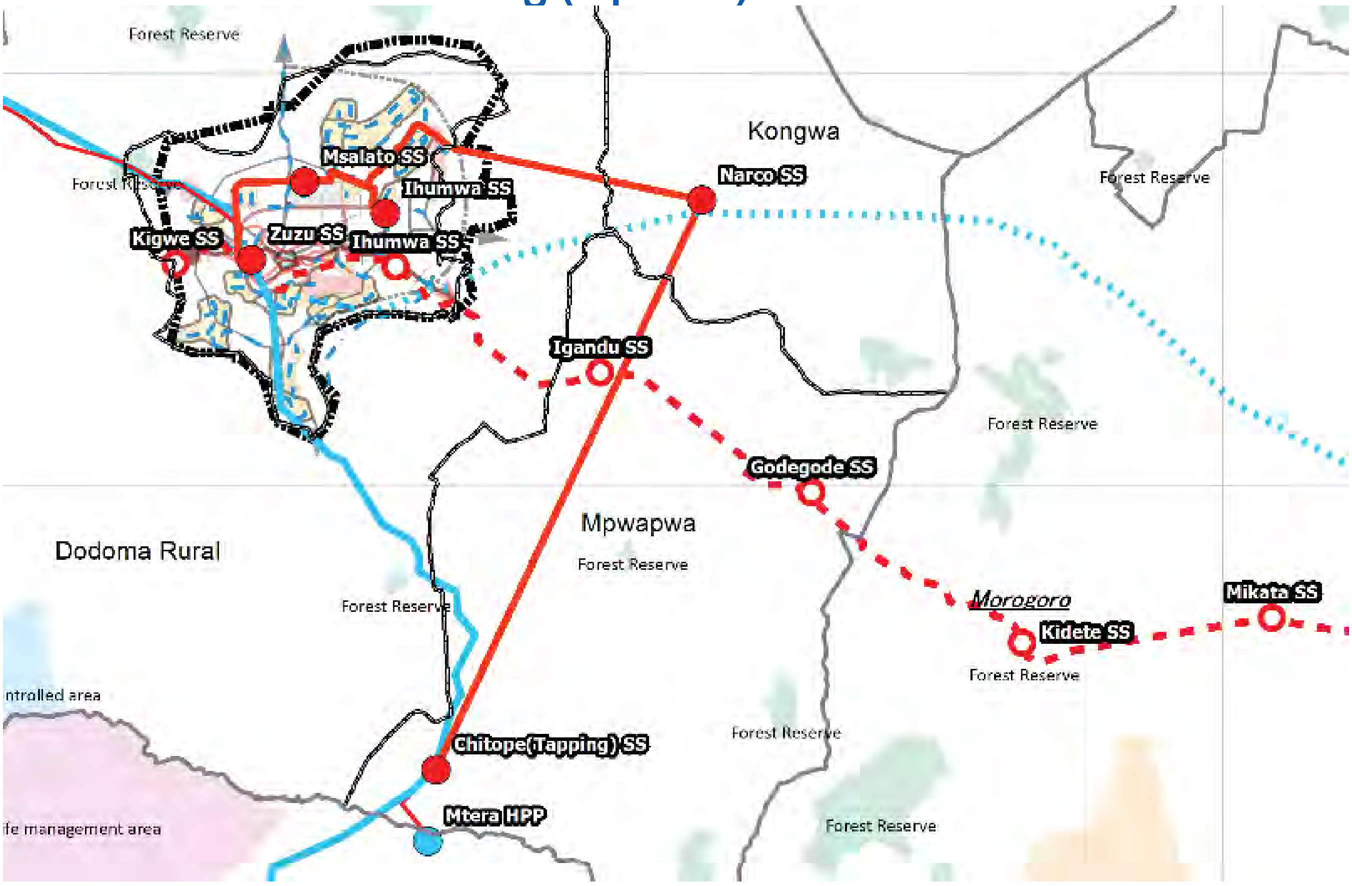
5.Transmission Planning (Base Case)



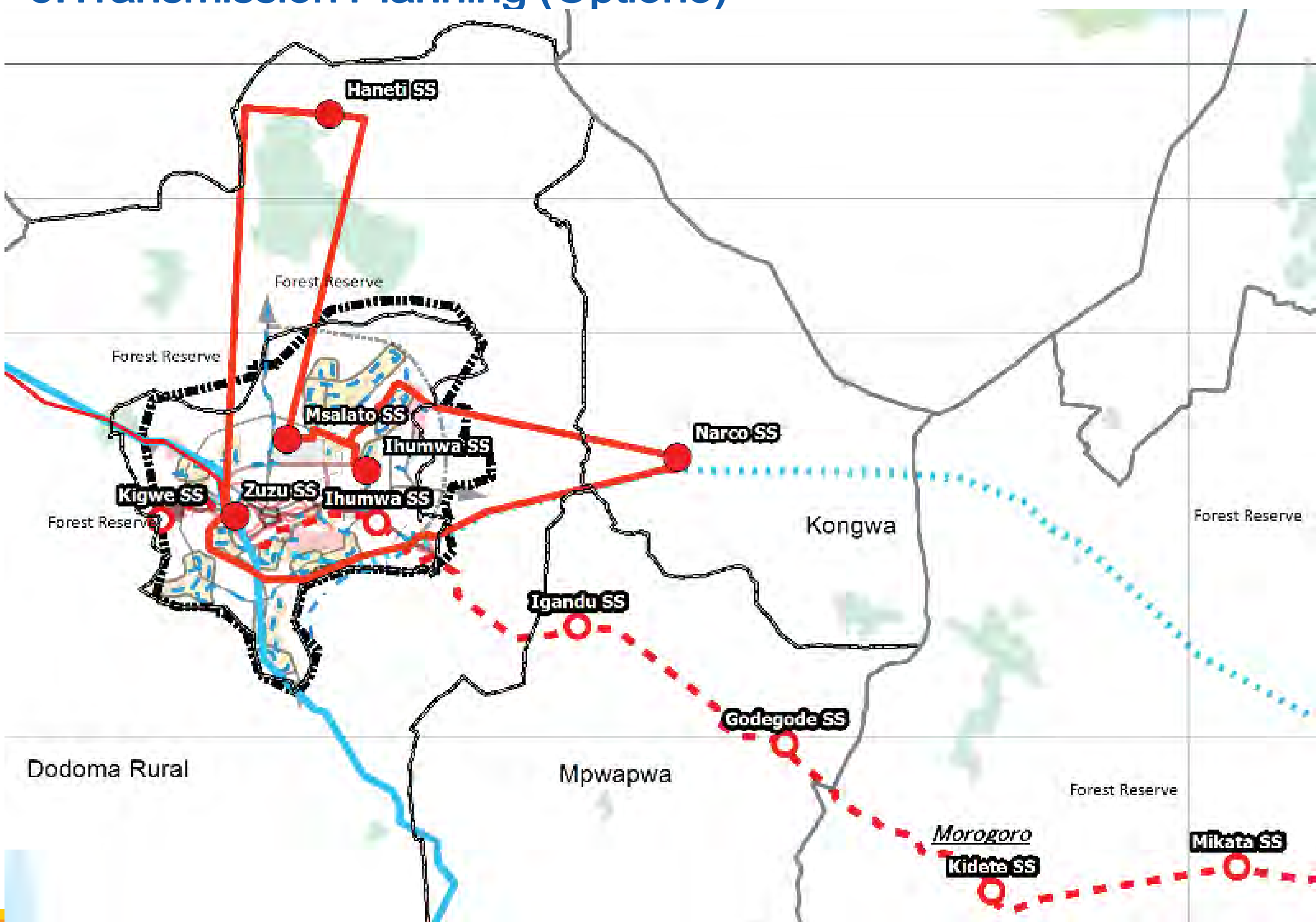
5.Transmission Planning (Option1)



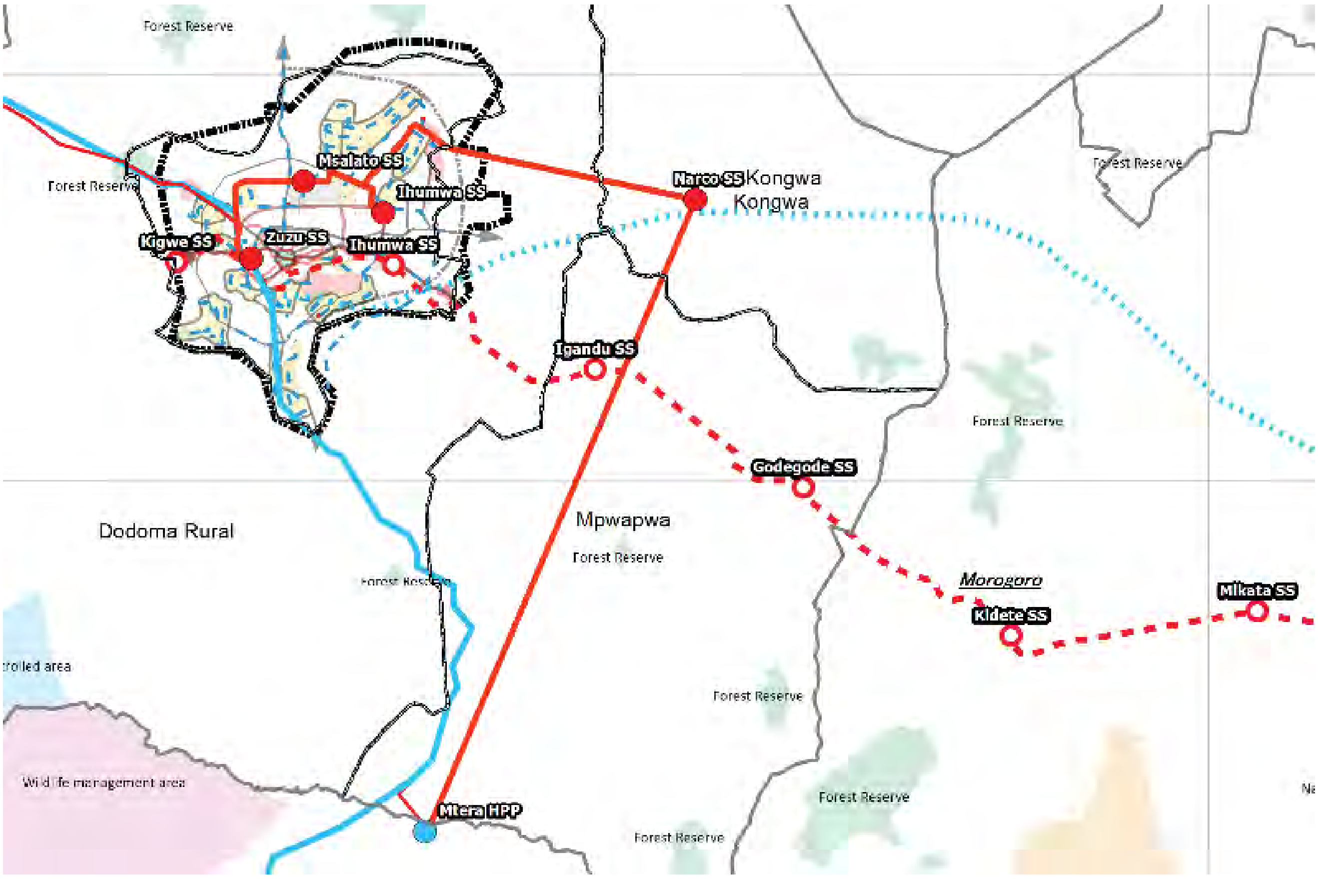
5.Transmission Planning (Option2)



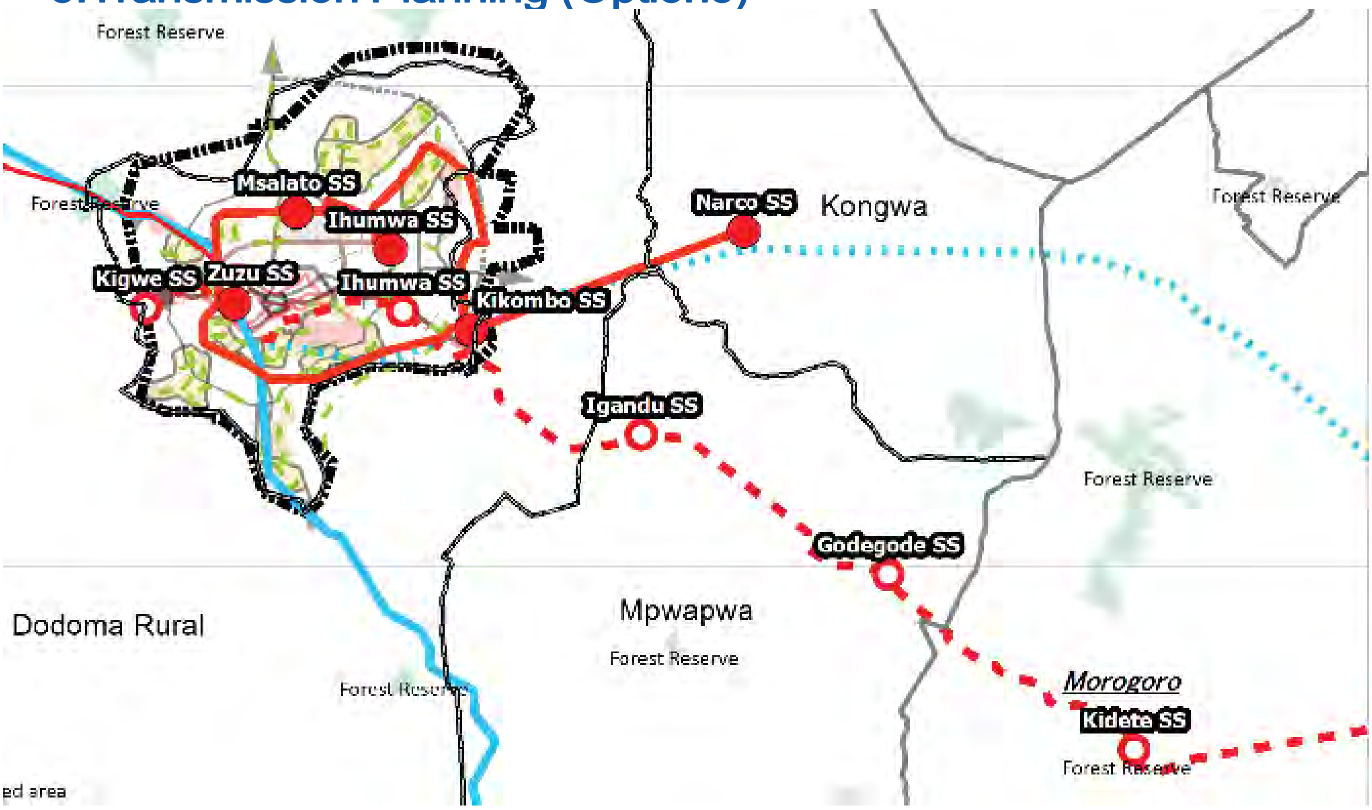
5.Transmission Planning (Option3)



5.Transmission Planning (Option4)



5.Transmission Planning (Option5)



5. Transmission Planning

B) Result of comparison

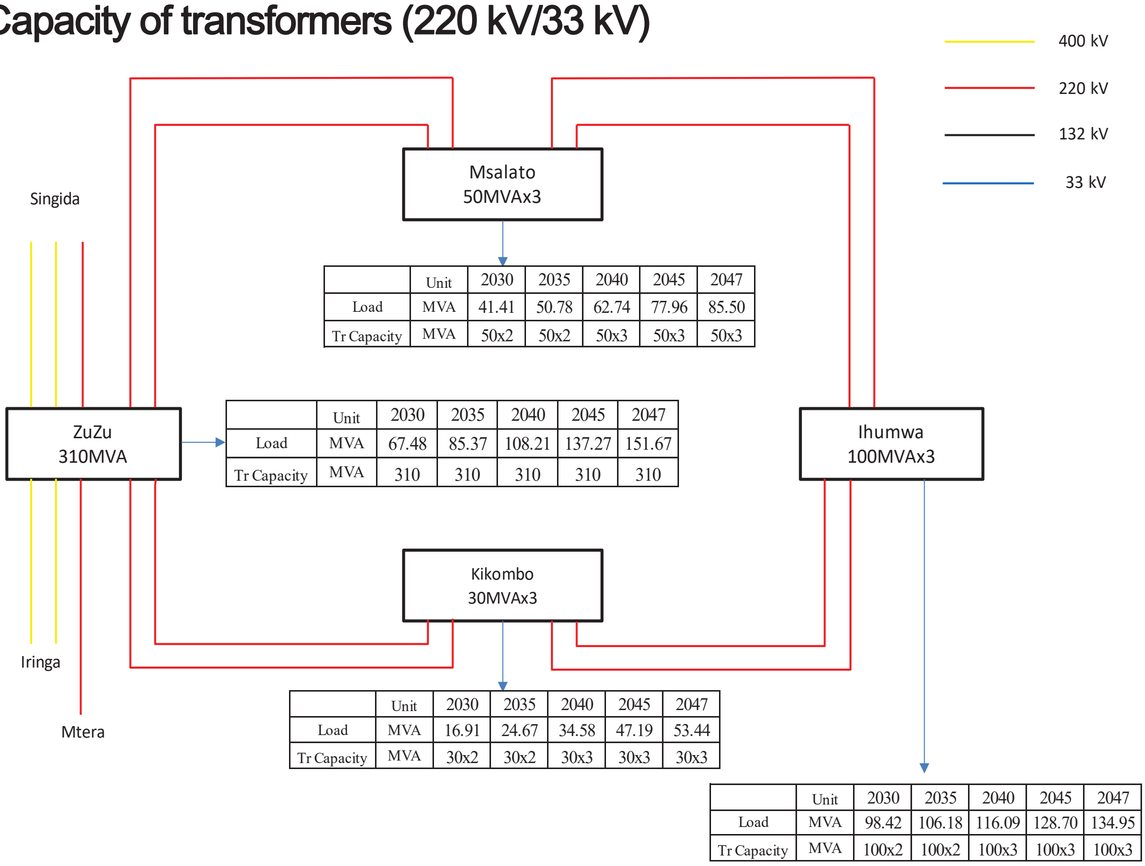
	Base case	Option 1	Option 2	Option 3	Option 4	Option 5
Line length (New construction)	165km (165km)	235km (235km)	355km (245km)	390km (390km)	390km (260km)	215km (215km)
Rough Cost	◎ Base	○ Base x 1.4	○ Base x 1.5	△ Base x 2.3	○ Base x 1.6	◎ Base x 1.2
Grid Reliability*1	◎	○	△	△	△	◎
Social Impact*2	○	○	◎	○	◎	○
Note	–	–	Tapping is very difficult (Existing tower is Cat head type)	–	–	220kV Ring T/L 165km ※Same as Base case 220kV T/L (Kikombo to Narco) 50km
Result	◎	○	△	△	△	◎

*1 Evaluated by the total length of Ring transmission line

*2 Evaluated by length of transmission line that pass through near the residential area

6. Substation Planning

Capacity of transformers (220 kV/33 kV)



Msalato:

	Unit	2030	2035	2040	2045	2047
Load	MVA	41.41	50.78	62.74	77.96	85.50
Tr Capacity	MVA	50x2	50x2	50x3	50x3	50x3

ZuZu:

	Unit	2030	2035	2040	2045	2047
Load	MVA	67.48	85.37	108.21	137.27	151.67
Tr Capacity	MVA	310	310	310	310	310

Kikombo:

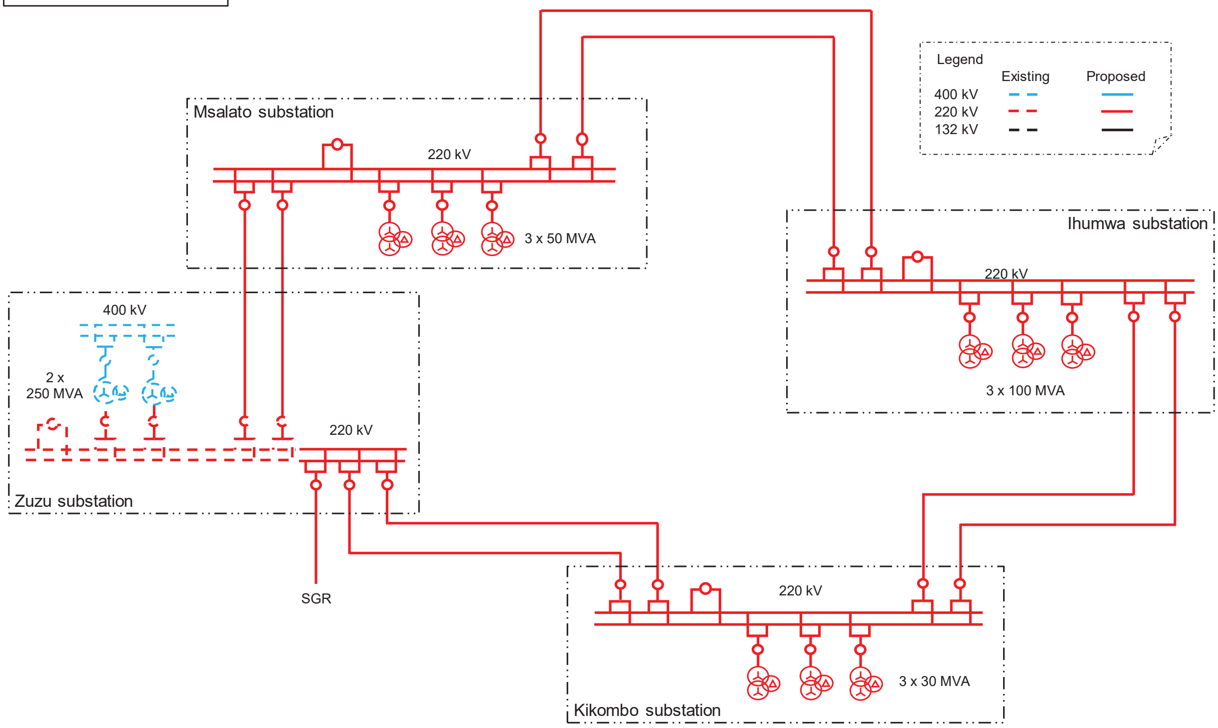
	Unit	2030	2035	2040	2045	2047
Load	MVA	16.91	24.67	34.58	47.19	53.44
Tr Capacity	MVA	30x2	30x2	30x3	30x3	30x3

Ihumwa:

	Unit	2030	2035	2040	2045	2047
Load	MVA	98.42	106.18	116.09	128.70	134.95
Tr Capacity	MVA	100x2	100x2	100x3	100x3	100x3

6. Substation Planning

Base case



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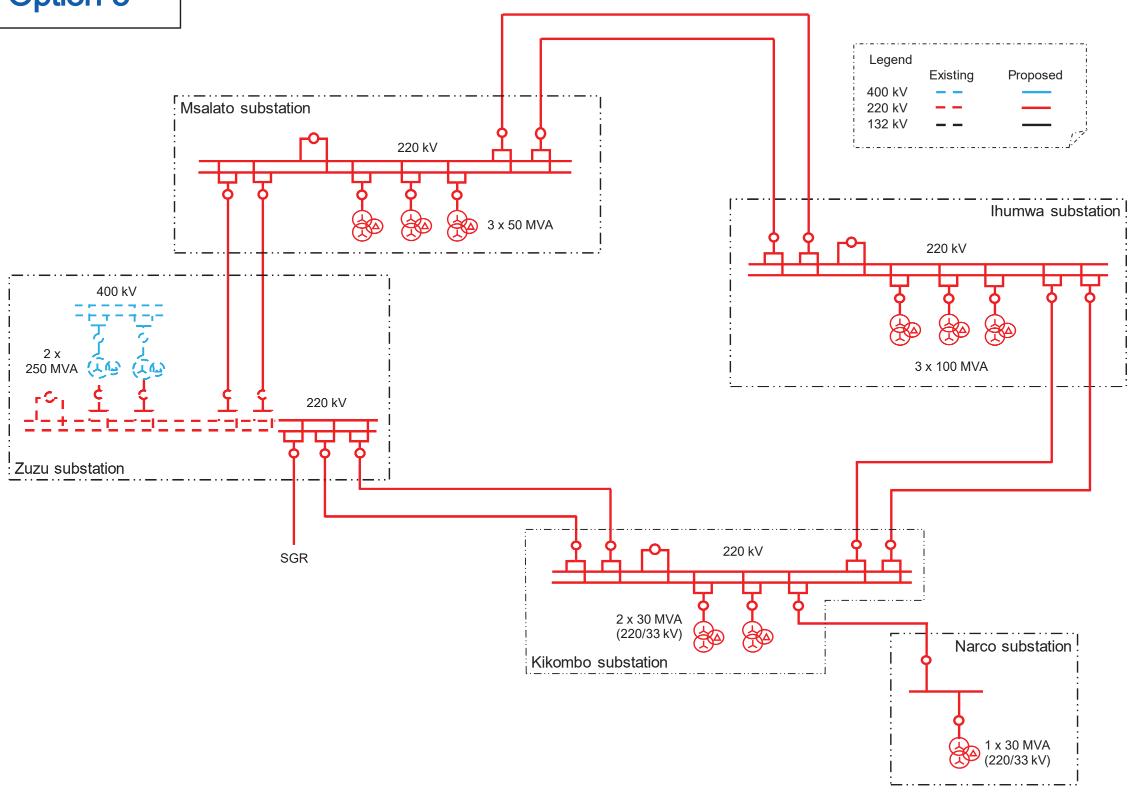
6. Substation Planning

Option-5



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7. Distribution Planning

◆ Existing Power Supply

- Power supply for Dodoma region (Customer-base)

- Approx. 85.5% from Zuzu
- Approx. 13.1% from Kondoa
- Approx. 1.5% from Others (Iringa, Morogoro, Tanga)

7. Distribution Planning ◆ Existing Distribution Line

DISTRIBUTION NETWORK INFORMATION - Supplied from Zuzu substation

220KV S/S	33/11KV SUB STATION NAME AND CAPACITY	NAMES OF 11KV AND 33KV FEEDERS	NUMBER OF TRANSFORMERS	LENGTH OF 11 KV AND 33KV LINE (KM)	LENGTH OF LV LINE (KM)	NUMBER OF CUSTOMERS	REMARKS/AREA OF FEEDER SUPPLY
ZUZU		MPWAPWA	363	1,389	726	30,855	CHAMWINO, KONGWA, MPWAPWA&GAIRO
		CHAMWINO	73	87	146	6,205	CHAMWINO
		MZAKWE	1	33	1	1	MZAKWE WATER PUMP
		MNADANI	-	15	-	-	MNADANI SUBSTATION
		TOWN	-	7.2	-	-	DODOMA MUNICIPAL
		BAHI	33	61	66	2,805	BAHI DISTRICT
		INTERCONNECTOR	-	1	-	-	POWER STATION
		MPWAPWA-TOWN	17	26	34	1,445	MPWAPWA DISTRICT COUNCIL
	TOWN (10MVA)	INDUSTRIAL	36	32	72	3,060	ILAZO, MAKOLE, IPAGALA
		TOWN NORTH	32	34	64	2,720	MAJENGO, AIRPORT, JAMHURI, MJI MPYA
		TOWN SOUTH	22	17	44	1,870	UZUNGUNI, GENERAL HOSPITAL
	POWER STATION (5MVA)	ZUZU SOUTH	28	16	56	2,380	UZUNGUNI, KIKUYU
		BRICK/BUSH	38	142	76	3,230	MVUMI, MPUNGUZI, BIHAWANA
		ZUZU NORTH	59	21	118	5,015	NDACHI, NKUHUNGU, AREA A
	MNADANI (15MVA)	MNADANI-TOWN	43	28	86	3,655	AREA C, AREA D, AREA E, MAILI MBILI
		MNADANI-VEYULA	27	33	54	2,295	MAKUTOPOLA, VEYULA, MSALATO
	MZAKWE	MAMBA YA MBALI	10	12	20	850	MAMBA YA MBALI
		BOOSTER PUMP	2	0	4	170	MZAKWE BOOSTER PUMP
		KILUNGULE&MUNDEMU	11	15	22	935	KILUNGULE, MUNDEMU

Source: Received from TANESCO in October, 2019

DISTRIBUTION NETWORK INFORMATION - Supplied from outside fo Dodoma region

Source Region/District	Source Substation	NAMES OF FEEDERS	NUMBER OF TRANSFORMERS	LENGTH OF HT LINE (KM)	LENGTH OF LV LINE (KM)	NUMBER OF CUSTOMERS	REMARKS/AREA OF FEEDER SUPPLY
IRINGA	TAGAMENDA	KILOLO	14	82	84	1,063	MPWAPWA
TANGA	KILOLE	HANDENI	2	33	12	165	KITETO KIJUNGU
MOROGORO	MSAMVU	BEREGE	4	12	24	126	GAIRO IYOGWE, MAKUYU
Kondoa	Bicha	KIBAYA	87	320	174	7,395	KONDOA AND KITETO
		PAHI	33	230	66	2,805	PAHI, KOLO, MNENIA
		KONDOA	23	58	46	1,955	KONDOA DISTRICT COUNCIL

Source: Received from TANESCO in October, 2019

7. Distribution Planning

◆ Existing Network

- Network Configuration
  - Radial network
  - 33kV, 11kV O/H
- Primary Substation
  - Zuzu substation
- Secondary Substation
  - Town substation
  - Mnandani substation
  - Mzakwe substation

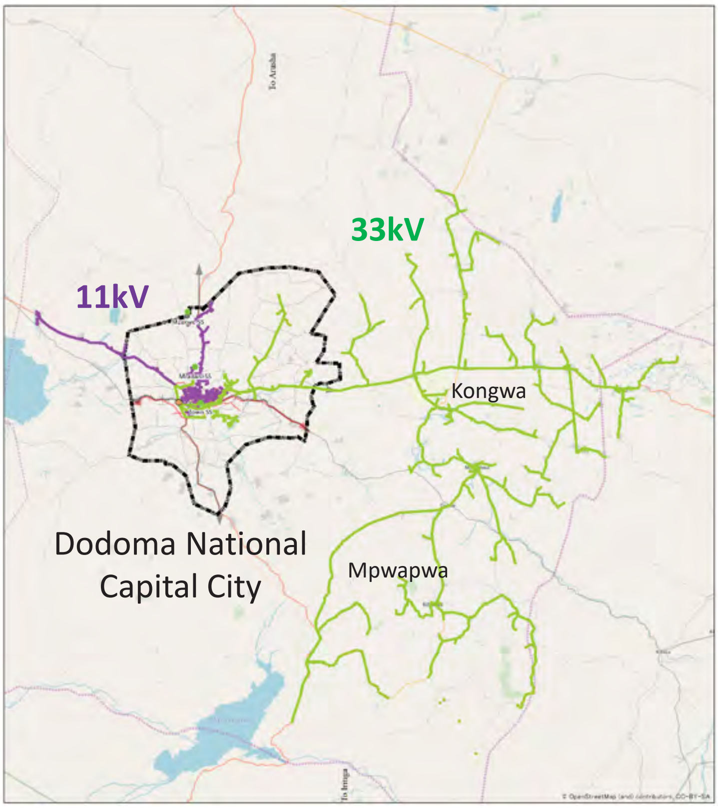


Figure: Power Supply From Zuzu substation

7. Distribution Planning

◆ What is happening on the existing network?

(To be analyzed)

- Technical Loss
- Non-technical Loss

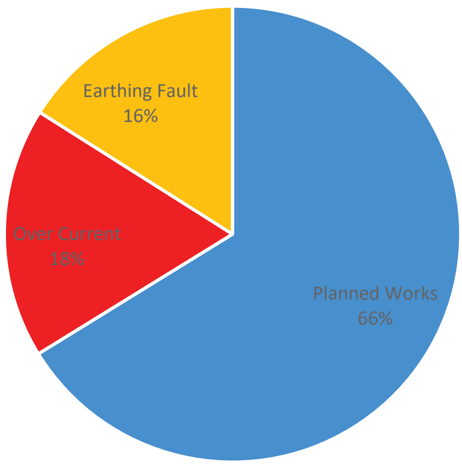


Figure: Lost Revenue Due to Feeder Outage

Source: Received from TANESCO in October, 2019

◆ Countermeasures by TANESCO

- Replacement, Upgrading, Extension, Expansion

7. Distribution Planning

◆ What is on-going, planning?

- Distribution Control Center (DCC)
- Rural Electrification for 21 villages in Dodoma region (REA III Round II)
- Improvement of Town substation with 2 x 15MVA-33/11kV transformers
- Improvement of Mzakwe substation with additional of 1 x 10MVA-33/11kV transformer
- Improvement of Mnadani substation with additional of 1 x 15MVA-33/11kV transformer
- Distribution Master Plan

\- Load forecast study for short term (5years), medium term (10years) and long term (25 years), etc.

8.Tentative Schedule

2019				2020		
9	10	11	12	1	2	3

- ■ Analysis in Japan (→ 10–11)
- ■ Draft Final Report (→ 12)
- ■ Final Report (→ 1–2)

Thank you for your attention

DATA COLLECTION SURVEY ON DODOMA TRANSMISSION AND DISTRIBUTION SYSTEM IN THE UNITED REPUBLIC OF TANZANIA

Applicable quality infrastructure for Dodoma Capital City District

OCTOBER 10TH, 2019
JICA STUDY TEAM

Contents

1. Background : What is Quality Infrastructure?
2. LATEST Technologies for Transmission and Distribution network.

Distribution Facility	(a) Low-loss distribution transformer
Transmission facilities	(b) Low-loss conductor
	(c) External gapped transmission line arresters
Substation facilities	(d) Low-loss transformer
	(e) Special 3 phase transformer
	(f) Low SF6 gas leakage rate
	(g) Gas insulated transformer
	(h) High seismic resistance of substation equipment
	(i) Special protection system
	(j) Spring operation mechanism for GCB
	(k) Compact type GIS

3. Effects of Applying Latest Technologies

1

1. Background – (1)

- In order to ensure the quality and reliability of electric power, a transmission and distribution network expansion plan in DODOMA urban area is being investigated by TANESCO.

What is Quality Infrastructure ?

1. Background – (2)

- A transmission and distribution network ensures that the quality and reliability is considered as Quality Infrastructure which has following features.

  - ✓ High quality
  - ✓ High reliability
  - ✓ Cost reduction
  - ✓ Reduced environmental impact
  - ✓ Improved maintenance and inspection
  - ✓ Etc.

1. Background – (3)

- We would like to introduce latest technologies.
- We would like to know;

  What are you interested in?

  What do you focus on?

  What are your challenges?

Proposed Electrical Network for Dodoma Urban

3. Outline of LATEST Technology

(a) Low-loss distribution transformer → Cost reduction

- Lowers hysteresis losses
- Have very thin laminations → Eddy current losses reduce as compared to Iron.

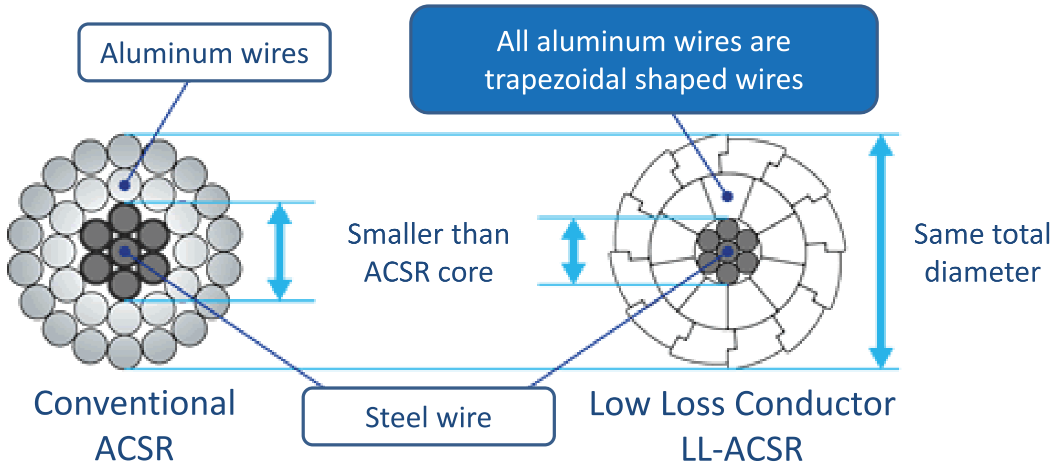
Source: Based on manufacture catalog

Amorphous Metal Distribution Transformers

3. Outline of LATEST Technology

(b) Low-loss conductor → Cost reduction

- Low-loss conductor has improved aluminum occupancy by adopting trapezoidal aluminum conductors.
- As a result, transmission loss can be reduced by approximately 20%.



Source: Based on manufacture catalog

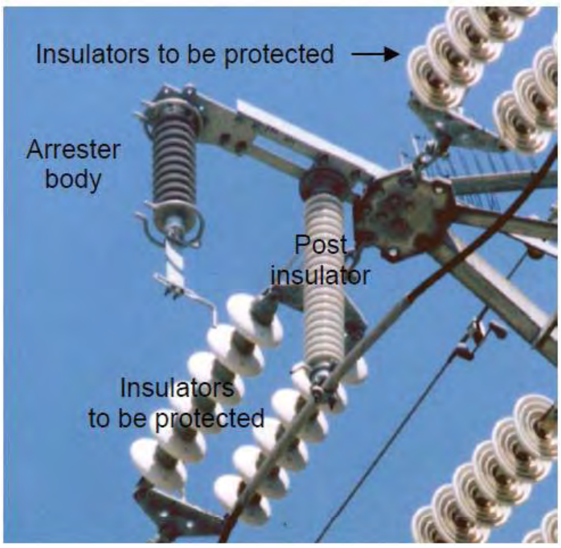
Low Loss Conductor LL-ACSR

3. Outline of LATEST Technology

(c) External gapped transmission line arresters(EGLA)

→ High quality | High reliability

- When a lightning strikes transmission tower or power line conductor, transient overvoltage will be induced across the insulator.



Source: Based on Technical paper

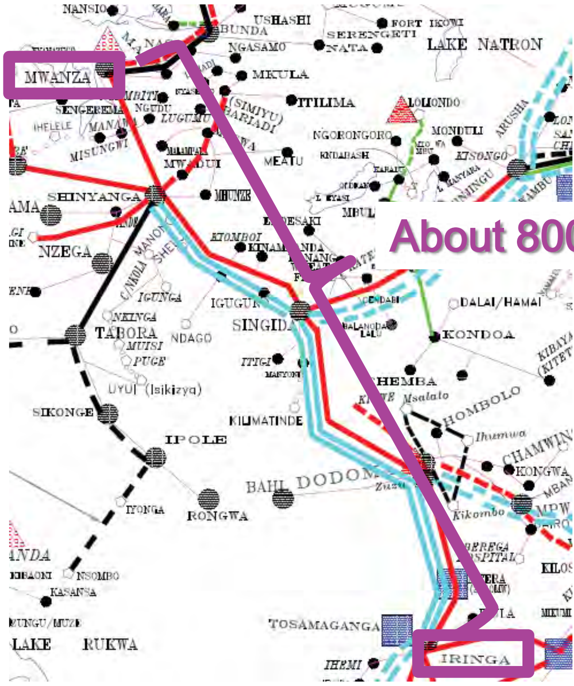
EGLA for 77 kV System

- EGLA, consisting of arrester body and series air gap, is installed in parallel with the insulator to be protected.
- EGLA can **prevent instantaneous voltage drop and power outages due to permanent ground faults.**

3. Outline of LATEST Technology

(c) External gapped transmission line arresters(EGLA)

→ High quality | High reliability



- There are no arc horn for about 800 km from IRINGA to MWANZA on transmission tower.
- In order to increase system reliability, additional installation of arc horns and EGLA are recommended.

3. Outline of LATEST Technology

(d) Low-loss transformer → Cost reduction

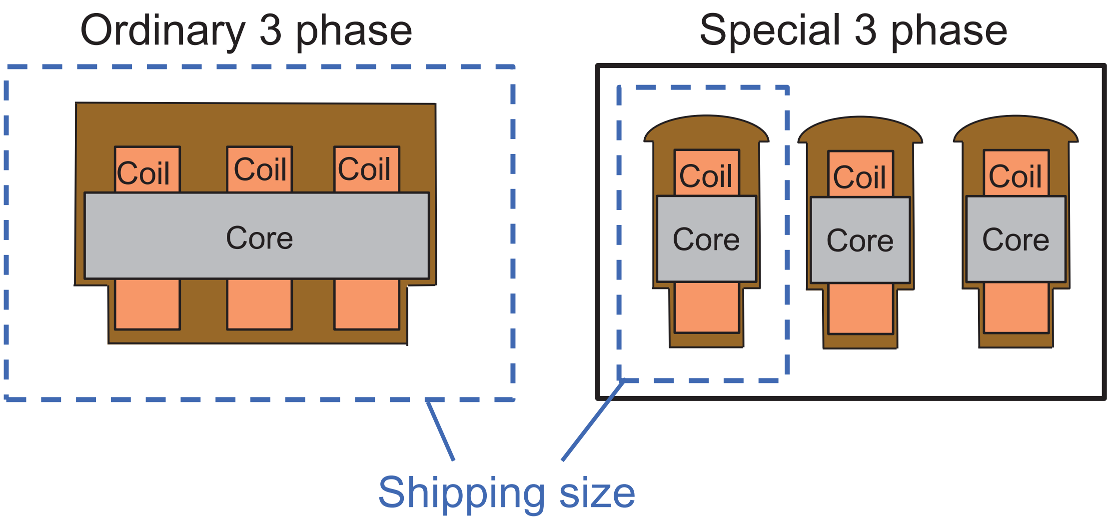
- Low-loss transformer with low-loss silicon steel sheet as the core material

Source: Based on manufacture catalog

765kV Class Power Transformer

3. Outline of LATEST Technology

(e) Special 3 phase transformer → Reduced environmental impact



- **Special 3 phase transformer can be applied to areas where transportation weight is limited and transportation methods are specified.**

3. Outline of LATEST Technology

(f) Low SF_6 gas leakage rate → Reduced environmental impact

- It is important to reduce gas leakage rate.
  To consider environment protection
  To secure high quality and reliability for long term usage

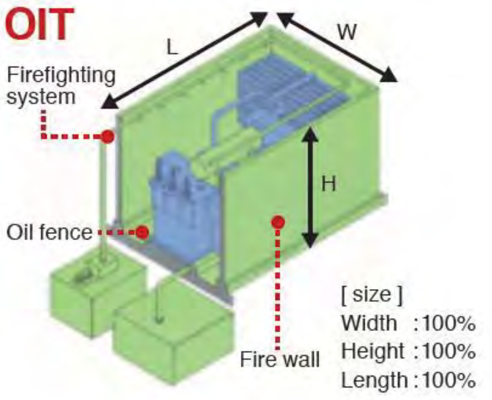
	Factory Test	Site Test
Latest Technology	< 0.1 % / year	< 0.1 % / year
IEC Standard	< 0.5 % / year	< 0.5 % / year

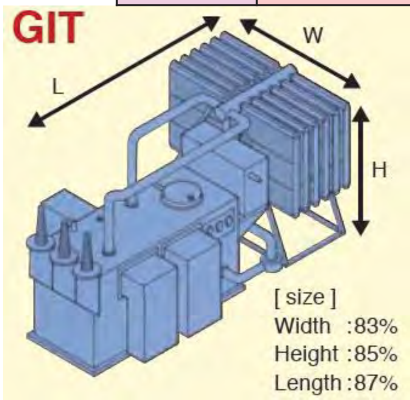
- Due to the low gas leakage rate, the deterioration rust of the flange can be suppressed, therefore substation facilities can be used for a long time.

3. Outline of LATEST Technology

(g) Gas insulated transformer(GIT) →

High reliability	Cost reduction	Improved maintenance and inspection





Source: Based on manufacture website

Comparison of Oil-immersed Transformers(OIT) and GIT

- Features GIT as follows;
  - ✓ **Non-Flammable, Non-Explosive**
  - ✓ **No fire-fighting system requirement**
  - ✓ **Flexible arrangement**
  - ✓ **Easy maintenance**
  - ✓ **Reduction of installation period**

3. Outline of LATEST Technology

(g) Gas insulated transformer(GIT) →

High reliability	Cost reduction	Improved maintenance and inspection

110kV-50MVA GIT
(Low pressure type)

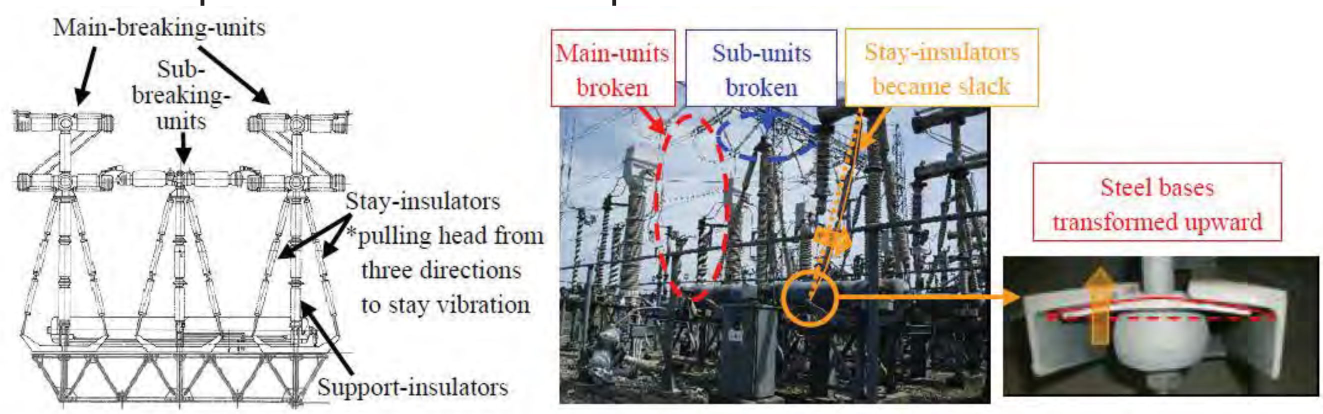
Source: Based on Technical papers

275kV-300MVA GIT
(High pressure type)

3. Outline of LATEST Technology

(h) High seismic resistance of substation equipment
→ High reliability

- To apply substation equipment with High seismic resistance in order to improve the reliability of infrastructure.
- Substation equipment that reflects the experience of many earthquakes should be adopted.



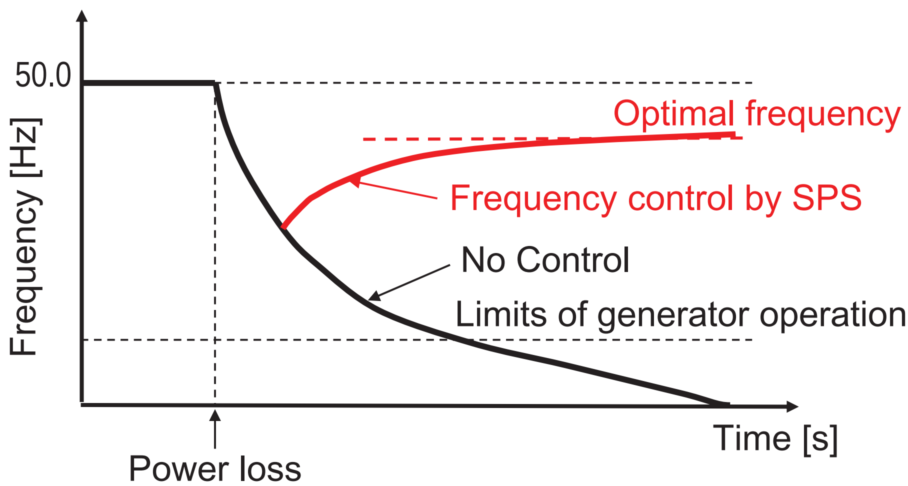
Source: Based on Technical papers

Damages of 275 kV air circuit-breaker
by the Great East Japan Earthquake

3. Outline of LATEST Technology

(i) Special protection system (SPS) → High reliability

To monitor the condition of the power system in real time
To prevents power outages when an accident occurs
To minimizes the effect of accident.



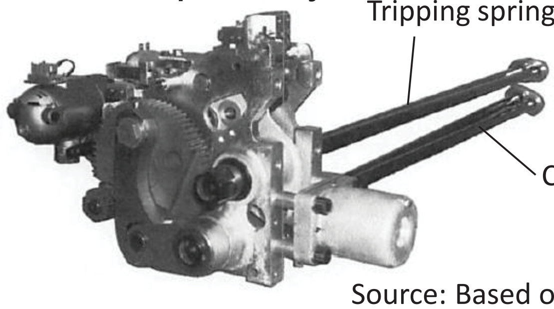
Conceptual diagram of Special Protection System

3. Outline of LATEST Technology

(j) Spring operation mechanism for Gas circuit breaker

→ High quality | High reliability

- **Maintenance free**
  - ✓ Less electrical / mechanical parts
    →less chance of failure
- **High efficiency**
  - ✓ Stable operating characteristic
    → Negligible degradation of spring characteristics
  - ✓ Efficient energy consumption by torsion bar spring



Source: Based on Technical Paper

300kV Torsion bar Spring Mechanism

3. Outline of LATEST Technology

(k) Compact GIS → High reliability | Cost reduction

- The advantages of using Compact GIS are as follows:
  - ✓ **Reduction of installation area**
  - ✓ **Realization of Bay transportation including Local Control Panel(LCP)**
    →High quality by omitting LCP and Bay connection work on-site
    →Reduction the installation period

145 kV GIS
for City Center Substation
in Dar es Salaam

330 kV GIS

3. Effects of Applying LATEST Technology (Summarize)

		High quality	High reliability	Cost reduction	Reduced environmental impact	Improved maintenance and inspection
Distribution Facility	(a) Low-loss distribution transformer			○		
Transmission facilities	(b) Low-loss conductor			○		
	(c) External gapped transmission Line arresters	○	○			
Substation facilities	(d) Low-loss transformer			○		
	(e) Special 3 phase transformer				○	
	(f) Low SF6 gas leakage rate				○	
	(g) Gas insulated transformer		○	○		○
	(h) High seismic resistance of substation equipment		○			
	(i) Special protection system		○			
	(j) Spring operation mechanism for Gas circuit breaker (GCB)	○	○			○
	(k) Compact type GIS		○	○		

Thank you for your kind attention

SECOND TECHNICAL MEMORANDUM
FOR
DATA COLLECTION SURVEY
ON
DODOMA TRANSMISSION AND DISTRIBUTION SYSTEM
IN THE UNITED REPUBLIC OF TANZANIA
AGREED BETWEEN
TANZANIA ELECTRIC SUPPLY COMPANY LIMITED (TANESCO)
AND
JICA STUDY TEAM

Dodoma, January 31st, 2020

阿部 真

Mr. Makoto Abe
Chief Consultant
JICA Study Team
Yachiyo Engineering Co., Ltd.

Dr. Tito E. Mwinuka
Managing Director
Tanzania Electric Supply Company Ltd. (TANESCO)

Ministry of Energy (hereinafter referred to as MoE), Tanzania Electric Supply Company Ltd. (hereinafter referred to as "TANESCO") and JICA Study Team for the Data Collection Survey on Dodoma Transmission and Distribution System in the United Republic of Tanzania (hereinafter referred to as "the Team") had series of technical discussions to form a mutual understandings of the findings from the Second Field Survey and the parties agreed to record the following points as a conclusion of the discussions.

1. Main objectives of the Survey

The team explained that the main objectives of the Survey are as follows:

(1) To confirm progress and details of the Dodoma Capital City Master Plan,

(2) To conduct a survey to investigate and analyze the current and future power demand, facilities, system and applicable quality infrastructure for Dodoma Capital City District, and

(3) To contribute to JICA's cooperation policy consideration for Dodoma Transmission and Distribution network expansion.

2. Scope of the Survey

The team explained that the scope of the Survey is as follows:

(1) Power Demand Forecast

1. Review the existing power demand forecast predicted by TANESCO and propose updated power demand forecast.
2. Allocate the updated power demand to proposed substations.

(2) Power System Planning

3. Review the existing power system and expansion plan.
4. Propose power system configuration for Dodoma Urban area with recommended voltage level.

(3) Transmission Planning

5. Review the existing transmission plan.
6. Propose transmission plan and alternatives (if any).

(4) Substation Planning

7. Review the existing substation plan.
8. Propose substation plan based on the discussion with TANESCO, result of power demand forecast for substations and power system plan.

(5) Distribution Planning

9. Review the existing distribution plan.
10. Propose distribution plan based on the discussion with TANESCO, result of power demand forecast for substations and power system plan.

3. Expected Output

The team explained that the expected output of the Survey is as follows:

Updated transmission and distribution development plan for Dodoma urban area proposed by the Team

4. Issues discussed and/or agreed among the parties during the Second Field Survey

< General >

4-1 The Team explained the above objectives, scope of the survey and expected output.

< Dodoma Capital City Master Plan >

4-2 TANESCO informed the Team that the Dodoma Capital City Master Plan has been officially approved by the Government of Tanzania in December, 2019.

4-3 The Team requested TANESCO to provide progress with % (percentage) of construction work of the development, which contains in the Draft Final Report by the Team, by 7th February, 2020. TANESCO responded that, it is difficulty to monitor construction work development (%). So it is advised the team to consider Approved Dodoma City Master Plan.

< Permission and Authorization >

4-4 The Team asked TANESCO if Permission or Authorization, other than obtaining land title, will be necessary to implement projects for the development of power system in Dodoma. TANESCO explained that, all projects follows Laws and Regulations of the Country including getting approval from relevant authorities

< Transmission Line Route >

4-5 The Team explained a proposed transmission line route with consideration of manageability of future maintenance, effective utilization of existing wayleave, etc.

4-6 The Team asked TANESCO whether shortening of the line route will be possible or not. TANESCO explained that in order to avoid interfering with the Statehouse, the original line route between Ihumwa substation and Kikombo substation must be rerouted. For that reason, TANESCO will negotiate with the Dodoma City Council for an alternative line route by short-cutting between Ihumwa substation and Kikombo substation as shown in the attached drawing. TANESCO will inform the Team with the result of negotiation with City Council by 14th February, 2020.

4-7 TANESCO basically agreed with the line route except route between Ihumwa substation and Kikombo substation in which is subjected to item 4-6 as attached in the drawing.

< Location of substations >

4-8 Alternative location of substations was proposed by the Team, however TANESCO explained that TANESCO has already started the land acquisition procedures with original locations for Msalato, Ihumwa and Kikombo substations.

4-9 TANESCO has identified that no involuntary resettlement to secure the land for the above three substations and some compensation for the farmland for Msalato and Kikombo substations will be made by TANESCO.

4-10 The Team requested TANESCO to provide with the Land Valuation report for the land demarcation. However, TANESCO explained that the Land Valuation is owned by the Government and unable to share the report.

4-11 Since the land acquisition process for original proposed substation locations is ongoing, TANESCO requested the Team to consider the original locations. The Team agreed to consider the original substation locations.

< Presentation on the "Draft Final Report" >

4-12 The Team explained outline of the Draft Final Report by a presentation on the "Draft Final Report" for TANESCO, Ministry of Energy and Ministry of Finance and Planning on 28th and 29th January, 2020 and exchange opinions.

4-13 The Team explained the details of Scenario Study with the evaluation of three Scenarios and recommend Tanzania side to consider Scenario-1 or 2. Main reasons to recommend Senario-1 or 2 are to prevent unusual annual operation and maintenance cost, to prevent over investment and to meet appropriate timing of the implementation for the power demand.

4-14 TANESCO and MoE recommend to go with the Scenario-3 with some modification in which the Design of power Structure should be Double Circuit two conductors per phase up to proposed NARCO Substation so as to accommodate the long term power system planning, to save time and effort by making One Project, to minimize total investment cost, and also consider other loads beyond Dodoma City. Initially the line should be strung on one side.

< Presentation on the "Applicable Quality Infrastructure" >

4-15 The Team had a presentation on the "Applicable quality infrastructure" for TANESCO, Ministry of Energy and Ministry of Finance and Planning on 28th and 29th January, 2020 and exchange opinions.

4-16 The Team introduced five latest technology which might be adapted to the power system in Dodoma for TANESCO's considerations.

4-17 The Team explained effectiveness of those five technology in terms of quality, reliability, cost impact and environmental impact. However, the Team added that every calculation made for the presentation is calculations with preconditions as a preliminary information for TANESCO's reference.

4-18 TANESCO intended that any technology to reduce power loss or power outages should be taken into account for considerations in Tanzania power system.

4-19 TANESCO basically agreed with the Team however TANESCO request, further analysis of those five technologies should be done before adapting in Dodoma Power System

< Draft Final Report >

4-20 The Team submitted the softcopy and hard copy of the Draft Final Report to TANESCO and MoE. TANESCO shall review the Draft Final Report and provide comments to the Team <u>by 12th February, 2020</u>, if any.

5. Tentative Schedule

5-1 Finalizing the Draft Final Report in Japan: February, 2020

5-2 Submission of Final Report to JICA Headquarters: March, 2020

5-3 Submission of Final Report to TANESCO: End of March, 2020

Attachment

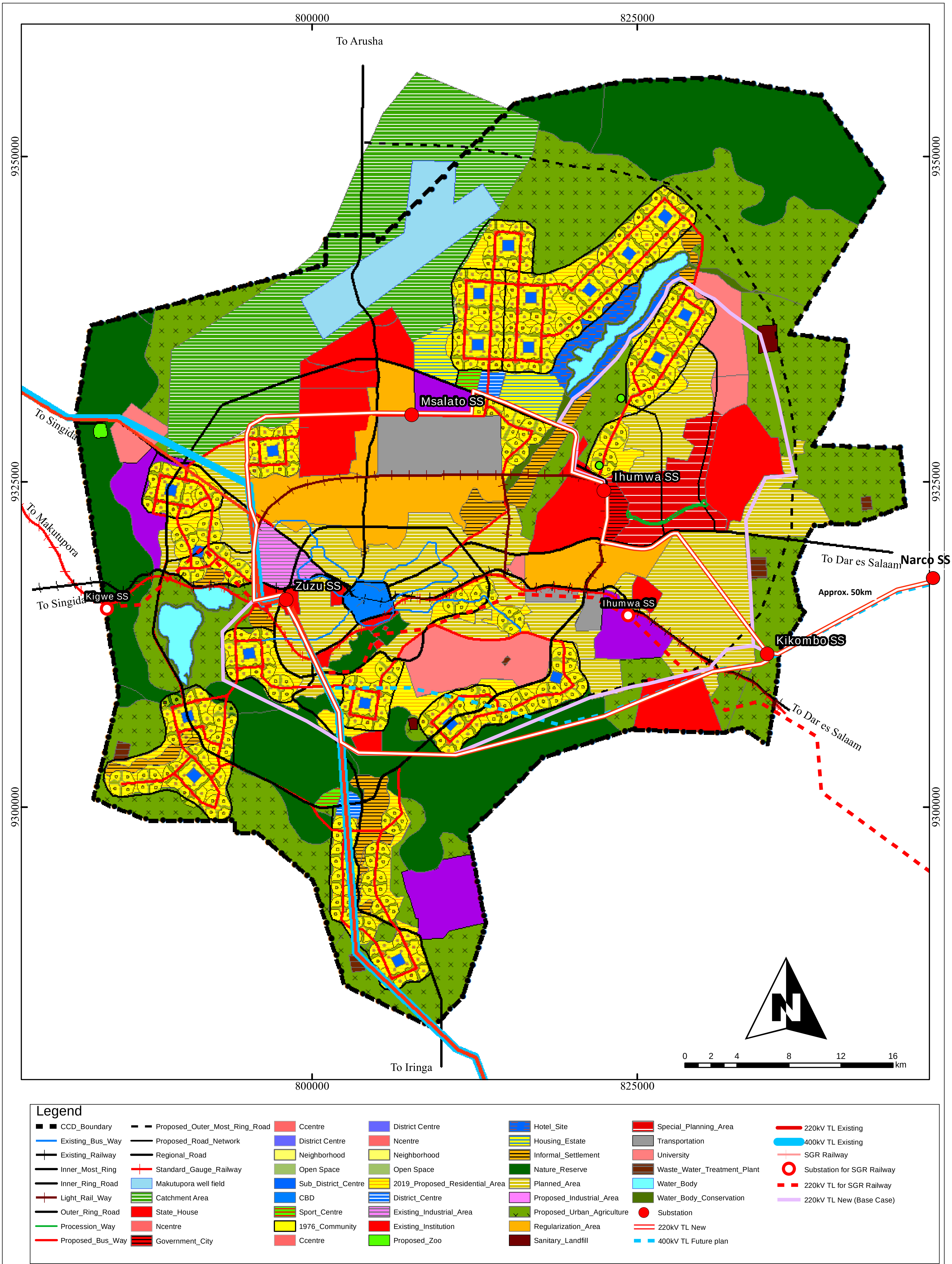
Attachment-1: Proposed Transmission Line Route and Location of Substations

Attachment-2: Presentation on the "Draft Final Report"

Attachment-3: Presentation on the "Applicable quality infrastructure"

DODOMA NATIONAL CAPITAL CITY MASTER PLAN

Proposed Transmission Line Route and Location of Substations



DATA COLLECTION SURVEY ON
DODOMA TRANSMISSION AND DISTRIBUTION SYSTEM
IN THE UNITED REPUBLIC OF TANZANIA

Presentation for Discussion

on the

Draft Final Report

JANUARY 29TH, 2020
JICA STUDY TEAM

Contents

1. Introduction

<Main Objectives>

- To confirm progress and details of the Dodoma National Capital City Master Plan,
- To conduct a survey to investigate and analyze the current and future power demand, facilities, system and applicable quality infrastructure for Dodoma Capital City District, and
- To contribute to JICA's cooperation policy consideration for Dodoma Transmission and Distribution network expansion.

<Expected Output>

- Updated transmission and distribution development plan for Dodoma urban area proposed by JICA Study Team

1. Introduction (Scope of the Survey)

Power Demand Forecast

- Review the existing power demand forecast predicted by TANESCO and propose updated power demand forecast.

Power System Planning

- Allocate the updated power demand to proposed substations.
- Review the existing power system and expansion plan.
- Propose power system configuration for Dodoma Urban area with recommended voltage level.

1. Introduction (Scope of the Survey)

◆ Transmission Planning

- Review the existing transmission plan.
- Propose transmission plan and alternatives (if any).

◆ Substation Planning

- Review the existing substation plan.
- Propose substation plan based on the discussion with TANESCO, result of power demand forecast for substations and power system plan.

◆ Distribution Planning

- Review the existing distribution plan.
- Propose distribution plan based on the discussion with TANESCO, result of power demand forecast for substations and power system plan.

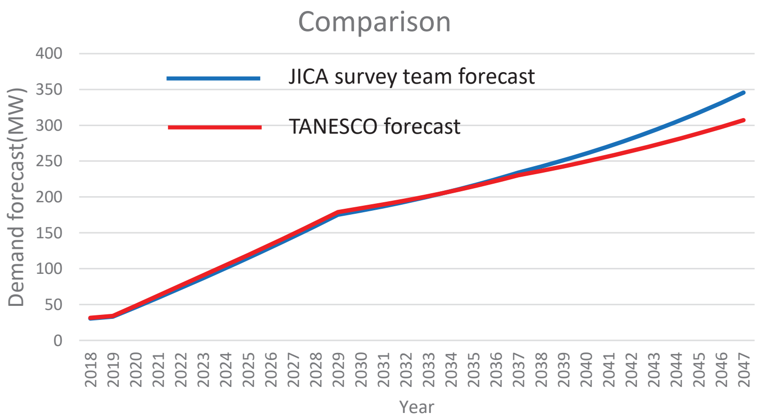
2. Power Demand Forecast

<Dodoma Demand Forecast>

■ Validity of the demand forecast for Dodoma implemented by TANESCO has been judged in consideration of

- Long term demand forecast cases of PSMP2016 as the base
- Specific loads by relocation of the capital function to be additionally considered.

(MW)	2018	2020	2025	2030	2035	2040	2045	2047
TANESCO	31	48	119	184	215	250	289	307
JICA Study Team	31	46	115	181	216	261	317	345



TANESCO's Forecast

⇩

Similar to Low case of PSMP2016

⇩

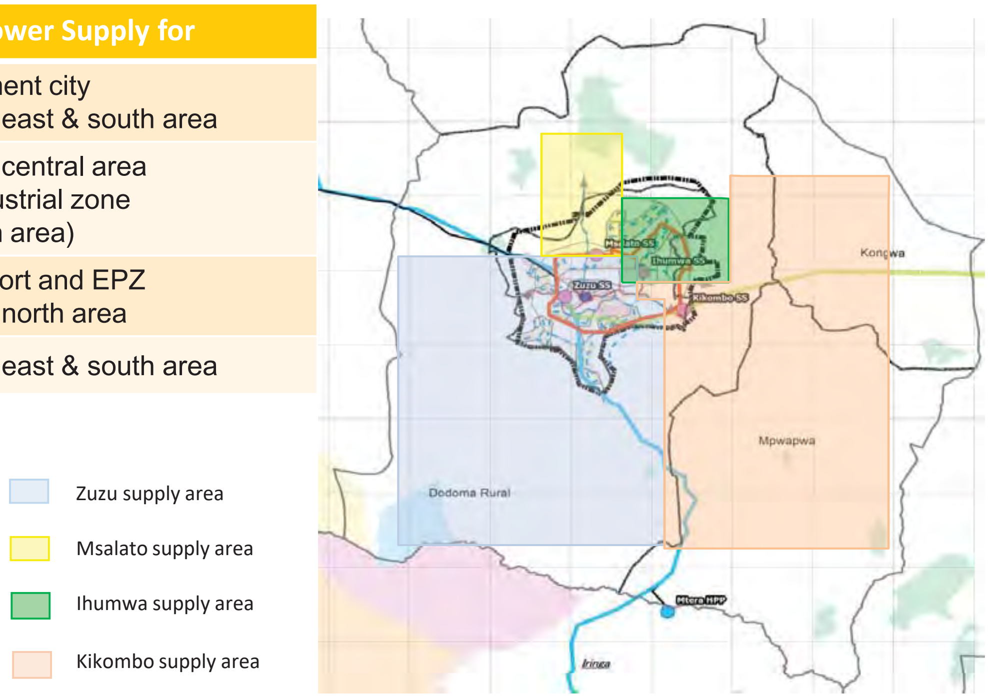
Judged valid

2. Power Demand Forecast

<Demand Allocation for Substations>

■ Purpose of Substations

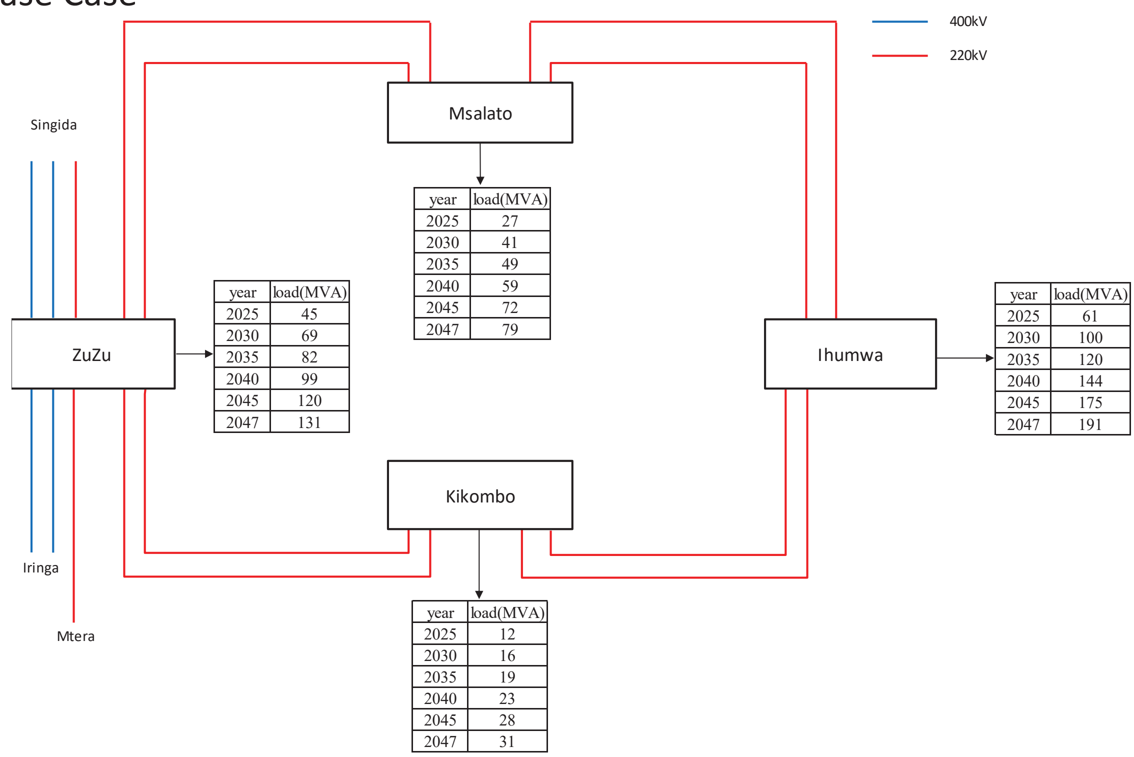
Substation	Power Supply for
Ihumwa	• Government city • Dodoma east & south area
Zuzu	• Dodoma central area • New industrial zone (western area)
Msalato	• New airport and EPZ • Dodoma north area
Kikombo	• Dodoma east & south area



2. Power Demand Forecast

<Demand Allocation for Substations>

■ Base Case



Msalato

year	load(MVA)
2025	27
2030	41
2035	49
2040	59
2045	72
2047	79

ZuZu

year	load(MVA)
2025	45
2030	69
2035	82
2040	99
2045	120
2047	131

Ihumwa

year	load(MVA)
2025	61
2030	100
2035	120
2040	144
2045	175
2047	191

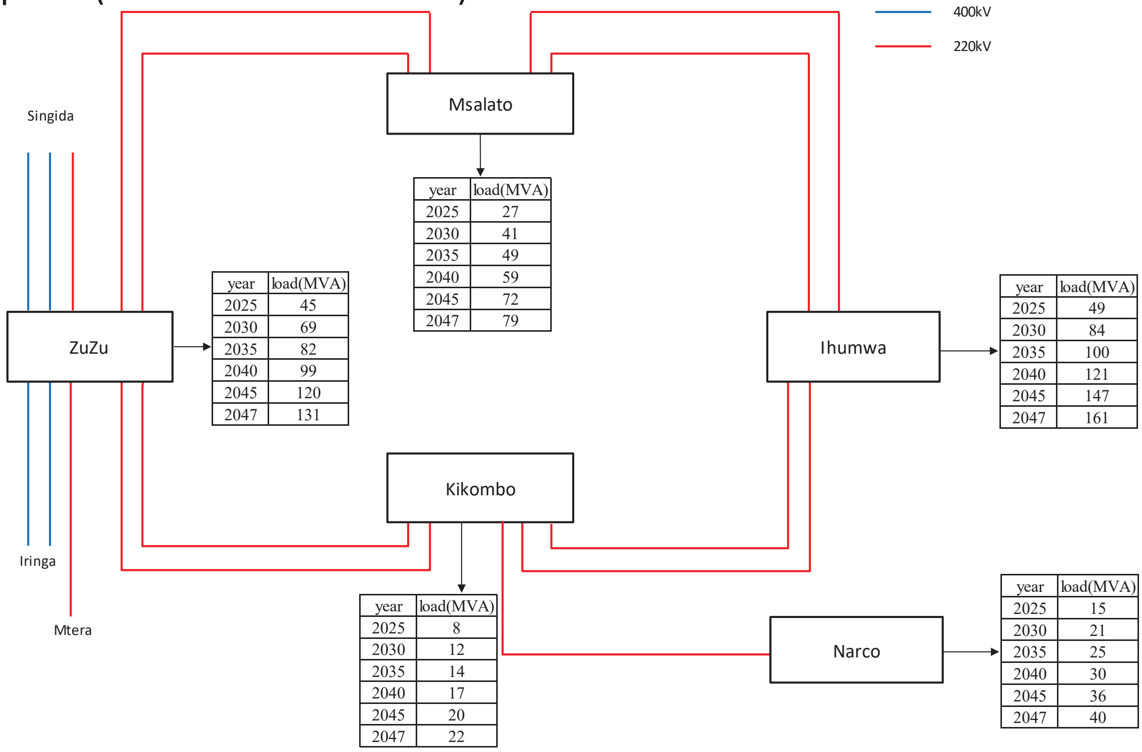
Kikombo

year	load(MVA)
2025	12
2030	16
2035	19
2040	23
2045	28
2047	31

2. Power Demand Forecast

<Demand Allocation for Substations>

- Option (with Narco substation)



Msalato

year	load(MVA)
2025	27
2030	41
2035	49
2040	59
2045	72
2047	79

ZuZu

year	load(MVA)
2025	45
2030	69
2035	82
2040	99
2045	120
2047	131

Ihumwa

year	load(MVA)
2025	49
2030	84
2035	100
2040	121
2045	147
2047	161

Kikombo

year	load(MVA)
2025	8
2030	12
2035	14
2040	17
2045	20
2047	22

Narco

year	load(MVA)
2025	15
2030	21
2035	25
2040	30
2045	36
2047	40

3. Power System Planning

<Basic Policy>

- Ensuring high reliability in power supply to government offices district
- High-quality power supply
  (maintain voltage level and low power interruption rate)
- Back-up capable system configuration
- Long life facilities with a target of 30 years
- Appropriate specification of facilities
- Economy
- Low loss

3. Power System Planning

<Study Results>

- Voltage class of ring circuit system
  - ***220kV is advantageous*** than 132kV as long as future demand exceeds 150MW in 2047 considering life cycle cost of the ring configuration of Dodoma transmission line system
- Concept of ensuring reliability
  - Transmission line
    - ✓

Double circuit Installed on the same tower	VS	Two routes of single circuit (No sharing tower for circuits)

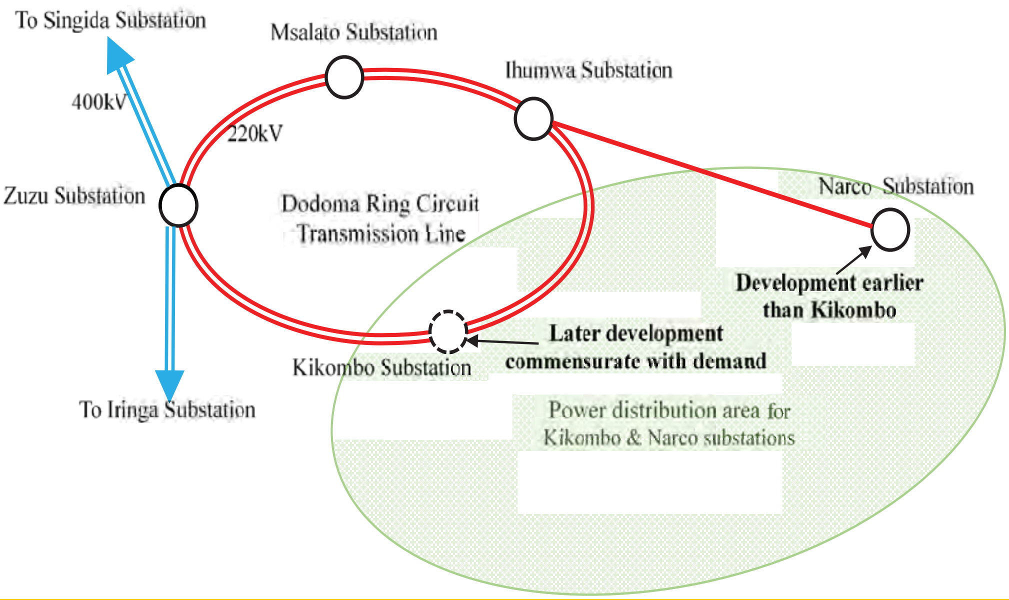
    - ✓ Application of EGLA (external gapped transmission line arrester)
  - Transformer
    - ✓ Multiple transformers configuration
    - ✓ Expansion according to demand growth

3. Power System Planning

<Study Results>

- Power Supply for Narco substation

  In case step-by-step development
  To be ***fed from Ihumwa substation*** instead of Kikombo substation



3. Power System Planning

<Study Results>

■ Transmission Line to Narco substation

132kV voltage is appropriate for the demand of Narco substation

Issue of the Dodoma ring circuit power system
Power source is only one, i.e. Zuzu substation
Power supply in Dodoma area will be hindered at emergency situation in Zuzu substation itself.

↓

External power source other than Zuzu substation to the ring circuit system should be considered.

↓

Narco substation to be positioned for interconnection to external power source for example Morogoro substation.

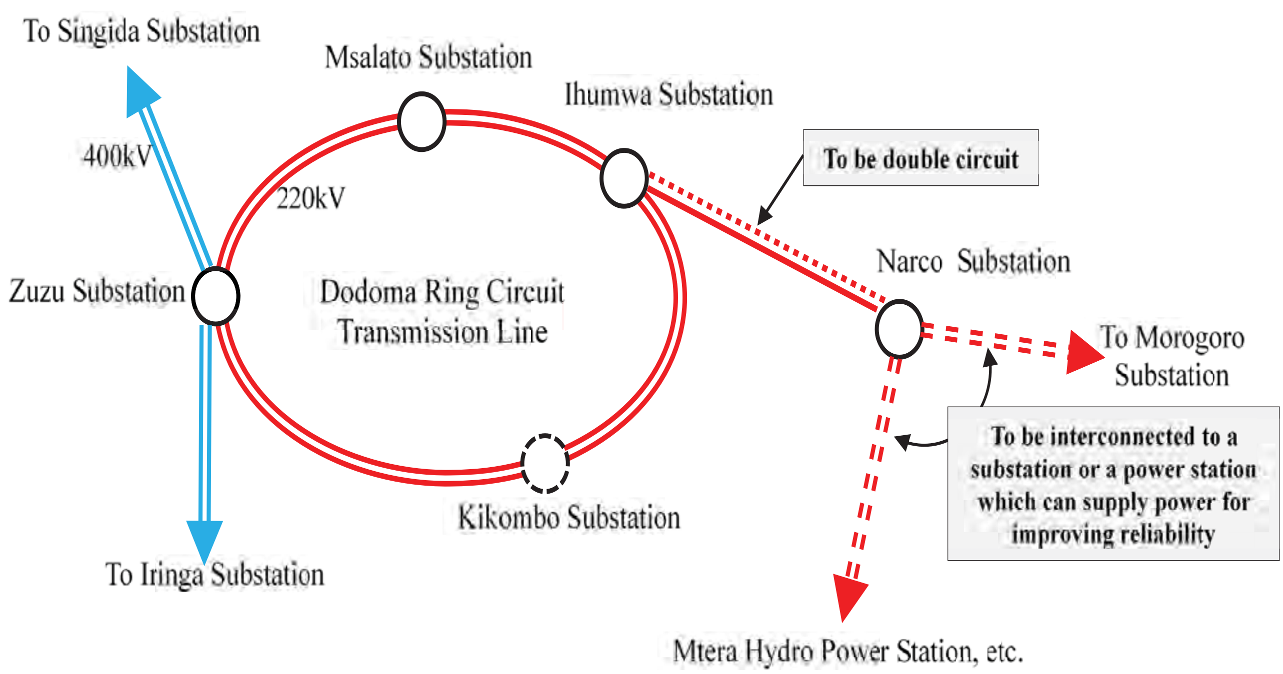
↓

Over 300MVA capacity required ➡ ***220kV voltage*** to be applied

3. Power System Planning

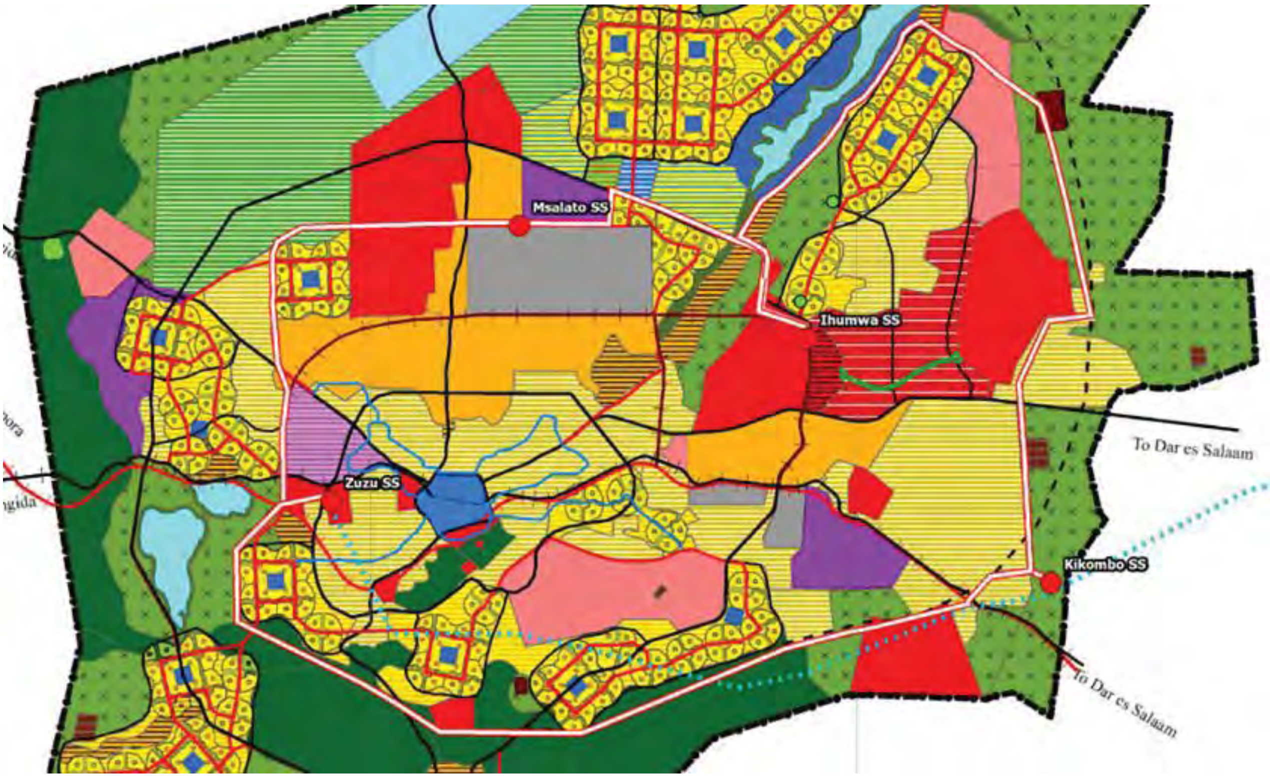
<Study Results>

■ Transmission Line to Narco substation



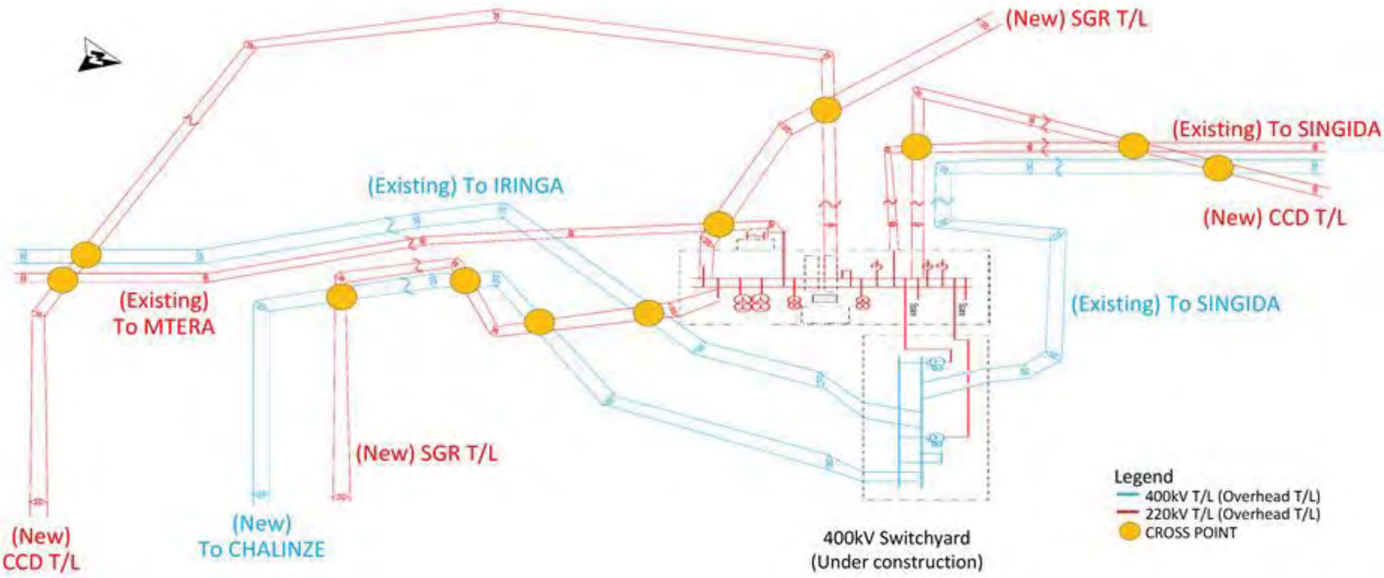
4. Transmission Planning

Planning status of the Ring Transmission Line



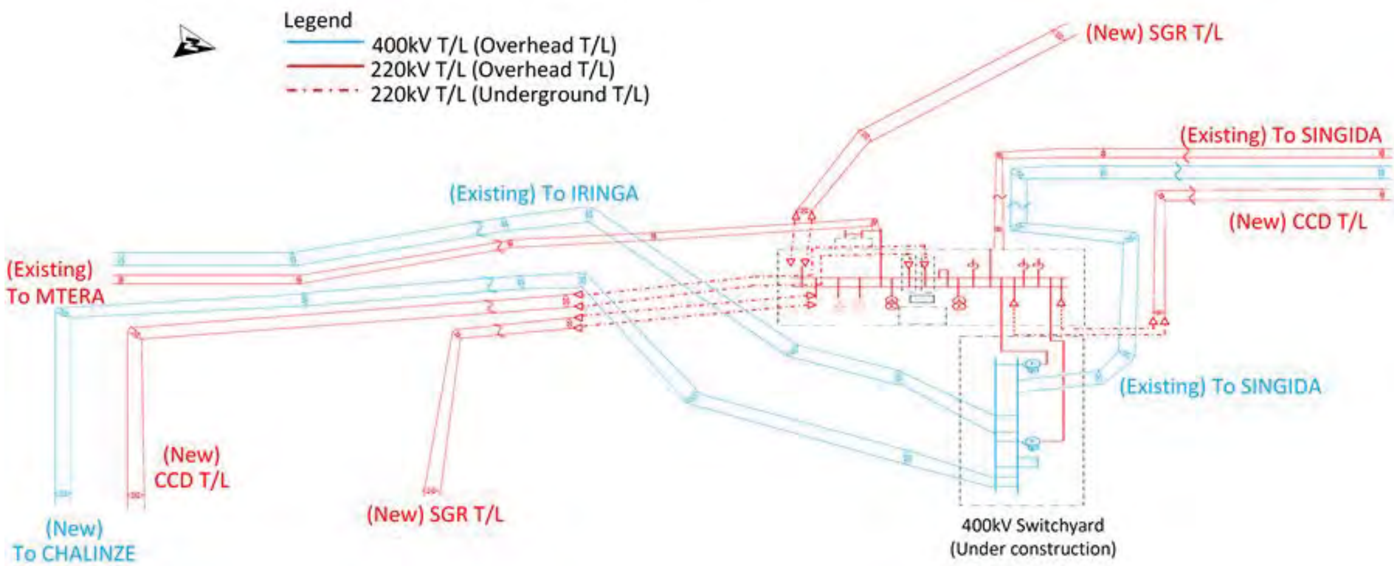
4. Transmission Planning

Planning routes around Zuzu substation



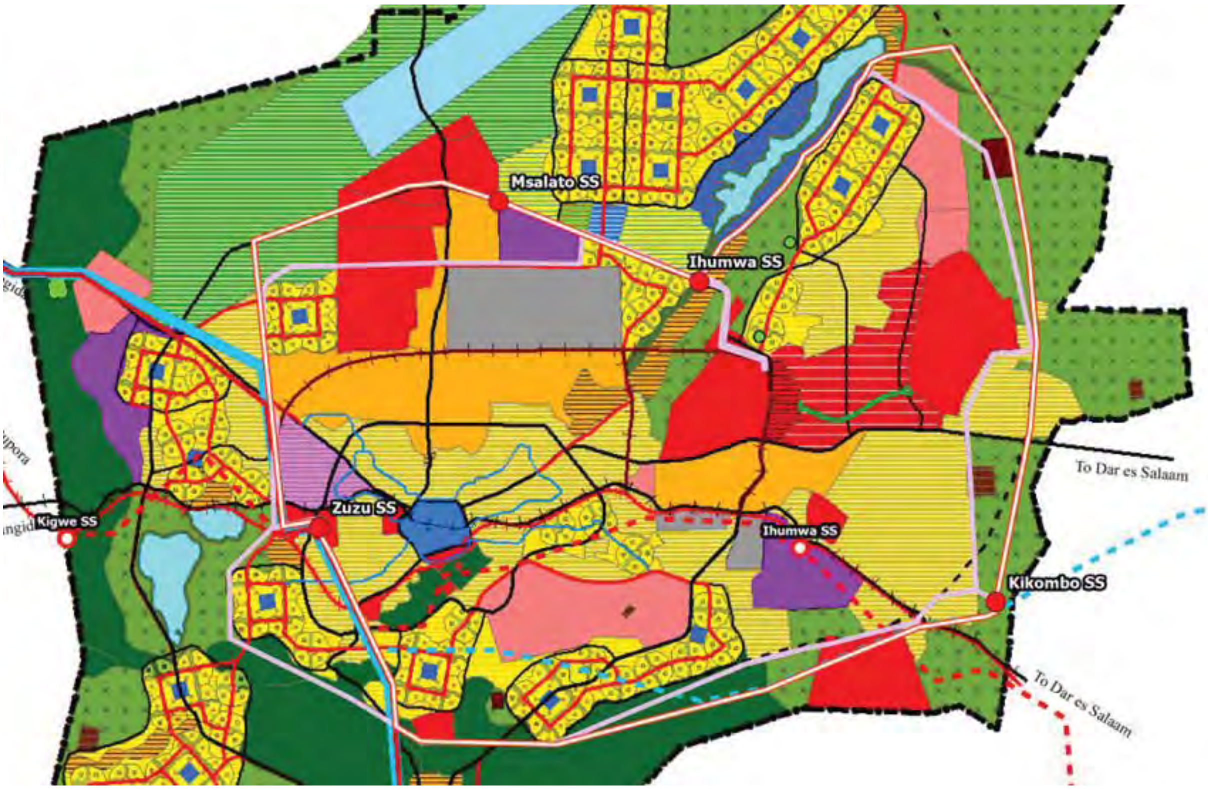
4. Transmission Planning

Proposal routes around Zuzu substation



4. Transmission Planning

- Proposal routes for the Ring Transmission Line



4. Transmission Planning

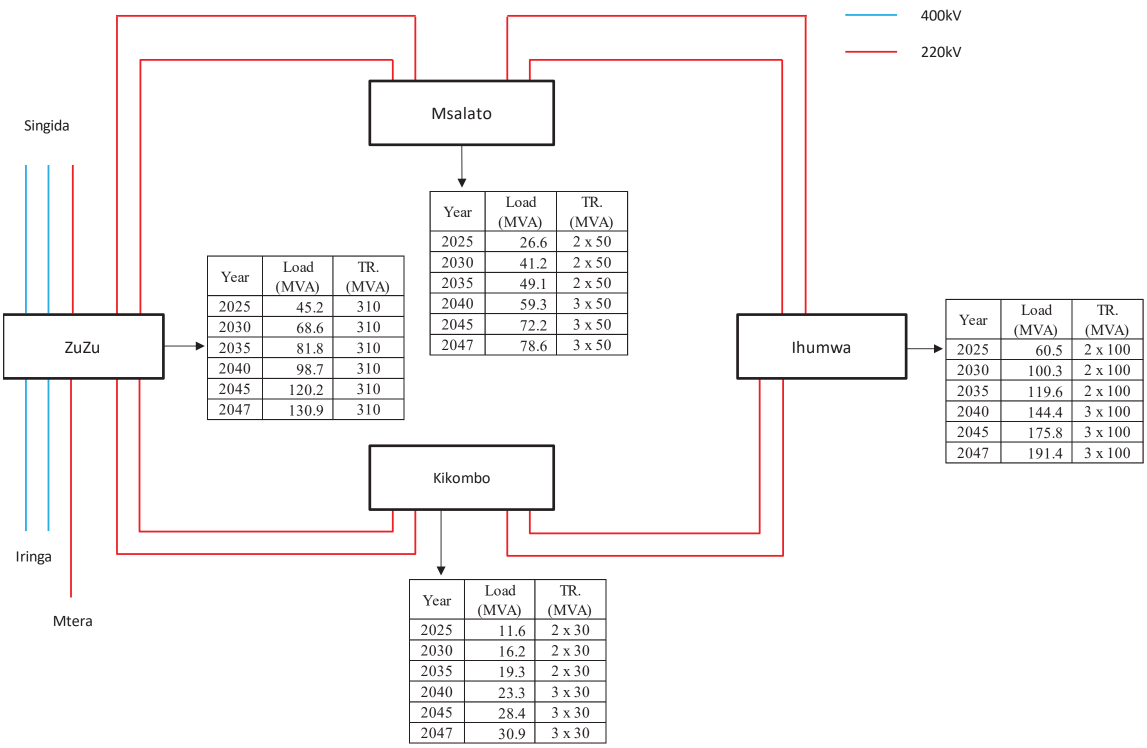
■ Result of comparison between Planed T/L routes and Proposal T/L routes

Specifications of proposal routes

Voltage class	Number of circuit	Transmission line section	Line Length	Change
220kV	Double circuit	Zuzu – Msalato	32km	+5km
220kV	Double circuit	Msalato – Ihumwa	12km	- 13km
220kV	Double circuit	Ihumwa - Kikombo	52km	- 10km
220kV	Double circuit	Kikombo – Zuzu	47km	- 4km
220kV	Single circuit	Kikombo - Narco	50km	—

5. Substation Planning

Capacity of Transformer(220/33kV)
[Base case]



Msalato

Year	Load (MVA)	TR. (MVA)
2025	26.6	2 x 50
2030	41.2	2 x 50
2035	49.1	2 x 50
2040	59.3	3 x 50
2045	72.2	3 x 50
2047	78.6	3 x 50

ZuZu

Year	Load (MVA)	TR. (MVA)
2025	45.2	310
2030	68.6	310
2035	81.8	310
2040	98.7	310
2045	120.2	310
2047	130.9	310

Ihumwa

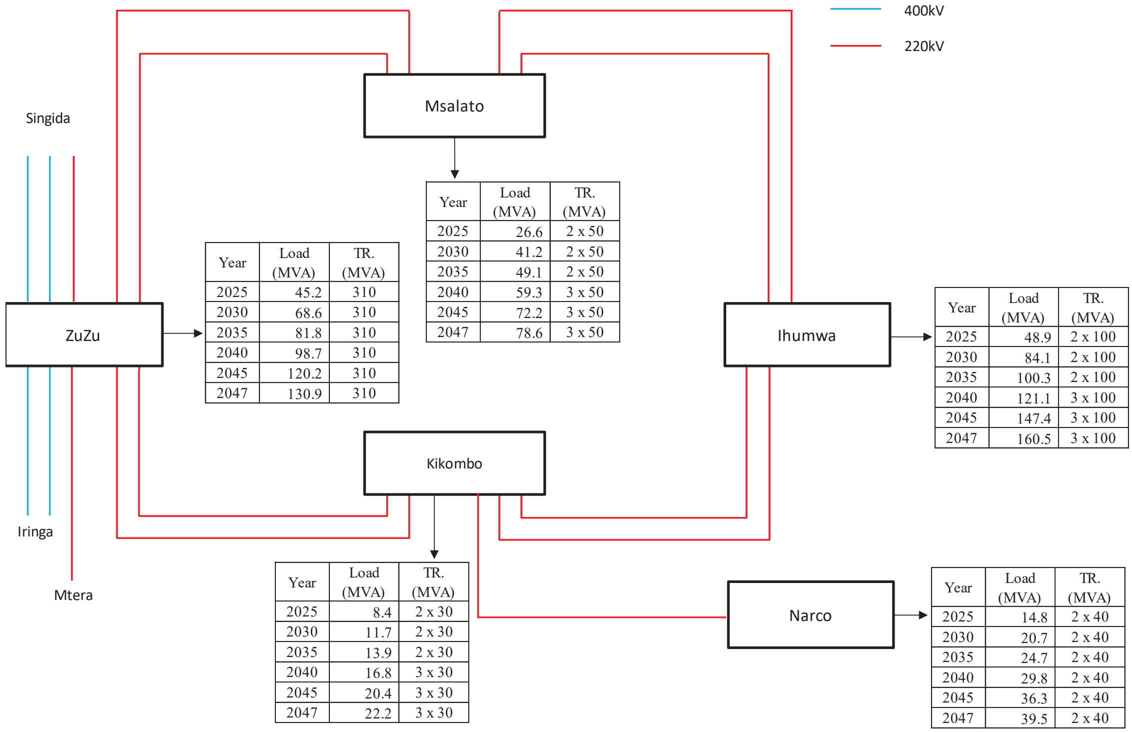
Year	Load (MVA)	TR. (MVA)
2025	60.5	2 x 100
2030	100.3	2 x 100
2035	119.6	2 x 100
2040	144.4	3 x 100
2045	175.8	3 x 100
2047	191.4	3 x 100

Kikombo

Year	Load (MVA)	TR. (MVA)
2025	11.6	2 x 30
2030	16.2	2 x 30
2035	19.3	2 x 30
2040	23.3	3 x 30
2045	28.4	3 x 30
2047	30.9	3 x 30

5. Substation Planning

Capacity of Transformer(220/33kV) [Option]



Msalato

Year	Load (MVA)	TR. (MVA)
2025	26.6	2 x 50
2030	41.2	2 x 50
2035	49.1	2 x 50
2040	59.3	3 x 50
2045	72.2	3 x 50
2047	78.6	3 x 50

ZuZu

Year	Load (MVA)	TR. (MVA)
2025	45.2	310
2030	68.6	310
2035	81.8	310
2040	98.7	310
2045	120.2	310
2047	130.9	310

Ihumwa

Year	Load (MVA)	TR. (MVA)
2025	48.9	2 x 100
2030	84.1	2 x 100
2035	100.3	2 x 100
2040	121.1	3 x 100
2045	147.4	3 x 100
2047	160.5	3 x 100

Kikombo

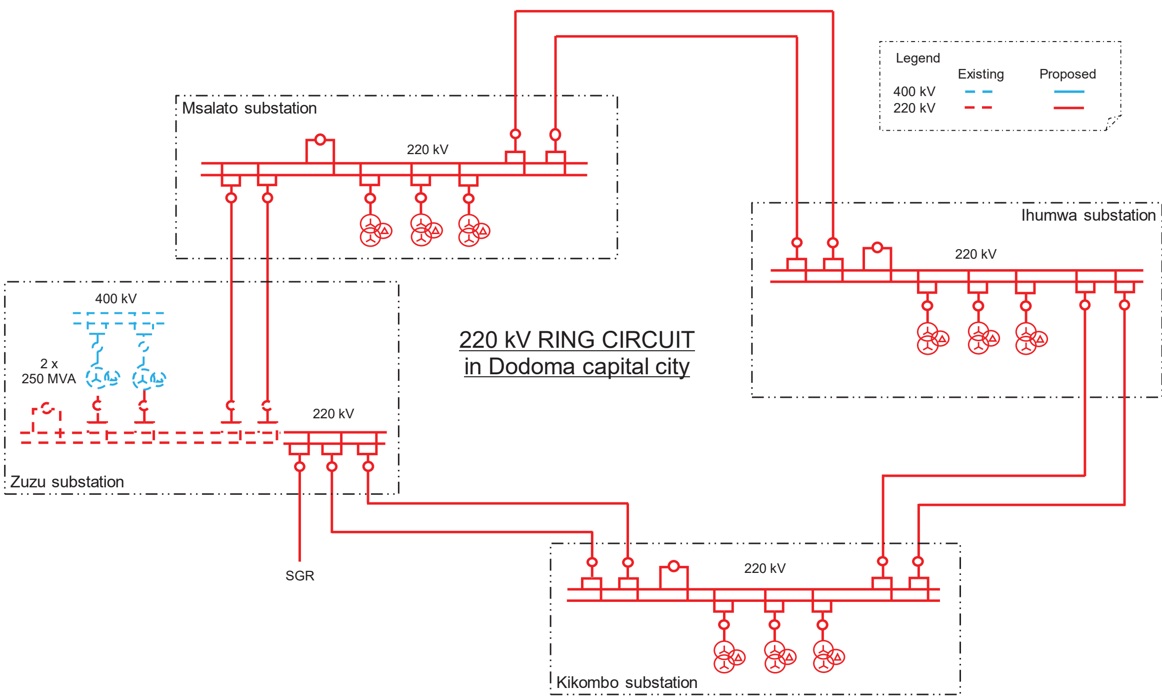
Year	Load (MVA)	TR. (MVA)
2025	8.4	2 x 30
2030	11.7	2 x 30
2035	13.9	2 x 30
2040	16.8	3 x 30
2045	20.4	3 x 30
2047	22.2	3 x 30

Narco

Year	Load (MVA)	TR. (MVA)
2025	14.8	2 x 40
2030	20.7	2 x 40
2035	24.7	2 x 40
2040	29.8	2 x 40
2045	36.3	2 x 40
2047	39.5	2 x 40

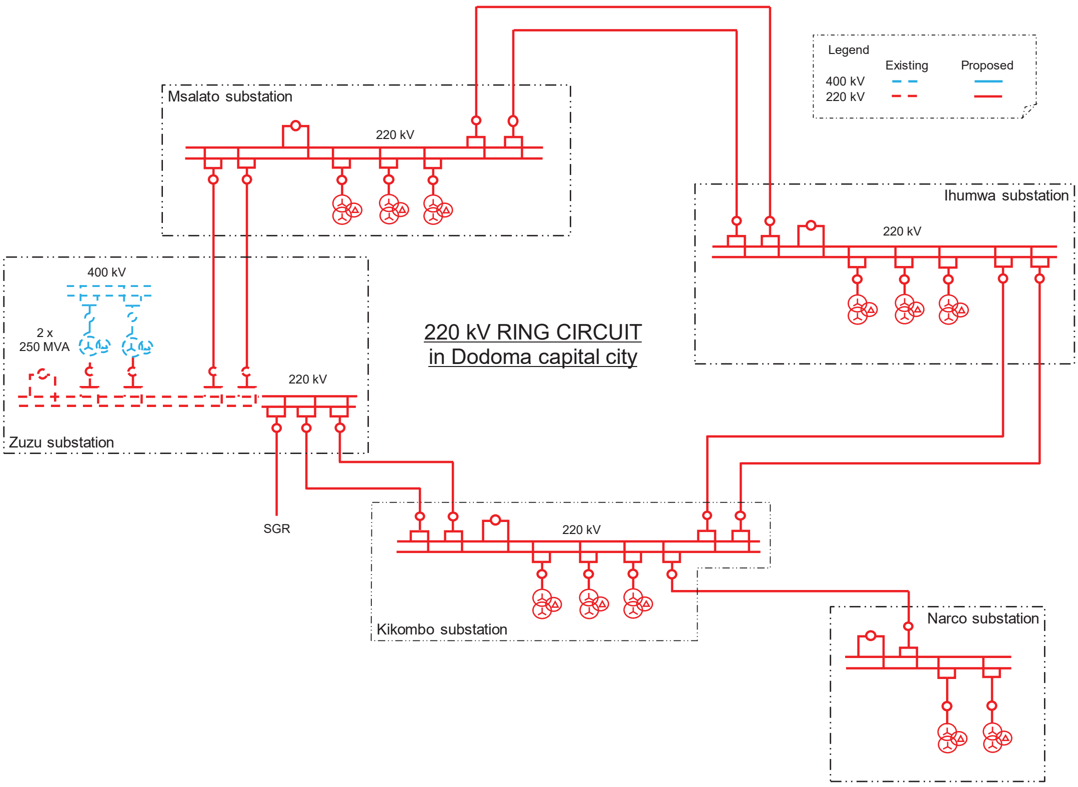
5. Substation Planning

Network Diagram of 220 kV Dodoma capital city [Base case]



5. Substation Planning

Network Diagram of 220 kV Dodoma capital city [Option]



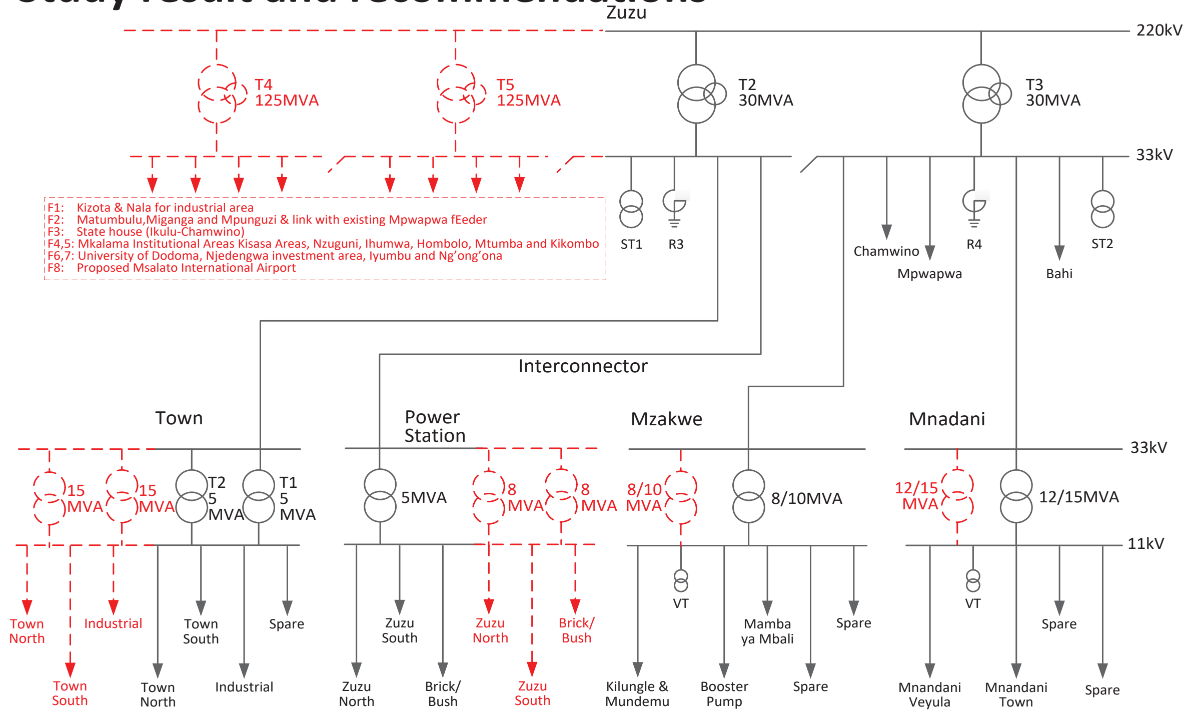
6. Distribution Planning

<Policy for the Consideration>

- To consider existing distribution plans and standard specifications
- To cooperate with Dodoma Capital Master plan
- To Relief existing distribution network
- To facilitate distribution network development for the essential loads
- Distribution system configuration
- Economy
- Low loss

6. Distribution Planning

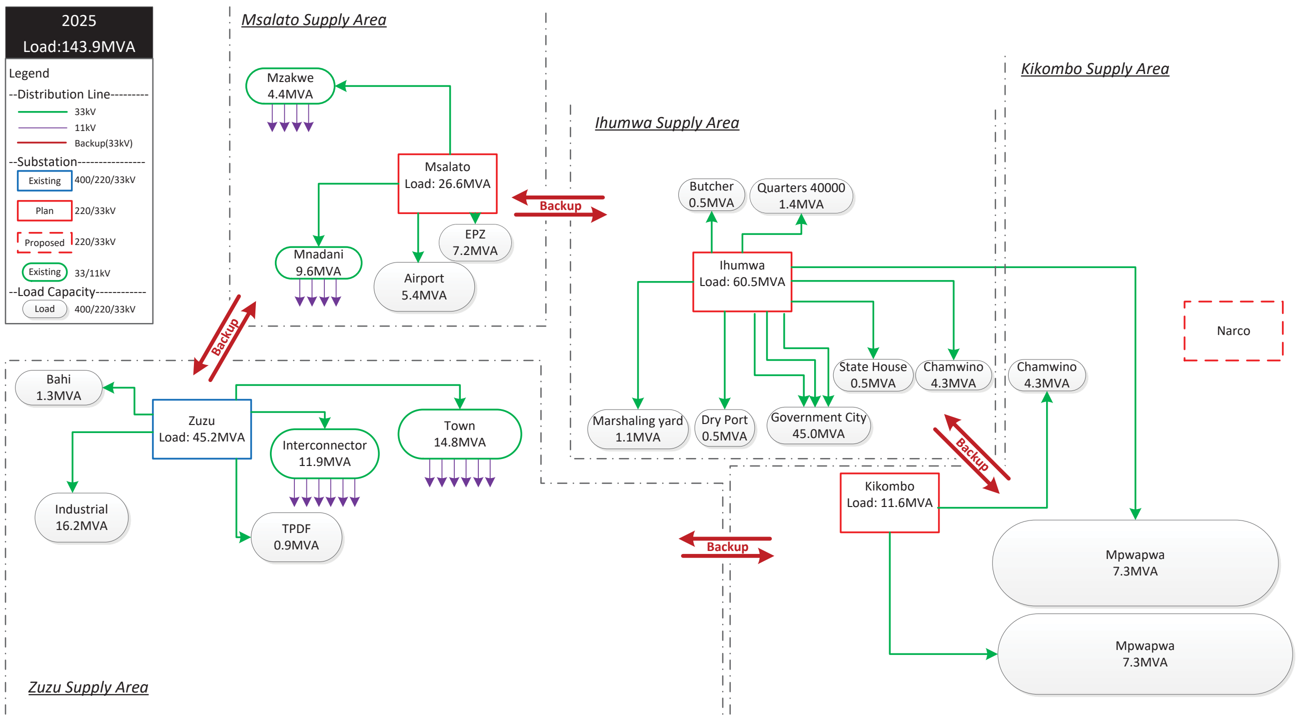
<Study result and recommendations>



Planned expansion
for Distribution Network of Dodoma Capital City District

6. Distribution Planning

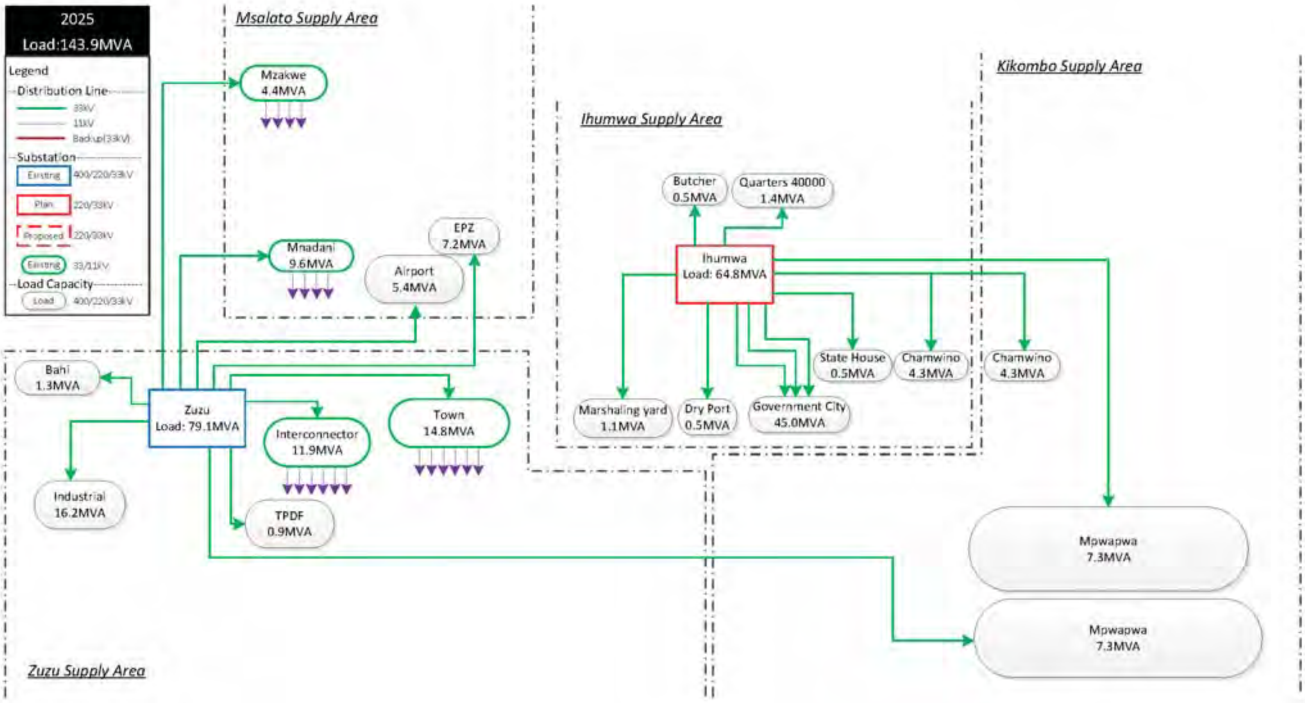
<Study result and recommendations>



Proposed Distribution Feeders
in Dodoma Capital City District (2025)

6. Distribution Planning

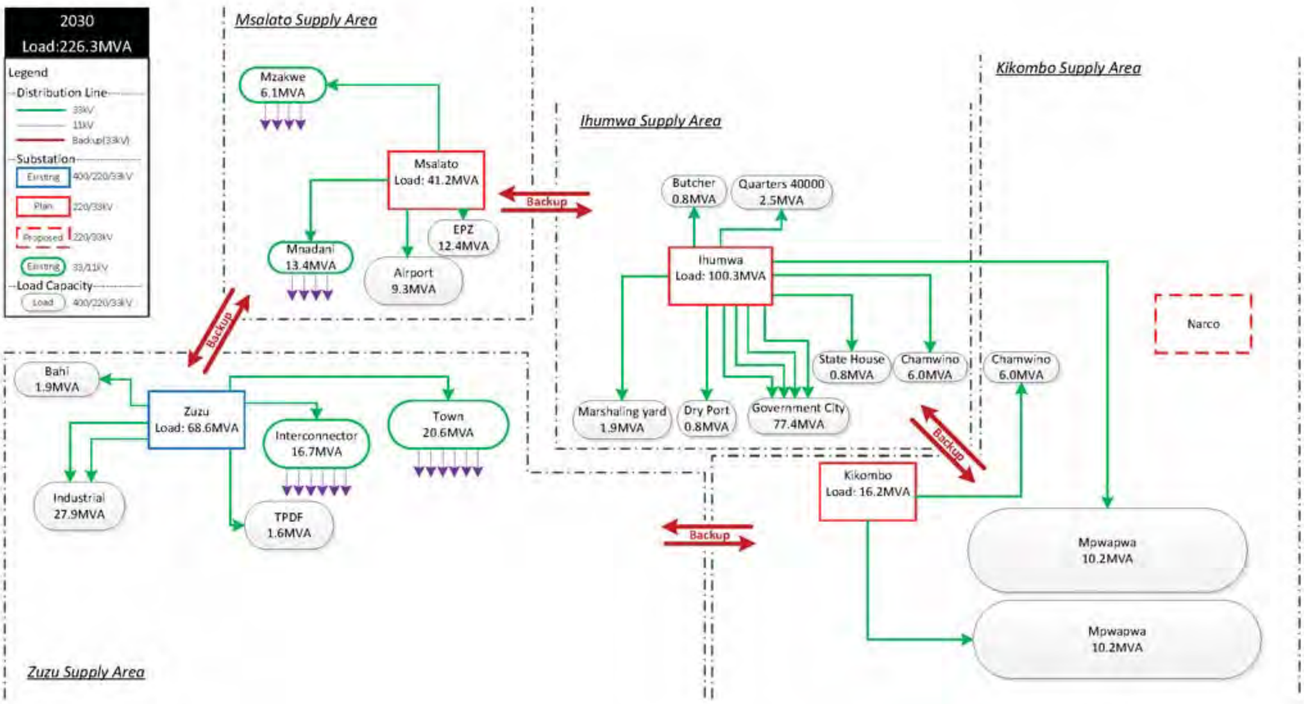
<Study result and recommendations>



Proposed Distribution Feeders in Dodoma Capital City District (2025 in stepwise)

6. Distribution Planning

<Study result and recommendations>



Proposed Distribution Feeders in Dodoma Capital City District (2030)

7. Scenario Study for Transmission System Development Plan

Outline of Dodoma Development plan [Transmission]

ID	Outline	Remarks
T-1	**Construction of Transmission Line (Zuzu-Msalato)** 220kV Double Circuits Approx.32km	At Zuzu substation, outgoing transmission line with Cable should be considered
T-2	**Construction of Transmission Line (Msalato-Ihumwa)** 220kV Double Circuits Approx.12km	-
T-3	**Construction of Transmission Line (Ihumwa-Kikombo)** 220kV Double Circuits Approx.52km	Outgoing transmission line to Narco from Ihumwa should be coordinated in case of stepwise development
T-4	**Construction of Transmission Line (Kikombo-Zuzu)** 220kV Double Circuits Approx.47km	Transmission line should be coordinated with the existing line. At Zuzu substation, outgoing transmission line with Cable should be considered
T-5	**Construction of Transmission Line (Kikombo-Narco)** 220kV Double Circuits Approx.50km (In case of one-time development)	In case of one-time development, Narco should be conntected to Kikombo.
	Construction of Transmission Line (Ihumwa-Narco) 220kV Double Circuits Approx.80km (In case of stepwise development)	In case of stepwise development, Narco should be conntected to Ihumwa.

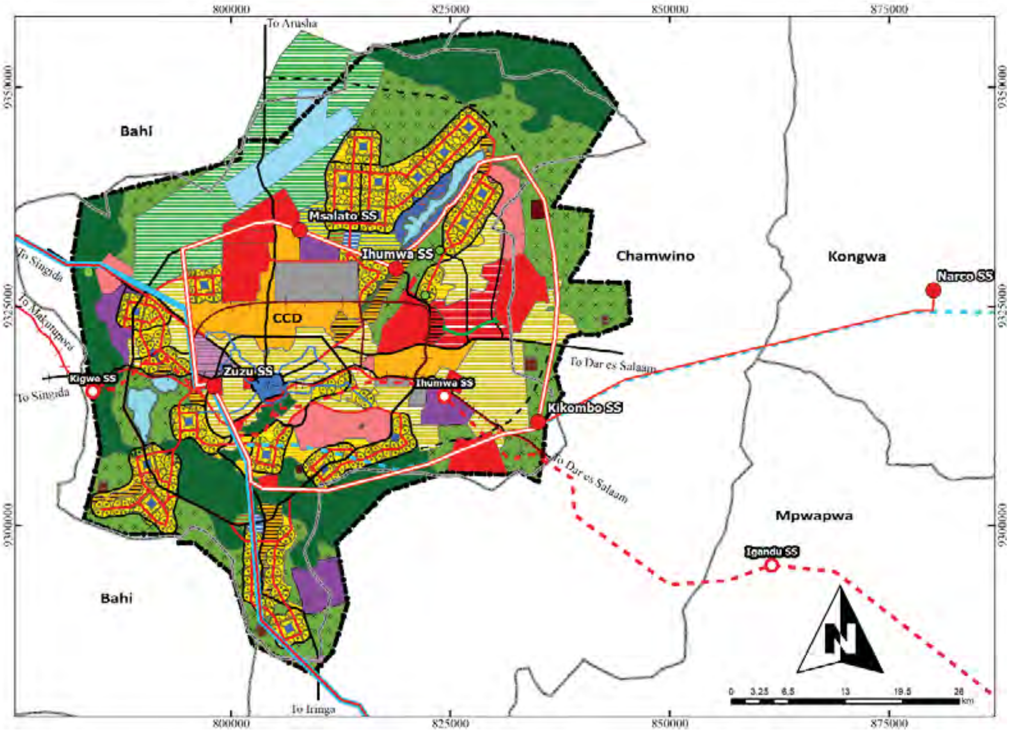
7. Scenario Study for Transmission System Development Plan

Outline of Dodoma Development plan [Substation]

ID	Outline	Remarks
S-1	**Construction of Msalato substation** 2x50MVA 220/33kV Transformer One lot of Switching and Information facilities Construction of Control Building, Civil Works, etc.	Potential location should be re-considered based on the proposal by JICA Study team
S-2	**Construction of Ihumwa substation** 2x100MVA 220/33kV Transformer One lot of Switching and Information facilities Construction of Control Building, Civil Works, etc.	Potential location should be re-considered based on the proposal by JICA Study team
S-3	**Construction of Kikombo substation** 2x40MVA 220/33kV Transformer One lot of Switching and Information facilities Construction of Control Building, Civil Works, etc.	Potential location is confirmed by JICA Study team, though not secured
S-4	**Construction of Narco substation** 1x30MVA 220/33kV Transformer One lot of Switching and Information facilities Construction of Control Building, Civil Works, etc.	Potential location is confirmed by JICA Study team, though not secured
S-5	**Rehabilitation of Zuzu substation** One lot of transmission line bay facilities	Existing 4-bay space should be secured for outgoing transmission lines

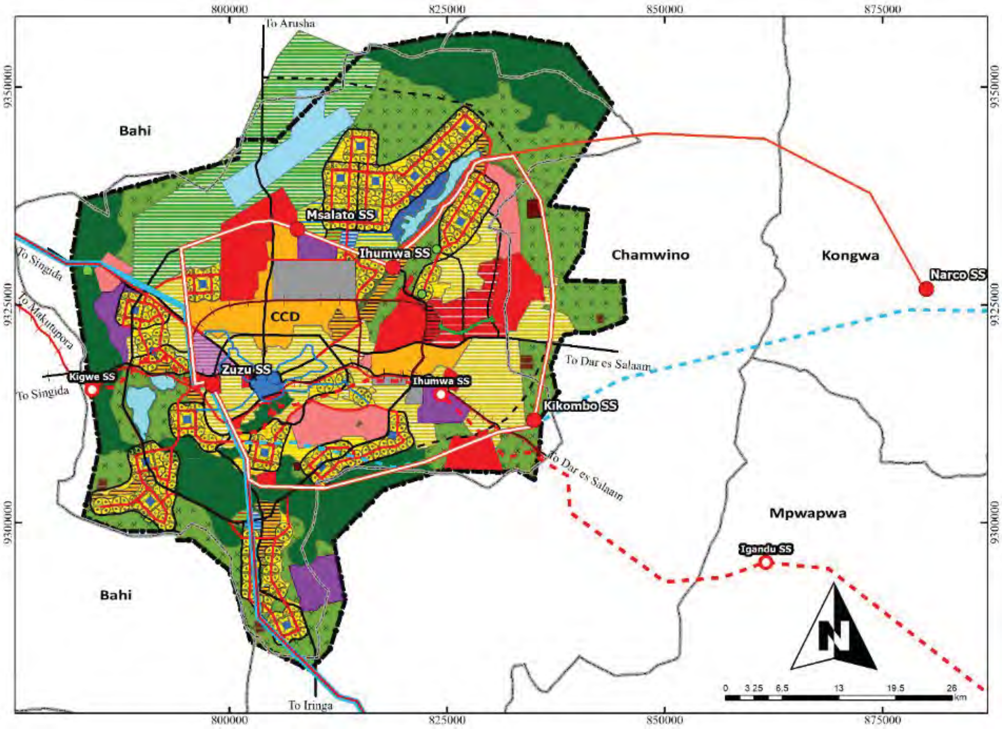
7. Scenario Study for Transmission System Development Plan

Outline of Dodoma Transmission System Development Plan (In case of one-time development)



7. Scenario Study for Transmission System Development Plan

Outline of Dodoma Transmission System Development Plan (In case of stepwise development)



7. Scenario Study for Transmission System Development Plan

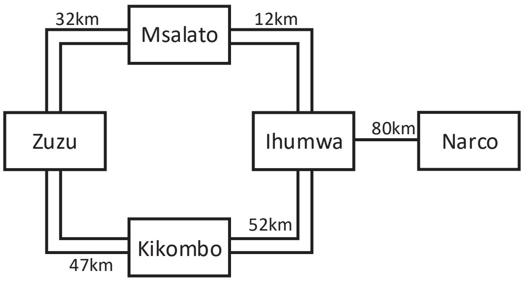
<Concept>

No.	Outline
I	Construction of Ihumwa substation should be completed by the end of Phase I of the Implementation Plan in Dodoma Capital City Master Plan (2024), and then immediately construction of Narco substation should be completed and should be started operation.
II	Construction of Msalato substation should be completed and started operation by the end of Phase II of the Implementation Plan in Dodoma Capital City Master Plan (2029)
III	Construction of Kikombo substation should be completed and started operation with the single circuit loop transmission line by the end of Phase III of the Implementation Plan (2034). Loop transmission line in double circuits is planned according to the progress of Phase IV of the Implementation Plan.

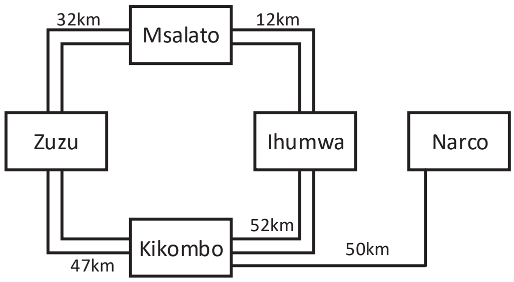
7. Scenario Study for Transmission System Development Plan

<Scenario Settings>

Scenario	Outline
1	**<Stepwise Development Plan 1>** **Establishing a single line loop circuit as early and to secure power supply reliability**
2	**<Stepwise Development Plan 2>** **Ensuring power supply reliability by constructing double-circuit transmission lines on the north side with emphasis on urgency**
3	**<One-time development plan>** **Advanced development with double-circuit transmission loop system**



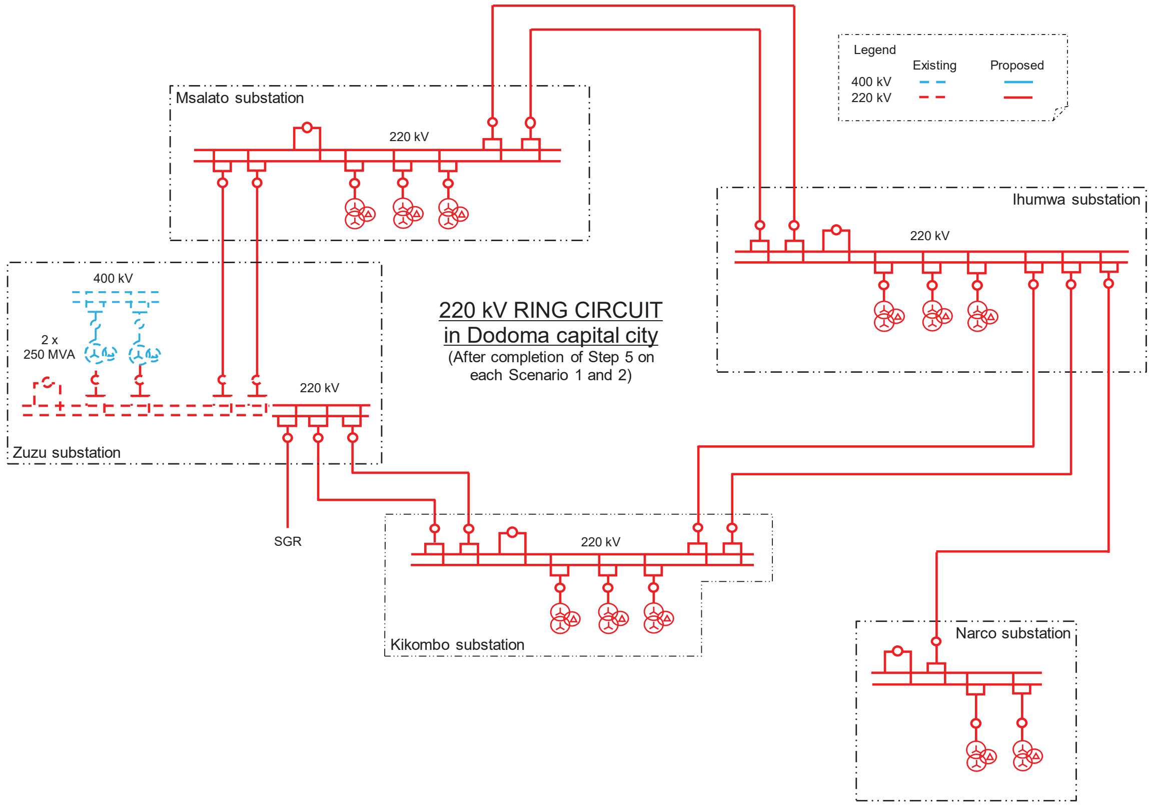
Final Power system Configuration (Stepwise Development)



Final Power system Configuration (One-time development)

7. Scenario Study for Transmission System Development Plan

Network Diagram of 220 kV Dodoma capital city [Scenario 1 & 2]



7. Scenario Study for Transmission System Development Plan

Transformer Capacity [Scenario 1 & 2]

Msalato

Year	2025	2026	2027	2030	2035	2040	2045	2047	Remarks
Load (MVA)	-	-	33.07	41.19	49.14	59.30	72.22	78.63	
Backup Load (MVA)	-	-	*33*	*43*	*50*	*61*	*74*	*80*	Half of Ihumwa load
Transformer (MVA)			2 x 50	2 x 50	2 x 50	3 x 50	3 x 50	3 x 50	

Zuzu substation can backup the deficit of the capacity.

Ihumwa

Year	2025	2026	2027	2030	2035	2040	2045	2047	Remarks
Load (MVA)	72.09	57.81	66.02	85.06	100.33	121.06	147.44	160.51	
Backup Load (MVA)	-	-	*17*	*21*	*25*	*30*	*36*	*39*	Half of Msalato load
Transformer (MVA)	2 x 100	2 x 100	2 x 100	2 x 100	2 x 100	3 x 100	3 x 100	3 x 100	

Kikombo

Year	2025	2026	2027	2030	2035	2040	2045	2047	Remarks
Load (MVA)	-	-	-	-	13.90	16.77	20.42	22.23	
Backup Load (MVA)	-	-	-	-	*50*	*61*	*74*	*80*	Half of Ihumwa load
Transformer (MVA)	-	-	-	-	2 x 30	3 x 30	3 x 30	3 x 30	

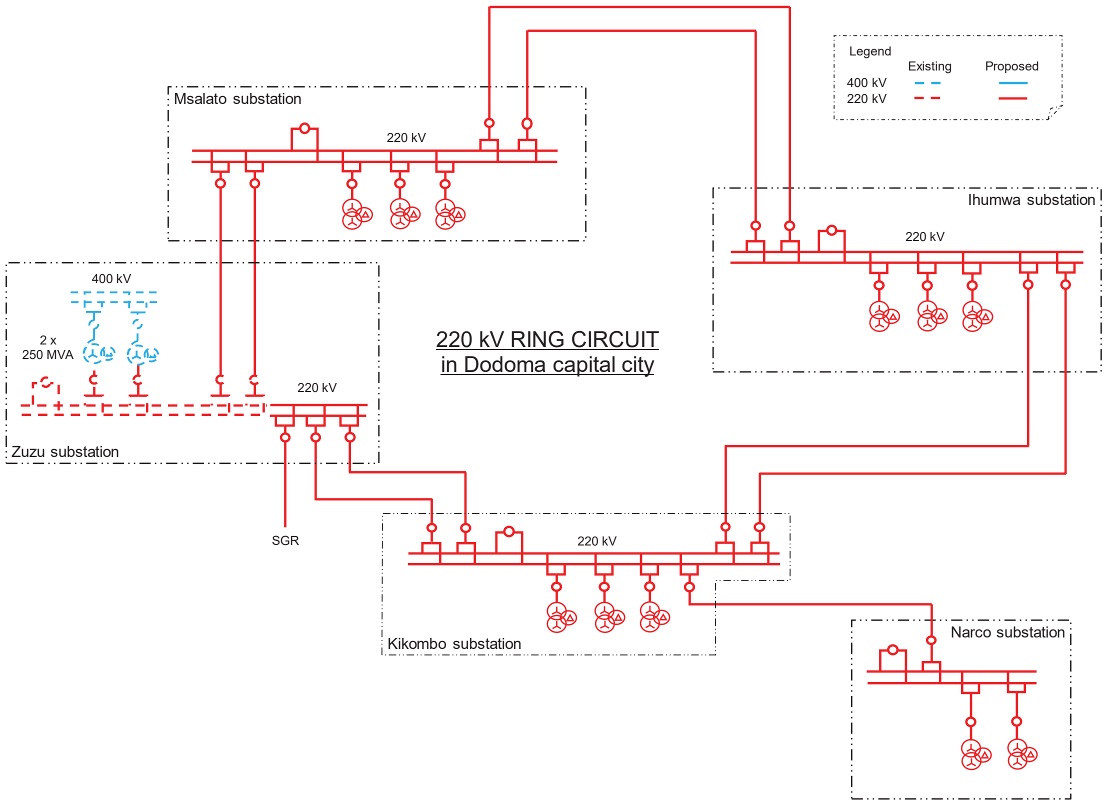
Zuzu substation can backup the deficit of the capacity.

Narco

Year	2025	2026	2027	2030	2035	2040	2045	2047	Remarks
Load (MVA)	-	24.25	26.15	31.38	24.70	29.81	36.31	39.52	
Transformer (MVA)	-	2 x 40	2 x 40	2 x 40	2 x 40	2 x 40	2 x 40	2 x 40	

7. Scenario Study for Transmission System Development Plan

Network Diagram of 220 kV Dodoma capital city [Scenario 3]



7. Scenario Study for Transmission System Development Plan

Transformer Capacity [Scenario 3]

Msalato

Year	2025	2026	2027	2030	2035	2040	2045	2047	Remarks
Load (MVA)	26.59	29.79	33.07	41.19	49.14	59.30	72.22	78.63	
Backup Load (MVA)	*24*	*29*	*31*	*42*	*50*	*61*	*74*	*80*	Half of Ihumwa load
Transformer (MVA)	2 x 50	2 x 50	2 x 50	2 x 50	2 x 50	3 x 50	3 x 50	3 x 50	

Zuzu substation can backup the deficit of the capacity.

Ihumwa

Year	2025	2026	2027	2030	2035	2040	2045	2047	Remarks
Load (MVA)	48.91	57.06	62.51	84.08	100.33	121.06	147.44	160.51	
Backup Load (MVA)	*13*	*15*	*17*	*21*	*25*	*30*	*36*	*39*	Half of Msalato load
Transformer (MVA)	2 x 100	2 x 100	2 x 100	2 x 100	2 x 100	3 x 100	3 x 100	3 x 100	

Kikombo

Year	2025	2026	2027	2030	2035	2040	2045	2047	Remarks
Load (MVA)	8.35	9.00	9.71	11.65	13.90	16.77	20.42	22.23	
Backup Load (MVA)	*24*	*29*	*31*	*42*	*50*	*61*	*74*	*80*	Half of Ihumwa load
Transformer (MVA)	2 x 30	2 x 30	2 x 30	2 x 30	3 x 30	3 x 30	3 x 30	3 x 30	

Zuzu substation can backup the deficit of the capacity.

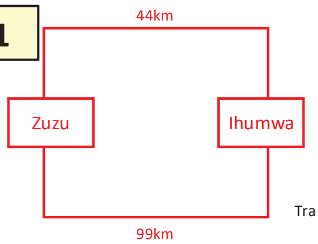
Narco

Year	2025	2026	2027	2030	2035	2040	2045	2047	Remarks
Load (MVA)	14.84	16.00	17.26	20.71	24.70	29.81	36.31	39.52	
Transformer (MVA)	2 x 40	2 x 40	2 x 40	2 x 40	2 x 40	2 x 40	2 x 40	2 x 40	

7. Scenario Study for Transmission System Development Plan

Scenario-1

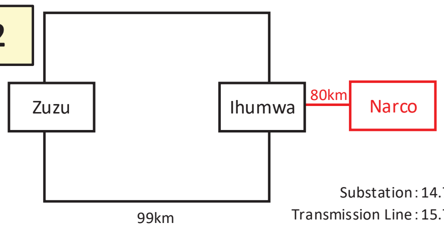
STEP1



Substation : 23.3 Million USD
Transmission Line : 29.6 Million USD
Rough Cost : 52.9 Million USD

Construction of Ihumwa substation with the loop transmission line in sigle circuit will be completed.
(Start operation from 2025)

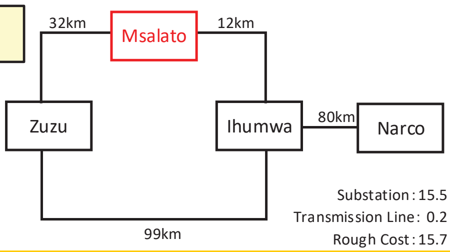
STEP2



Substation : 14.7 Million USD
Transmission Line : 15.7 Million USD
Rough Cost : 30.4 Million USD

Construction of Narco Substation
(Start operation from 2026)

STEP3



Substation : 15.5 Million USD
Transmission Line : 0.2 Million USD
Rough Cost : 15.7 Million USD

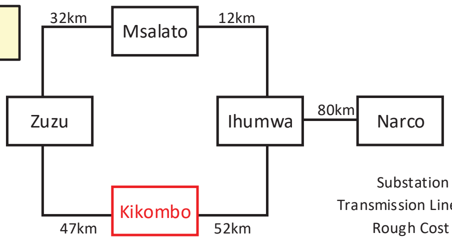
Construction of Msalato Substation
(Start operation from 2027)

Note: Rough Cost does not include consulting services, land preparation and cost for Environmental and Social considerations

7. Scenario Study for Transmission System Development Plan

Scenario-1 <Stepwise Development Plan 1>

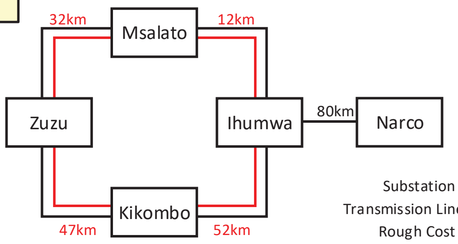
STEP4



Substation : 14.5 Million USD
Transmission Line : 0.2 Million USD
Rough Cost : 14.7 Million USD

Construction of Kikombo Substation
(Start operation from 2035)

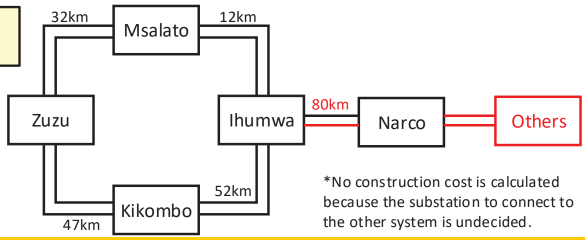
STEP5



Substation : 11.4 Million USD
Transmission Line : 9.5 Million USD
Rough Cost : 20.9 Million USD

Construction of the double-circuit transmission lines
(Start operation by 2045)

Option



*No construction cost is calculated because the substation to connect to the other system is undecided.

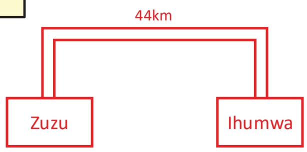
Connection to other power systems

Note: Rough Cost does not include consulting services, land preparation and cost for Environmental and Social considerations

7. Scenario Study for Transmission System Development Plan

Scenario-2 <Stepwise Development Plan 2>

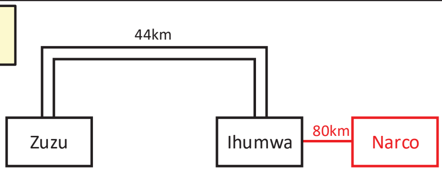
STEP1



Substation：22.5 Million USD
Transmission Line：11.3 Million USD
Rough Cost：33.8 Million USD

Construction of Ihumwa substation and the double-circuit transmission lines will be completed.
(Start operation from 2025)

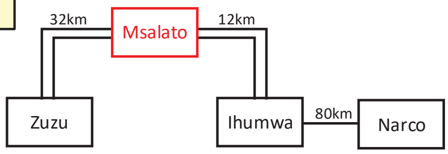
STEP2



Substation:14.7 Million USD
Transmission Line:15.7 Million USD
Rough Cost:30.4 Million USD

Construction of Narco Substation
(Start operation from 2026)

STEP3



Substation:17.5 Million USD
Transmission Line:0.2 Million USD
Rough Cost:17.7 Million USD

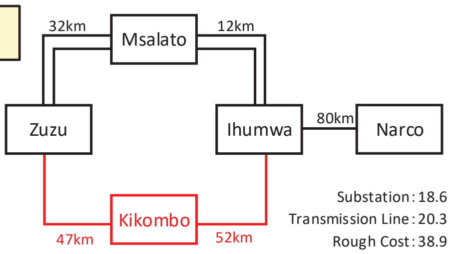
Construction of Msalato Substation
(Start operation from 2027)

Note: Rough Cost does not include consulting services, land preparation and cost for Environmental and Social considerations

7. Scenario Study for Transmission System Development Plan

Scenario-2

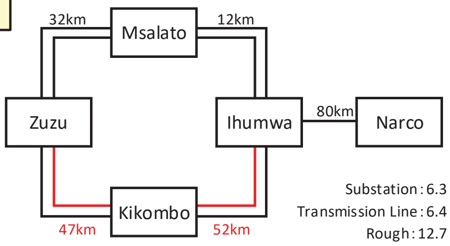
STEP4



Substation:18.6 Million USD
Transmission Line:20.3 Million USD
Rough Cost:38.9 Million USD

Construction of Kikombo Substation
(Start operation from 2035)

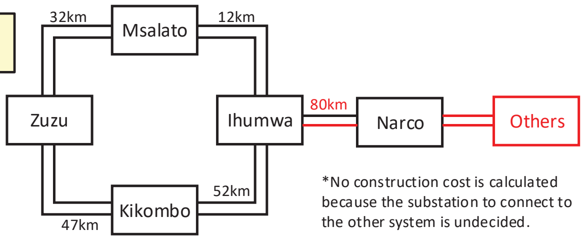
STEP5



Substation:6.3 Million USD
Transmission Line:6.4 Million USD
Rough:12.7 Million USD

Construction of the double-circuit transmission lines
(Start operation by 2045)

Option



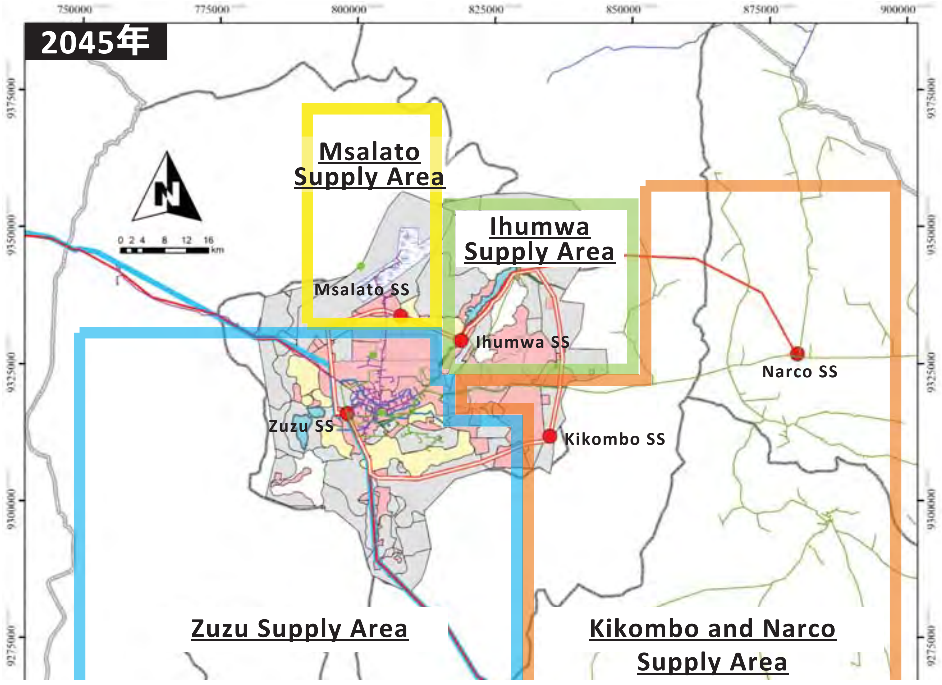
*No construction cost is calculated because the substation to connect to the other system is undecided.

Connection to other power systems

Note: Rough Cost does not include consulting services, land preparation and cost for Environmental and Social considerations

7. Scenario Study for Transmission System Development Plan

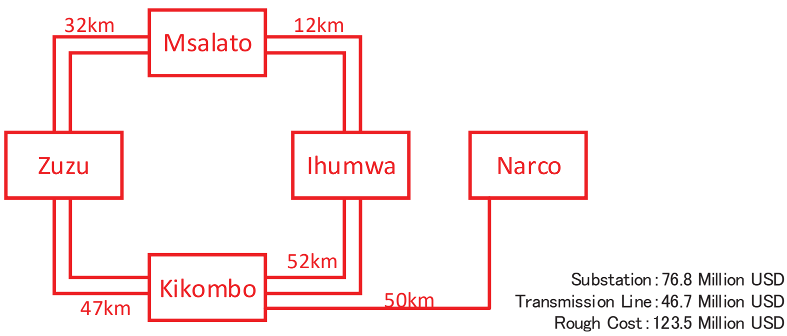
Scenario-1 & Scenario-2



Site Location(STEP5:2045)

7. Scenario Study for Transmission System Development Plan

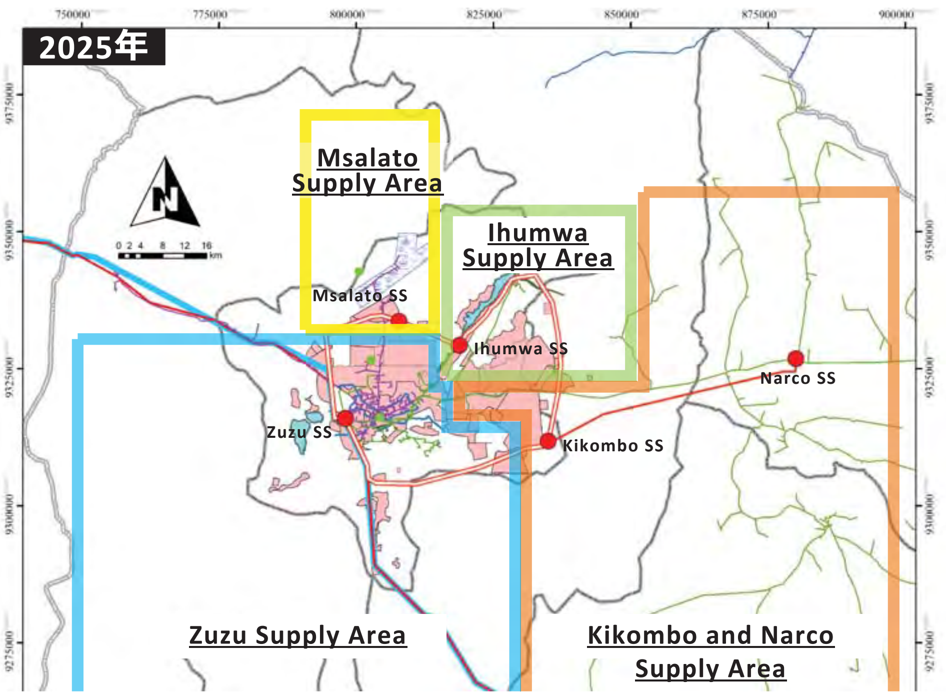
Scenario-3 <One-time development plan>



Construction of all substations and transmission lines with the loop transmission line in double circuit
(Start operation from 2025)

7. Scenario Study for Transmission System Development Plan

Scenario-3



Site Location(STEP5:2045)

7. Scenario Study for Transmission System Development Plan

Proposed Implementation Schedule and Cooperation Schemes

<table>
<tr><th>Year</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th><th>2031</th><th>2032</th><th>2033</th><th>2034</th><th>2035</th><th>2036</th><th>2037</th><th>2038</th><th>2039</th></tr>
<tr><td>■ Dodoma National Capital City Master Plan</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>- Completion of ongoing development
- Development of 12 communities</td><td colspan="6">Phase I</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>- Land acquisition and planning for development of 52 communities</td><td></td><td></td><td></td><td></td><td></td><td colspan="16">Phase IA</td></tr>
<tr><td>- Development of 13 communities</td><td></td><td></td><td></td><td></td><td></td><td colspan="6">Phase II</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>- Development of 16 communities</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">Phase III</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>- Development of 21 communities</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="6">Phase IV</td></tr>
<tr><td>■ Scenario and Scheme for consdierations</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Scenerio3</td><td></td><td></td><td></td><td></td><td colspan="2">ALL</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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7. Scenario Study for Transmission System Development Plan

Preliminary Evaluation Scenario-1 <Stepwise Development Plan 1>

Feature	Challenge	Cost		Technical		Implementation			Max Score 18
		Cost by Scenario	For Influence on Cost (For Fundability)	High reliability of power supply at the end of Capital MP Phase I	Considerations items for cooperative development with distribution systems	Coordination with demand forecast	Development delay risk (Project scale)	To secure Wayleave	
1. Lower initial costs than One--time development. Therefore, development according to the increase in demand becomes possible. 2. Since the construction of the Nalco substation will be completed by 2025, the distribution of power to Kongwa and Mpwapwa areas can be achieved quickly. 3. Construction of a loop transmission line having high reliability is quickly realized.	Since the project scale in STEP1 is rather large, It is necessary to make a business plan and carry out an environmental and social considerations survey in a short period.	Initial cost :52.9 M $	Standard	Better	Standard	Better	Standard	Better	More Better
		Total : 134.6 M $	2	3	2	3	2	3	15
		By establishing early system reliability and carrying out Stepwise Development, the total cost is maximized in all scenario, but the initial cost can be suppressed.		Although the project scale of STEP1 is large, it can be expected to respond to urgency because it is Stepwise Development. Since the loop transmission line in single circuits is constructed quickly, power supply reliability can be secured the fastest.		Since the scenario is based on the development plan of Dodoma MP, Coordination with demand forecast is the highest.			◎

Evaluation: ◎ (More Better: 15-18), ○ (Better: 11-14), △ (Average: 6-10)

7. Scenario Study for Transmission System Development Plan

Preliminary Evaluation Scenario-2 <Stepwise Development Plan 2>

Feature	Challenge	Cost		Technical		Implementation			Max Score 18
		Cost by Scenario	For Influence on Cost (For Fundability)	High reliability of power supply at the end of Capital MP Phase I	Considerations items for cooperative development with distribution systems	Coordination with demand forecast	Development delay risk (Project scale)	To secure Wayleave	
1. Lower initial costs than One-time development. Therefore, development according to the increase in demand becomes possible. 2. Since the construction of the Nalco substation will be completed by 2025, the distribution of power to Kongwa and Mpwapwa areas can be achieved quickly. 3. By constructing of north side Double Circuit transmission lines, it becomes possible to transmit power in the event of a one-circuit outage.	In the construction of transmission lines in STEP 4, it may be difficult to secure Wayleave in Dodoma urban area.	Initial cost :33.8 M $	Better	Standard	Standard	Better	Better	Standard	More Better
		Total : 133.5 M $	3	2	2	3	3	2	15
		Although the total cost is slightly higher than in the scenario-3, the initial investment cost can be suppressed as compared with the scenario-1.		Since the initial project scale is the smallest, it can be expected to respond to urgency.		Since STEP1 has a small project scale, it is easiest to secure Wayleave. However, when constructing the transmission line in STEP 4, there is a possibility that it is necessary to secure a wayleave while Dodoma Capital Development is progressing.			◎

Evaluation: ◎ (More Better: 15-18), ○ (Better: 11-14), △ (Average: 6-10)

7. Scenario Study for Transmission System Development Plan

Preliminary Evaluation Scenario-3 <One-time development plan>

Feature	Challenge	Cost		Technical		Implementation			Max Score 18
		Cost by Scenario	For Influence on Cost (For Fundability)	High reliability of power supply at the end of Capital MP Phase I	Considerations items for cooperative development with distribution systems	Coordination with demand forecast	Development delay risk (Project scale)	To secure Wayleave	
1. Since the development of the transmission system prior to the capital development plan becomes possible, it has an advantage in terms of Wayleave and environmental and social considerations. 2. Since the operation will start as the loop transmission line with double circuits from 2025, A highly reliable system can be constructed at an early stage.	Since the project scale is large due to one-time development, it is necessary to make a project plan and conduct an environmental and social considerations survey in a short period.	Initial cost :123.5 M $	Worse	Better	Worse	Worse	Worse	Better	Average
		Total : 123.5 M $	1	3	1	1	1	3	10
		Although the overall cost can be suppressed as compared with the scenarios-1 and 2, the initial cost may be large and fund procurement may be difficult.		There are many considerations for coordination with distribution system construction. For example, it is necessary to consider a change in the power distribution system, a switching work in consideration of the power outage time and the number of power outages, and so it is difficult to make a plan in a short time.		Since the project scale is large due to one-time development, the risk of development delay is high. In order to switch or expand the distribution system according to the scenario, it is necessary to concentrate resources (human and economical), which may increase the risk of development delay.			△

Evaluation: ◎ (More Better: 15-18), ○ (Better: 11-14), △ (Average: 6-10)

Thank you for your attention

DATA COLLECTION SURVEY ON DODOMA TRANSMISSION AND DISTRIBUTION SYSTEM IN THE UNITED REPUBLIC OF TANZANIA

Applicable quality infrastructure

for Dodoma Capital City District

JANUARY 29TH, 2020
JICA STUDY TEAM

Contents

Application of Latest technology to Dodoma transmission and distribution network development.

		High quality	High reliability	Cost reduction	Reduced environmental impact
Distribution Facility	(1) Low-loss distribution transformer			○	
Transmission facilities	(2) Low-loss conductor			○	
	(3) External gapped transmission Line arresters	○	○		
Substation facilities	(4) Special 3 phase transformer				○
	(5) Low-loss transformer			○	

(1) Low-loss distribution transformer

- ➢ Lowers hysteresis losses
- ➢ Have very thin laminations → Eddy current losses reduce as compared to Iron.

Source: Based on manufacture catalog

Amorphous Metal Distribution Transformers

(1) Low-loss distribution transformer

- ➢ **Hysteresis Loss**

  Random molecular structure enables ease of magnetization and demagnetization. Hence, lower hysteresis losses compared to conventional core material.
- ➢ **Lowers hysteresis losses**

  Resistivity of Core Material is proportional to the Square of the thickness of Laminations, Due to Lower thickness (approximately 1/10th of conventional core), eddy current losses are lower.

↓

Low Hysteresis and Eddy Current losses helps in Significant reduction of No-Load Losses

(1) Low-loss distribution transformer (Payback calculations)

(Example Calculations)

[Conditions]

Rating and Price

Rating	CIF Price[$]		Extra Investment to buy Amorphous Transformer[$]
	Si Transformer	Amorphous Core Transformer	
100 kVA, 11/ 0.42 kV	3555	4190	635

Losses of Transformer

Losses[W]	Si Transformer	Amorphous Core Transformer
No-Load Losses	145	90
Load Losses	1210	815

[Payback Calculations]

Annual Savings

No-load losses [W]	Load losses[W]	Annual Savings[kWh] (Losses[W] x LLF x 8460[hr])/1000			Annual Savings[$]
		Due to No-load losses with LLF1.0	Due to load losses with LLF 0.5*1	Total	
55	395	481.80	1730.10	2212.00	199.07*2

*1 :LLF→ 70%Load Loss factor considered to calculate LLF, *2 :@unit kWh→ 0.09$

(1) Low-loss distribution transformer

[Payback Calculations]

Payback Calculations

Years	Extra investment on purchase[$]	Interest on extra investment 8.5% per year	Energy cost [$/kWh]	Cost of energy saved [kWh/year]	Extra investment (Principal) carried forward
1	635.00	53.975	0.09	199.07	489.90
2	489.90	41.64	0.09	199.07	332.47
3	332.47	28.26	0.09	199.07	161.66
4	161.66	13.74	0.09	199.07	**(23.67)**
5	**(23.67)**	-2.01	0.09	199.07	**(224.75)**
6	**(224.75)**	-19.1	0.09	199.07	**(442.91)**

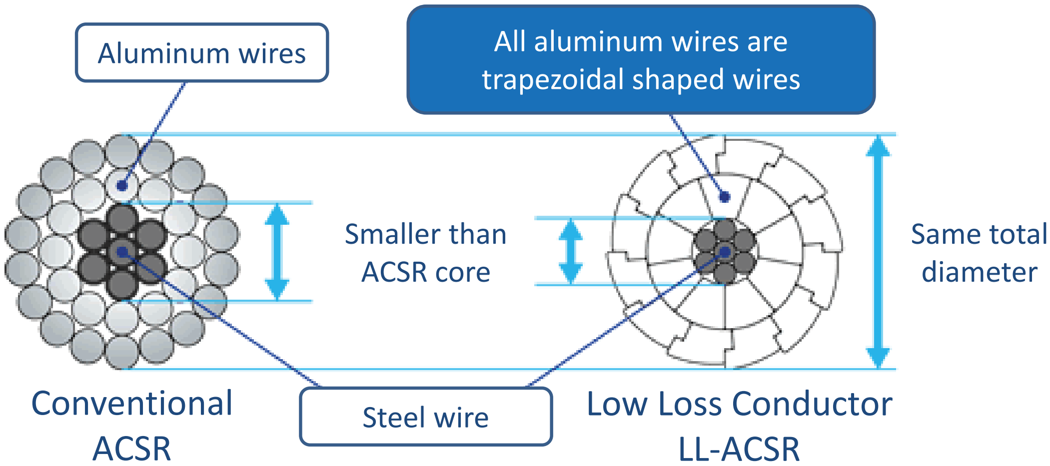
NOTES:

- ✓ The extra investment & Payback calculations depends on Loss Capitalization rates.
- ✓ The Loss Capitalization rates depends on Cost of Energy, Bank Interest rate, number of hours of operation & Life span of Transformer and Transformer Loading factor.
- ✓ Exact Payback Calculations can be done for a Particular Country based on above parameters which are Country specific.

Payback Starts from 4th year

(2) Low-loss conductor

- Low-loss conductor has improved aluminum occupancy by adopting trapezoidal aluminum conductors.
- As a result, transmission loss can be reduced by approximately 20%.



Source: Based on manufacture catalog

Low Loss Conductor LL-ACSR

(2) Low-loss conductor (Transmission line Specification)

- In accordance with Dodoma's transmission system development plan scenario, the application effects of low-loss conductor.

Transmission line specifications

Item	Unit	220kV		
		Conventional ACSR (Blue Jay)	LL-ACSR/AS (719mm2)	LL-ACSR/AS (600/29mm2)
Overall Diameter	mm	31.96	31.96	31.96
Weight	kg/km	1,868	2,154	1,860
Nominal Cross section	mm2	603.3	741.2	624.6
Current Capacity (75℃)	A	773 at 75℃	870 at 75℃	796 at 75℃
AC Resistance	Ω/km	0.0652	0.0516	0.0616

- Conventional ACSR is Blue Jay, which is widely used for 220kV transmission lines in Tanzania.

(2) Low-loss conductor (Evaluation method)

✓ Unit price of Transmission line

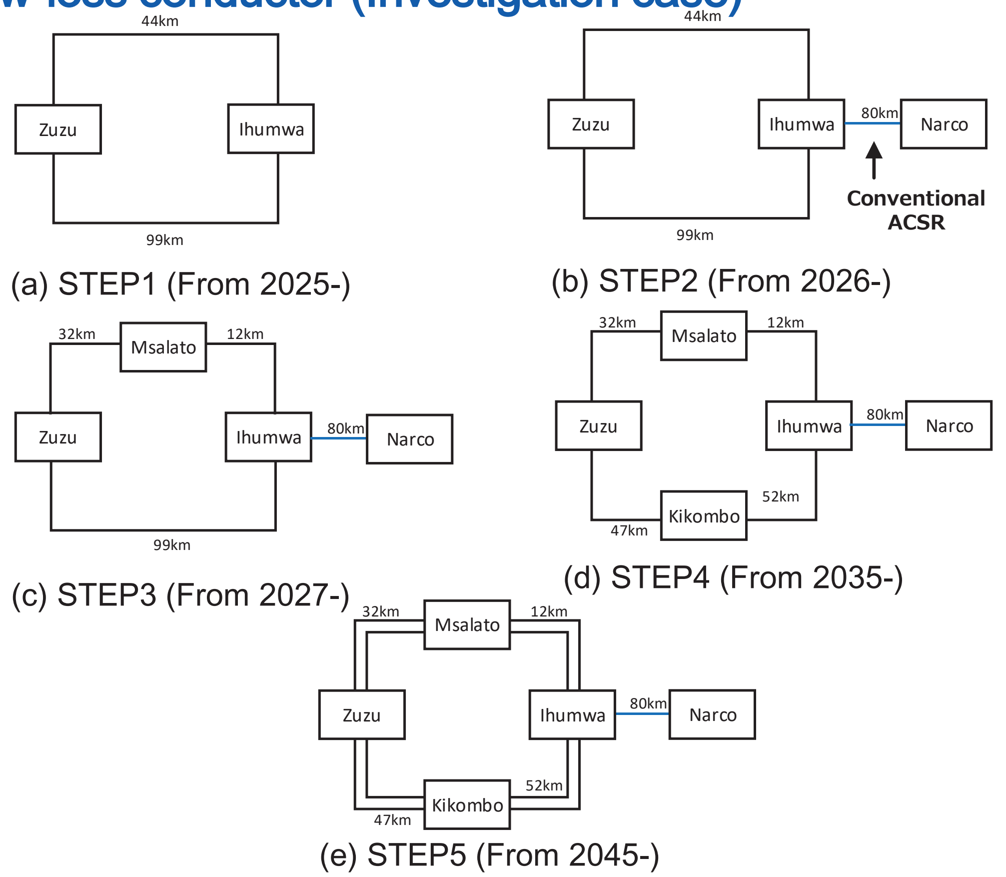
Transmission line type	Price(USD/m)
Conventional ACSR(Blue Jay)	9.1
LL-ACSR/AS($719mm^2$)	10.8
LL-ACSR/AS($600/29mm^2$)	9.4

✓ Unit price of Power generation

The unit price of power generation was determined from the fuel costs and repair costs for power generation and the amount of power generated. → 0.1 USD/kwh

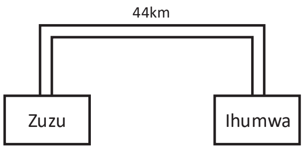
✓ The power generation cost corresponding to the loss amount of each year was added to the transmission line cost (initial cost), and pay back period was investigated.

(2) Low-loss conductor (Investigation case)

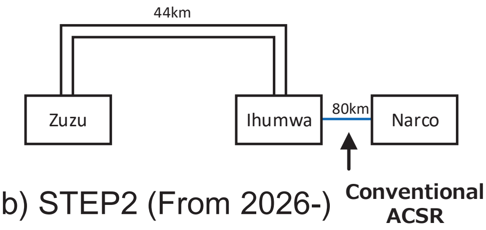


Scenario-1 Stepwise Development

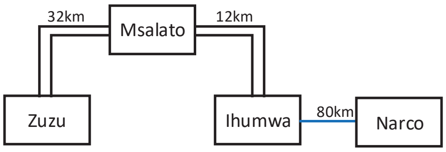
(2) Low-loss conductor (Investigation case)



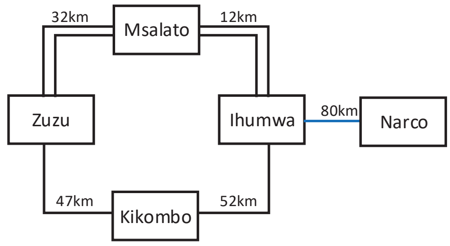
(a) STEP1 (From 2025-)



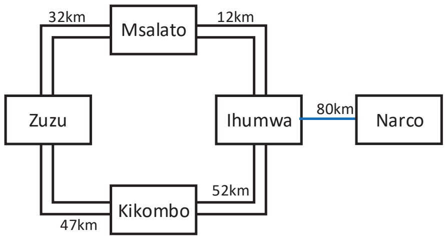
(b) STEP2 (From 2026-)



(c) STEP3 (From 2027-)



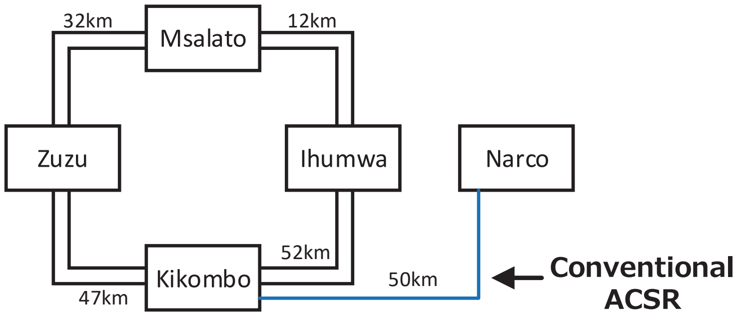
(d) STEP4 (From 2035-)



(e) STEP5 (From 2045-)

Scenario-2 Stepwise Development

(2) Low-loss conductor (Investigation case)



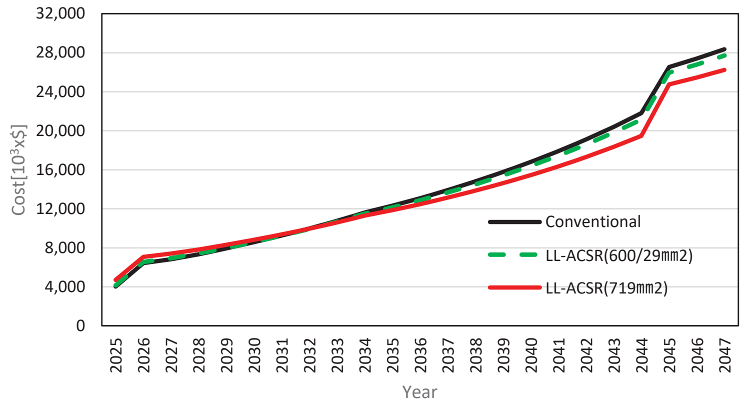
(From 2025-)

Scenario-3 One-time Development

(2) Low-loss conductor (Investigation case)

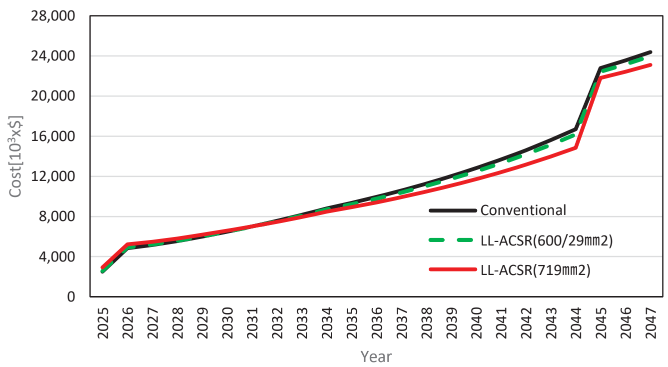
Cost of construction for transmission equipment and recovery year

Scenario	LL-ACSR/AS(719mm^2)	LL-ACSR/AS(600/29mm^2)
Scenario-1	2032	2031
Scenario-2	2032	2030
Scenario-3	2046	2043

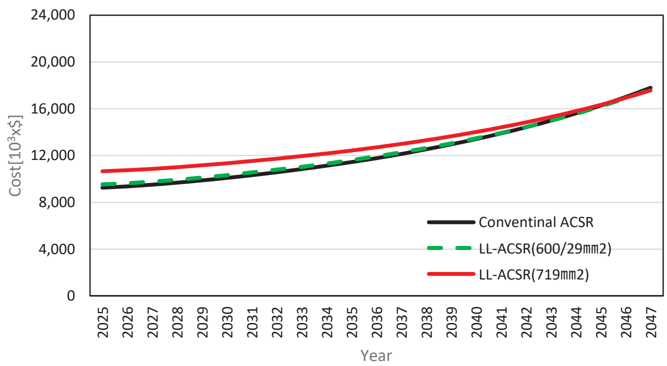


Recovery year of low-loss conductor (Scenario-1)

(2) Low-loss conductor (Investigation case)



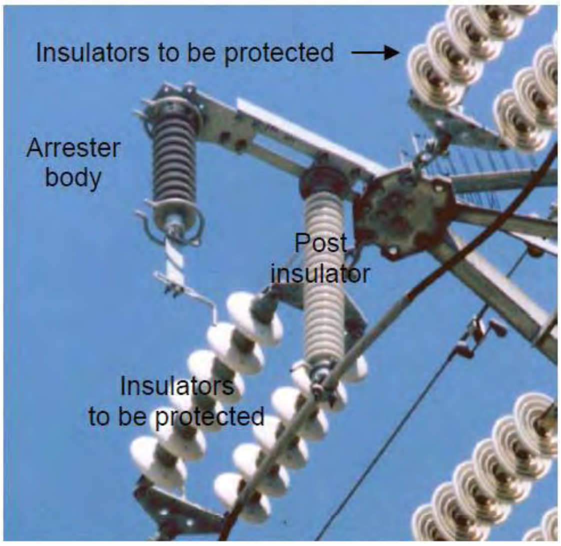
Recovery year of low-loss conductor (Scenario-2)



Recovery year of low-loss conductor (Scenario-3)

(3) External Gapped Transmission Line arresters(EGLA)

- When a lightning strikes transmission tower or power line conductor, transient overvoltage will be induced across the insulator.

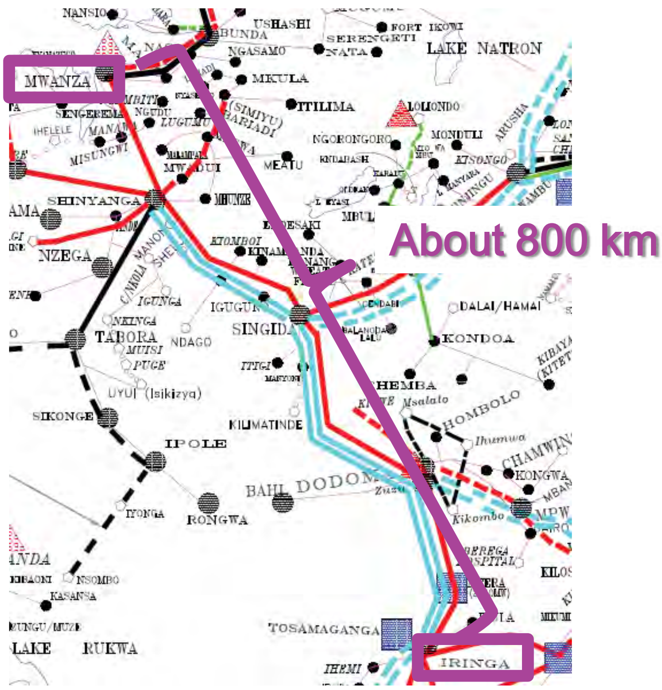


Source: Based on Technical paper

EGLA for 77 kV System

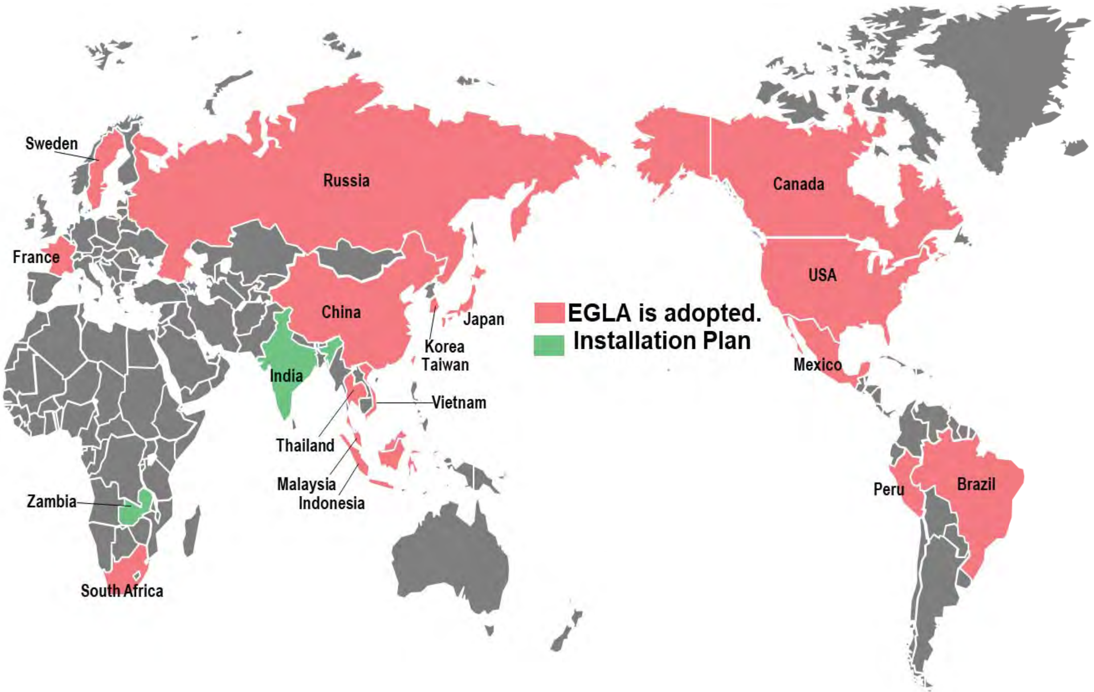
- EGLA, consisting of arrester body and series air gap, is installed in parallel with the insulator to be protected.
- EGLA can **prevent instantaneous voltage drop and power outages due to permanent ground faults.**

(3) External Gapped Transmission Line arresters(EGLA)



- There are no arc horn for about 800 km from IRINGA to MWANZA on transmission tower.
- In order to increase system reliability, additional installation of arc horns and EGLA are recommended.

(3) External Gapped Transmission Line arresters(EGLA)



Applicable situation of EGLA in the world

- External Gapped Transmission Line Arresters are currently used in over 20 countries in the world

(3) External Gapped Transmission Line arresters(EGLA)

1) Improve power reliability by preventing power outages
→ Reducing economic losses

2) Securing sales for electric utilities by preventing power outages

3) Reduce maintenance costs by preventing damage
to transmission line equipment

4) Application cost of EGLA

To Consider cost-effectiveness

(3) External Gapped Transmission Line arresters(EGLA)

1) Improve power reliability by preventing power outages
→ Reducing economic losses

[Conditions]

Item	Conditions
Supply Capacity	100MVA
Annual Power outage time (C)	0.33hr(20min.)*1
Failure rate due to lightning(D)	42.7%*2
Operation period(E)	20 years

*1:Annual Power outage time: Data quote from SAIDI (System Average Interruption Duration Index)
*2: Failure rate due to lightning (D): Report of Central Research Institute of Electric Power Industry in Japan, T72, Guide to Lightning Protection Design for Transmission lines (2003)

Number of customers supplying 100MVA and the amount of damage per customer for one hour of power outage

Consumer	Number of customers(A)*3	Impact of power outage(B)*4
General(2kW)	10,000(95.6%)	16$
Low Voltage (50kW)	400(3.8%)	2000$
High Voltage (500kW)	40(0.38%)	10,000$
Extra High Voltage(200kW)	20(0.19%)	69,091$

*3: Number of customers: Assumed based on cases of Japanese electric power companies
*4: Impact of power outage (B) : Report of Central Research Institute of Electric Power Industry in Japan, (2007), Impact of Supply Reliability and Blackout on Residential and Business Customers of Electric Power Companies in Japan

(3) External Gapped Transmission Line arresters(EGLA)

1) Improve power reliability by preventing power outages

[Economic loss estimation]

Economic loss was estimated by the following formula;.

Economic loss = Number of customers (A) x Impact of power outage (B) x Annual power outage time (C) xFailure rate due to lightning(D) x Operation period(E)

↓

About 7.7 million $

(3) External Gapped Transmission Line arresters(EGLA)

2) Securing sales for electric utilities by preventing power outages

[Conditions]

Item	Conditions
Supply Capacity(A)	100 MVA
Average load(B)	70%
Annual Power outage time(C)	0.33hr(20min.)

Item	Conditions
Failure rate due to lightning(D)	42.7%
Electricity charge(E)	¥30/kWh(0.3$/kWh)
Operation period(F)	20years

[Loss estimation due to power failure]

Loss due to power failure = Supply Capacity (A) x Average load (B) x Annual Power outage time (C) x Failure rate due to lightning(D) x Electricity charge (E) x Operation period(F)

About 50 thousand $

(3) External Gapped Transmission Line arresters(EGLA)

3) Reduce maintenance costs by preventing damage to transmission line equipment

[Conditions]

Item	Conditions
Number of accidents(A)	2times / year
Maintenance worker (B)	7people
Labor costs (C)	50,000yen / person day

Item	Conditions
Repair days (D)	3days
Operation period (E)	20years

[Estimation of maintenance cost]

Maintenance cost = Number of accidents (A) x Maintenance worker (B) x Labor costs (C) x Repair days(D) x Operation period(E)

About 364 thousand $

(3) External Gapped Transmission Line arresters(EGLA)

3) Reduce maintenance costs by preventing damage to transmission line equipment

[Conditions]

Item	Conditions
Number of accidents(A)	2times / year
Maintenance worker (B)	7people
Labor costs (C)	50,000yen / person day

Item	Conditions
Repair days (D)	3days
Operation period (E)	20years

[Estimation of maintenance cost]

Maintenance cost = Number of accidents (A) x Maintenance worker (B) x Labor costs (C) x Repair days(D) x Operation period(E)

About 364 thousand $

(3) External Gapped Transmission Line arresters(EGLA)

4) Application cost of EGLA

[Conditions]

Item	Conditions
Voltage	220kV
Transmission line length	44km
Number of transmission tower	130

Item	Conditions
Number of installed EGLA	390 (installed EGLA for one line)
Specification for EGLA	IEC60099-8, Class Y2 With External gap

[Application cost]

Estimated unit price of EGLA : 3273 $ - 3636 $

(Depending on the manufacturer)

Applicable cost of EGLA : 1.3million$ - 1.5million$

(3) External Gapped Transmission Line arresters(EGLA)

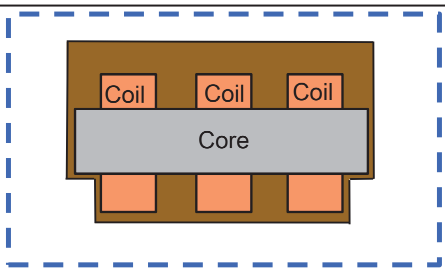
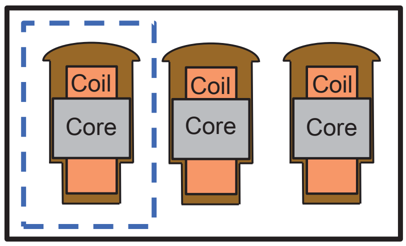
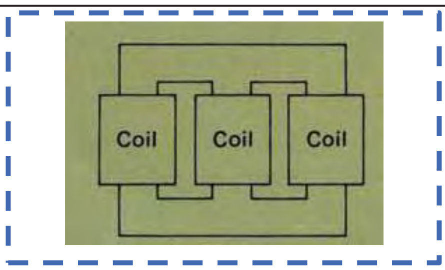
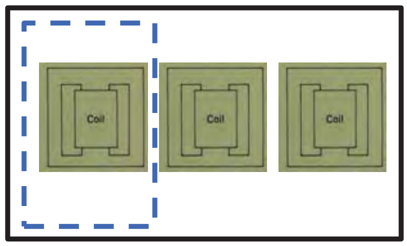
Consider cost-effectiveness

Loss reduction cost by applying EGLA: 8.2$

Applicable cost of EGLA : 1.3million$ - 1.5million$

- As a result of the trial calculation, it was confirmed that the application of EGLA improves the power quality and reduces the maintenance cost, so the economic effect is great.
- We would like to evaluate the economic efficiency when applied to the Dodoma urban area.

(4) Special 3 phase transformer

	Ordinary	Special 3 phase
Shell Type		
Core Type		

: Shipping size

- Special 3 phase transformer can be applied to areas where transportation weight is limited and transportation methods are specified.

(4) Special 3 phase transformer

- Some 220kV, 100MVA transformer are planned to be installed in Ifumwa substation.
- The candidate site of Ihumwa substation, is planned to develop roads around the substation in the future, so that there are no major restrictions on transportation.
- However, Tanzania is taxed according to the weight and volume of the equipment, therefore, the application merit of applying special three-phase transformer will be examined.

Specification of Transformer

Item	Specification
Voltage	220kV
Capacity	100MVA
Cooling system	ONAN/ONAF
Primary voltage	220kV±10×1.25%
Secondary voltage	33kV
Tertiary voltage	6.9kV(arbitrarily)
Vector group	YNyn0(d)
LIWV	HV : 1050kV HVN : 95kV LV : 170kV
AC	HV : 460kVrms HVN : 38kVrms LV : 70kVrms
%Z	13%
Elevation	1200m

(4) Special 3 phase transformer

Comparison results between Ordinary transformer and Special three phase transformer(Example : Core type)

		Ordinary	Special three phase	
			Phase V (with OLTC)	Phase U, W
Transport dimensions (mm)	W	3,000	3,000	3,000
	L	8,200	4,800	3,700
	H	4,200	3,700	3,700
Transport mass (ton)		**88**	**50**	**47**
Number of tank divisions		1	3	

- the ordinary transformer has a transport mass of 88 tons, and the special three-phase transformer has a maximum transport mass of 50 tons.
- We would like to evaluate the economic efficiency with the sum of taxes and transformer cost.

(5) Low-loss transformer

- Low-loss transformer with low-loss silicon steel sheet as the core material

Source: Based on manufacture catalog

765kV Class Power Transformer

(5) Low-loss transformer

- For special three-phase transformers and ordinary transformers, the loss was studied when Silicon steel sheet and **Low-loss silicon steel sheet (Magnetic domain finely oriented silicon steel sheet)**were applied to the transformer core.

Specification of Transformer

Item	Specification
Voltage	220kV
Capacity	100MVA
Cooling system	ONAN/ONAF
Primary voltage	220kV±10×1.25%
Secondary voltage	33kV
Tertiary voltage	6.9kV(arbitrarily)

Comparison of Transformer losses (Example)

	Silicon steel sheet	Low-loss silicon steel sheet (Japanese manufacture)
Ordinary	80kW	50kW
Special 3 phase	90kW	53kW

Thank you for your kind attention

Attachment 4. Demand Forecast for Scenario Formation (Reference)

Load allocation for each substations (Scenario 1&2)

Zuzu

MW

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Town	7.49	8.09	8.73	9.43	10.17	10.97	11.83	12.76	13.76	14.84	16.00	16.51	17.05	17.64	18.28	18.96	19.70	20.49	21.35	22.11	22.91	23.77	24.68	25.65	26.68	27.78	28.95	30.19	31.52
Inter connect	6.04	6.52	7.04	7.61	8.20	8.85	9.54	10.29	11.10	11.97	12.91	13.32	13.76	14.23	14.74	15.29	15.89	16.53	17.22	17.83	18.48	19.17	19.91	20.69	21.52	22.41	23.35	24.35	25.42
Mzakwe	2.21	2.39	2.58	2.79	3.01	3.24	3.497	3.77	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mwandani	4.87	5.26	5.68	6.13	6.62	7.14	7.696	8.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chamwino	4.33	4.68	5.05	5.46	5.89	6.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mpwapwa	7.41	8.00	8.64	9.33	10.06	10.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bahi	0.68	0.74	0.80	0.86	0.93	1.00	1.08	1.16	1.25	1.35	1.46	1.50	1.55	1.61	1.67	1.73	1.80	1.87	1.95	2.02	2.09	2.17	2.25	2.34	2.43	2.53	2.64	2.75	2.87
Indusrial	-	2.16	4.32	6.48	8.64	10.80	12.96	15.12	17.28	19.44	21.60	22.28	23.02	23.81	24.67	25.59	26.59	27.66	28.82	29.84	30.93	32.08	33.31	34.62	36.01	37.49	39.07	40.75	42.54
TPDF quarters	-	0.12	0.24	0.36	0.48	0.60	0.72	0.84	0.96	1.08	1.20	1.24	1.28	1.32	1.37	1.42	1.48	1.54	1.60	1.66	1.72	1.78	1.85	1.92	2.00	2.08	2.17	2.26	2.36
EPZ	-	0.96	1.92	2.88	3.84	4.80	5.76	6.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Airport	-	0.72	1.44	2.16	2.88	3.60	4.32	5.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dry port	-	0.06	0.12	0.18	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marshalling yard	-	0.14	0.29	0.43	0.58	0.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
State house	-	0.06	0.12	0.18	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butcher	-	0.06	0.12	0.18	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quaters 40000	-	0.19	0.38	0.58	0.77	0.96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Goverment City	-	6.00	12.01	18.01	24.02	30.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Capacity(MW)	33.04	46.16	59.49	73.04	86.79	100.79	57.40	64.00	44.35	48.68	53.17	54.85	56.66	58.62	60.72	63.00	65.45	68.09	70.94	73.45	76.13	78.97	82.00	85.22	88.65	92.30	96.18	100.31	104.71
Total Capacity(MVA)	41.30	57.70	74.36	91.31	108.49	125.99	71.75	80.00	55.44	60.85	66.46	68.56	70.83	73.27	75.91	78.75	81.81	85.11	88.68	91.82	95.16	98.72	102.50	106.53	110.81	115.37	120.23	125.39	130.88

Msalato

MW

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
EPZ	-	-	-	-	-	-	-	-	7.68	8.64	9.6	9.903	10.23	10.58	10.96	11.37	11.82	12.29	12.81	13.26	13.74	14.26	14.8	15.39	16.01	16.66	17.37	18.11	18.9
Airport	-	-	-	-	-	-	-	-	5.76	6.48	7.2	7.427	7.673	7.937	8.223	8.53	8.862	9.22	9.606	9.946	10.31	10.69	11.1	11.54	12	12.5	13.02	13.58	14.18
Mzakwe	-	-	-	-	-	-	-	-	4.067	4.386	4.73	4.88	5.041	5.215	5.402	5.604	5.822	6.058	6.311	6.535	6.773	7.026	7.295	7.582	7.887	8.211	8.557	8.924	9.315
Mwandani	-	-	-	-	-	-	-	-	8.951	9.654	10.41	10.74	11.09	11.48	11.89	12.34	12.81	13.33	13.89	14.38	14.91	15.46	16.06	16.69	17.36	18.07	18.83	19.64	20.5
Total Capacity(MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.46	29.16	31.94	32.95	34.04	35.21	36.48	37.84	39.32	40.90	42.62	44.13	45.73	47.44	49.26	51.19	53.25	55.45	57.78	60.26	62.90
Total Capacity(MVA)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.07	36.45	39.93	41.19	42.55	44.02	45.60	47.30	49.14	51.13	53.27	55.16	57.16	59.30	61.57	63.99	66.57	69.31	72.22	75.32	78.63

Ihumwa

MW

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Dry port	-	-	-	-	-	-	0.36	0.42	0.48	0.54	0.6	0.619	0.639	0.661	0.685	0.711	0.739	0.768	0.801	0.829	0.859	0.891	0.925	0.962	1	1.042	1.085	1.132	1.182
Marshalling yard	-	-	-	-	-	-	0.864	1.008	1.152	1.296	1.44	1.485	1.535	1.587	1.645	1.706	1.772	1.844	1.921	1.989	2.062	2.139	2.221	2.308	2.401	2.5	2.605	2.717	2.836
State house	-	-	-	-	-	-	0.36	0.42	0.48	0.54	0.6	0.619	0.639	0.661	0.685	0.711	0.739	0.768	0.801	0.829	0.859	0.891	0.925	0.962	1	1.042	1.085	1.132	1.182
Butcher	-	-	-	-	-	-	0.36	0.42	0.48	0.54	0.6	0.619	0.639	0.661	0.685	0.711	0.739	0.768	0.801	0.829	0.859	0.891	0.925	0.962	1	1.042	1.085	1.132	1.182
Quaters 40000	-	-	-	-	-	-	1.152	1.344	1.536	1.728	1.92	1.981	2.046	2.117	2.193	2.275	2.363	2.459	2.562	2.652	2.749	2.852	2.961	3.077	3.201	3.333	3.473	3.622	3.781
Goverment City	-	-	-	-	-	-	36.03	42.03	48.04	54.04	60.05	61.94	63.99	66.2	68.58	71.14	73.91	76.9	80.12	82.95	85.97	89.18	92.6	96.24	100.1	104.2	108.6	113.3	118.2
Chamwino	-	-	-	-	-	-	6.846	0.22	0.24	0.258	0.278	0.287	0.296	0.306	0.317	0.329	-	-	-	-	-	-	-	-	-	-	-	-	-
Mpwapwa	-	-	-	-	-	-	11.7	0.38	0.41	0.44	0.475	0.49	0.506	0.523	0.542	0.563	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Capacity(MW)	0.00	0.00	0.00	0.00	0.00	0.00	57.67	46.25	52.81	59.39	65.96	68.04	70.29	72.72	75.33	78.15	80.26	83.50	87.00	90.08	93.36	96.85	100.56	104.51	108.72	113.19	117.95	123.02	128.41
Total Capacity(MVA)	0.00	0.00	0.00	0.00	0.00	0.00	72.09	57.81	66.02	74.23	82.45	85.06	87.86	90.89	94.16	97.69	100.33	104.38	108.75	112.60	116.70	121.06	125.70	130.64	135.90	141.49	147.44	153.77	160.51

Kikombo

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Chamwino	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	4.10	4.27	4.45	4.61	4.77	4.95	5.14	5.34	5.56	5.79	6.03	6.29	6.57
Mpwapwa	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	7.01	7.30	7.60	7.87	8.16	8.46	8.79	9.13	9.50	9.89	10.31	10.75	11.22
Total Capacity(MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.12	11.57	12.05	12.48	12.93	13.41	13.93	14.48	15.06	15.68	16.34	17.04	17.79
Total Capacity(MVA)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.90	14.46	15.06	15.60	16.16	16.77	17.41	18.10	18.82	19.60	20.42	21.30	22.23

Naroco

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Chamwino	-	-	-	-	-	-	-	7.16	7.72	8.33	8.98	9.27	9.57	9.90	10.26	10.64	7.30	7.59	7.91	8.19	8.49	8.80	9.14	9.50	9.88	10.29	10.72	11.18	11.67
Mpwapwa	-	-	-	-	-	-	-	12.24	13.20	14.23	15.35	15.84	16.36	16.92	17.53	18.19	12.47	12.97	13.51	13.99	14.50	15.04	15.62	16.23	16.89	17.58	18.32	19.11	19.95
Total Capacity(MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.40	20.92	22.57	24.34	25.10	25.93	26.83	27.79	28.83	19.76	20.56	21.42	22.18	22.99	23.85	24.76	25.74	26.77	27.87	29.04	30.29	31.62
Total Capacity(MVA)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.25	26.15	28.21	30.42	31.38	32.42	33.54	34.74	36.04	24.70	25.70	26.78	27.73	28.74	29.81	30.95	32.17	33.46	34.84	36.31	37.87	39.52

Load allocation for each substations (Scenario 3)

Zuzu

MW

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Town	7.49	8.09	8.73	9.43	10.17	10.97	11.83	12.76	13.76	14.84	16.00	16.51	17.05	17.64	18.28	18.96	19.70	20.49	21.35	22.11	22.91	23.77	24.68	25.65	26.68	27.78	28.95	30.19	31.52
Inter connect	6.04	6.52	7.04	7.61	8.20	8.85	9.54	10.29	11.10	11.97	12.91	13.32	13.76	14.23	14.74	15.29	15.89	16.53	17.22	17.83	18.48	19.17	19.91	20.69	21.52	22.41	23.35	24.35	25.42
Mzakwe	2.21	2.39	2.58	2.79	3.01	3.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mwandani	4.87	5.26	5.68	6.13	6.62	7.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chamwino	4.33	4.68	5.05	5.46	5.89	6.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mpwapwa	7.41	8.00	8.64	9.33	10.06	10.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bahi	0.68	0.74	0.80	0.86	0.93	1.00	1.08	1.16	1.25	1.35	1.46	1.50	1.55	1.61	1.67	1.73	1.80	1.87	1.95	2.02	2.09	2.17	2.25	2.34	2.43	2.53	2.64	2.75	2.87
Indusrial	-	2.16	4.32	6.48	8.64	10.80	12.96	15.12	17.28	19.44	21.60	22.28	23.02	23.81	24.67	25.59	26.59	27.66	28.82	29.84	30.93	32.08	33.31	34.62	36.01	37.49	39.07	40.75	42.54
TPDF quarters	-	0.12	0.24	0.36	0.48	0.60	0.72	0.84	0.96	1.08	1.20	1.24	1.28	1.32	1.37	1.42	1.48	1.54	1.60	1.66	1.72	1.78	1.85	1.92	2.00	2.08	2.17	2.26	2.36
EPZ	-	0.96	1.92	2.88	3.84	4.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Airport	-	0.72	1.44	2.16	2.88	3.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dry port	-	0.06	0.12	0.18	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marshalling yard	-	0.14	0.29	0.43	0.58	0.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
State house	-	0.06	0.12	0.18	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butcher	-	0.06	0.12	0.18	0.24	0.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quaters 40000	-	0.19	0.38	0.58	0.77	0.96	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Goverment City	-	6.00	12.01	18.01	24.02	30.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Capacity(MW)	33.04	46.16	59.49	73.04	86.79	100.79	36.13	40.17	44.35	48.68	53.17	54.85	56.66	58.62	60.72	63.00	65.45	68.09	70.94	73.45	76.13	78.97	82.00	85.22	88.65	92.30	96.18	100.31	104.71
Total Capacity(MVA)	41.30	57.70	74.36	91.31	108.49	125.99	45.16	50.21	55.44	60.85	66.46	68.56	70.83	73.27	75.91	78.75	81.81	85.11	88.68	91.82	95.16	98.72	102.50	106.53	110.81	115.37	120.23	125.39	130.88

Msalato

MW

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
EPZ	-	-	-	-	-	-	5.76	6.72	7.68	8.64	9.60	9.90	10.23	10.58	10.96	11.37	11.82	12.29	12.81	13.26	13.74	14.26	14.80	15.39	16.01	16.66	17.37	18.11	18.90
Airport	-	-	-	-	-	-	4.32	5.04	5.76	6.48	7.20	7.43	7.67	7.94	8.22	8.53	8.86	9.22	9.61	9.95	10.31	10.69	11.10	11.54	12.00	12.50	13.02	13.58	14.18
Mzakwe	-	-	-	-	-	-	3.50	3.77	4.07	4.39	4.73	4.88	5.04	5.21	5.40	5.60	5.82	6.06	6.31	6.53	6.77	7.03	7.30	7.58	7.89	8.21	8.56	8.92	9.32
Mwandani	-	-	-	-	-	-	7.70	8.30	8.95	9.65	10.41	10.74	11.09	11.48	11.89	12.34	12.81	13.33	13.89	14.38	14.91	15.46	16.06	16.69	17.36	18.07	18.83	19.64	20.50
Total Capacity(MW)	0.0	0.0	0.0	0.0	0.0	0.0	21.27	23.83	26.46	29.16	31.94	32.95	34.04	35.21	36.48	37.84	39.32	40.90	42.62	44.13	45.73	47.44	49.26	51.19	53.25	55.45	57.78	60.26	62.90
Total Capacity(MVA)	0.0	0.0	0.0	0.0	0.0	0.0	26.59	29.79	33.07	36.45	39.93	41.19	42.55	44.02	45.60	47.30	49.14	51.13	53.27	55.16	57.16	59.30	61.57	63.99	66.57	69.31	72.22	75.32	78.63

Ihumwa

MW

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Dry port	-	-	-	-	-	-	0.36	0.42	0.48	0.54	0.60	0.62	0.64	0.66	0.69	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.09	1.13	1.18
Marshalling yard	-	-	-	-	-	-	0.86	1.01	1.15	1.30	1.44	1.49	1.53	1.59	1.64	1.71	1.77	1.84	1.92	1.99	2.06	2.14	2.22	2.31	2.40	2.50	2.60	2.72	2.84
State house	-	-	-	-	-	-	0.36	0.42	0.48	0.54	0.60	0.62	0.64	0.66	0.69	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.09	1.13	1.18
Butcher	-	-	-	-	-	-	0.36	0.42	0.48	0.54	0.60	0.62	0.64	0.66	0.69	0.71	0.74	0.77	0.80	0.83	0.86	0.89	0.93	0.96	1.00	1.04	1.09	1.13	1.18
Quaters 40000	-	-	-	-	-	-	1.15	1.34	1.54	1.73	1.92	1.98	2.05	2.12	2.19	2.27	2.36	2.46	2.56	2.65	2.75	2.85	2.96	3.08	3.20	3.33	3.47	3.62	3.78
Goverment City	-	-	-	-	-	-	36.03	42.03	48.04	54.04	60.05	61.94	63.99	66.20	68.58	71.14	73.91	76.90	80.12	82.95	85.97	89.18	92.60	96.24	100.1	104.2	108.6	113.3	118.2
Chamwino	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mpwapwa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Capacity(MW)	0.0	0.0	0.0	0.0	0.0	0.0	39.12	45.65	52.17	58.69	65.21	67.27	69.49	71.89	74.47	77.26	80.26	83.50	87.00	90.08	93.36	96.85	100.56	104.51	108.72	113.19	117.95	123.02	128.41
Total Capacity(MVA)	0.0	0.0	0.0	0.0	0.0	0.0	48.91	57.06	65.21	73.36	81.51	84.08	86.86	89.86	93.09	96.57	100.33	104.38	108.75	112.60	116.70	121.06	125.70	130.64	135.90	141.49	147.44	153.77	160.51

Kikombo

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Chamwino	-	-	-	-	-	-	2.46	2.66	2.87	3.09	3.33	3.44	3.55	3.68	3.81	3.95	4.10	4.27	4.45	4.61	4.77	4.95	5.14	5.34	5.56	5.79	6.03	6.29	6.57
Mpwapwa	-	-	-	-	-	-	4.21	4.54	4.90	5.28	5.70	5.88	6.07	6.28	6.51	6.75	7.01	7.30	7.60	7.87	8.16	8.46	8.79	9.13	9.50	9.89	10.31	10.75	11.22
Total Capacity(MW)	0.00	0.00	0.00	0.00	0.00	0.00	6.68	7.20	7.77	8.37	9.03	9.32	9.63	9.96	10.31	10.70	11.12	11.57	12.05	12.48	12.93	13.41	13.93	14.48	15.06	15.68	16.34	17.04	17.79
Total Capacity(MVA)	0.00	0.00	0.00	0.00	0.00	0.00	8.35	9.00	9.71	10.47	11.29	11.65	12.03	12.45	12.89	13.38	13.90	14.46	15.06	15.60	16.16	16.77	17.41	18.10	18.82	19.60	20.42	21.30	22.23

Naroco

Load	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
Chamwino	-	-	-	-	-	-	4.38	4.73	5.10	5.50	5.93	6.11	6.32	6.53	6.77	7.02	7.30	7.59	7.91	8.19	8.49	8.80	9.14	9.50	9.88	10.29	10.72	11.18	11.67
Mpwapwa	-	-	-	-	-	-	7.49	8.07	8.71	9.39	10.13	10.45	10.79	11.17	11.57	12.00	12.47	12.97	13.51	13.99	14.50	15.04	15.62	16.23	16.89	17.58	18.32	19.11	19.95
Total Capacity(MW)	0.00	0.00	0.00	0.00	0.00	0.00	11.87	12.80	13.80	14.89	16.06	16.56	17.11	17.70	18.34	19.02	19.76	20.56	21.42	22.18	22.99	23.85	24.76	25.74	26.77	27.87	29.04	30.29	31.62
Total Capacity(MVA)	0.00	0.00	0.00	0.00	0.00	0.00	14.84	16.00	17.26	18.61	20.07	20.71	21.39	22.13	22.92	23.78	24.70	25.70	26.78	27.73	28.74	29.81	30.95	32.17	33.46	34.84	36.31	37.87	39.52