United Republic of Tanzania

Ministry of Energy and Minerals

POWER SYSTEM MASTER PLAN
2016 UPDATE

December 2016

LIST OF ABBREVIATIONS

Advanced Sub-C	Advanced subcritical
AfDB	African Development Bank
bbl	blue barrel (US unit)
CCGTs	Combined-cycle gas turbines
CCT	Circuit
CO	Carbon monoxide
CO_2	Carbon dioxide
CRIDF	Climate Resilient Infrastructure Development Facility
DC	Direct Current
DME	Dimethyl Ether
DSM	Dar es Salaam
EE&C	Energy efficiency and conservation
EGC	Energy generation capability
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
EWURA	Energy and Water Utilities Regulatory Authority
F/S	Feasibility Study
FDI	Foreign Direct Investment
FOR	Forced outage rate
FYDP	Five Year Development Plan
GDP	Gross Domestic Product
GHG	Greenhouse gases
GWh	Gigawatt-hours = 1,000,000,000 watt-hours
GT	Gas Turbine
GTL	Gas to Liquids
HFO	Heavy Fuel Oil
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IPP	Independent Power Producer
IPTL	Independent Power Tanzania Limited
kWh	Kilowatt-hours = 1,000 watt-hours

JICA	Japan International Cooperation Agency
kA	kilo Ampere
kJ	kilo Joule
kV	Kilo Volt
kWh	Kilowatt-hours = 1,000 watt-hours
LGAs	Local Government Authorities
LNG	Liquefied Natural Gas
LOLP	Loss Of Load Probability
LTPP	Long Term Perspective Plan
MEM	Ministry of Energy and Minerals
mmBtu	Million British thermal Unit
MOF	Ministry of Finance
MUSD	Million United States Dollar
MVA	Mega Volt Ampere
MVar	Mega Volt Ampere Reactive
MW	Megawatt = 1,000,000 watts
MWh	Megawatt-hours = 1,000,000 watt-hours
N/A	Not Applicable
NBS	National Bureau of Statistics
NDC	National Development Corporation
NEAC	National Environmental Advisory Committee
NEMC	National Environment Management Council
NGUMP	Natural Gas Utilization Master Plan
NOx	Nitrogen oxides
OECD	Organization for Economic Co-operation and Development
O&M	Operation and Maintenance
P/S	Power Station
PM	Particulate Matter
PSMP	Power System Master Plan
REA	Rural Energy Agency
RUBADA	Rufiji Basin Development Authority
SC	Super-Critical
SCR	Selective Catalytic Reduction

SEA	Strategic Environmental Assessments
SNC	SNC-Lavalin International Inc.
SNCR	Selective noncatalytic reduction
SO_2	Sulfur dioxide
SPP	Small Power Project
SVC	Static Var Compensator
TANAPA	Tanzania National Parks Authority
TANESCO	Tanzania Electric Supply Company Limited
TANWAT	Tanzania Wattle Company
TBS	Tanzania Bureau of Standards
Tcf	Trillion cubic feet
T/D	Transmission and Distribution
TPDC	Tanzania Petroleum Development Corporation
Tr	Transformer
TZS	Tanzanian Shillings
USA	United States of America
USC	Ultra-Super-Critical
USD	United States Dollar
US$	United States Dollar
WASP	Wien Automatic System Planning Package
WB	World Bank
WMAs	Wildlife Management Areas
WTI	West Texas Intermediate

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ACKNOWLEDGEMENT

The 2016 PSMP Update is a joint effort by inter-governmental institutions which spent thirty months working hard and tirelessly to come up with this review. The entire work was carried out by a team of experts from Ministry of Energy and Minerals (MEM), National Bureau of Statistics (NBS), Rural Energy Agency (REA), Tanzania Electric Supply Company (TANESCO), Tanzania Petroleum Development Corporation (TPDC), Energy and Water Utilities Regulatory Authority (EWURA) and Japan International Cooperation Agency (JICA) through the Consultant, Yachiyo Engineering Co., Ltd. (YEC). The work was carried out from June 2014 to December 2016.

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CHAPTER ONE

1 INTRODUCTION

1.1 Purpose and Scope

The 2016 Power System Master Plan (PSMP) reflects and accommodates recent development in the economy, including development in the gas sub sector as well as government policy guidelines. The policy guidelines include, among others the desire by the government to accelerate economic growth through the Vision 2025, MKUKUTA and the Five Year Development Plan–II (2016/17-2020/21, FYDP-II). The government also aims to expedite economic growth by means of the revival and renovation of industries.

“Among the outcomes associated with the attainment of these objectives, FYDP 2016/17-2020/21 will raise annual real GDP growth to 10 percent by 2021 (from 7.0 percent in 2015), per capita income to US$ 1,500 (from US$ 1,043in 2014) and reduction of the poverty rate to 16.7 percent from 28.2 percent recorded in 2011/12. The Plan also envisages raising FDI flows from US$ 2.14 billion in 2014 to over US$ 9.0 billion by 2021; increase electricity generation from 1,501MW in 2015 to 4,915MW by 2020 and improving electricity connections to 60 percent of the population, up from 36 percent in 2015. On average, manufacturing sector will grow by over 10 percent per annum with its share in total exports increasing from 24 percent in 2014/15 to 30 percent in 2020.” The government vision is to become a middle income country by 2025 with electricity consumption of 490kWh/capita.

The fundamental objective is also to attain stable power supply in order to achieve Economic Growth, Energy Security and Environmental Protection. The government of Tanzania set the maximum target to reduce poverty by achieving high economic growth, which could be achieved through a stable and efficient power system.

The overall objective of the Plan is to re-assess short-term (2016 - 2020), mid-term (2021 - 2025) and long term (2026 - 2040), generation and transmission plans requirements and the need for connecting presently off-grid regions, options for power exchanges with neighboring countries, and increased supply of reliable power. While the short-term plan requires immediate decision and actions, the mid - long term plans require coordinated planning and project development studies to ensure that future electricity supply utilizes the least cost projects in consistent with sound planning criteria in order to address national interests. This report has been prepared drawing inference on specific data items or detailed procedures in the previous PSMP 2008 and the subsequent 2009 and 2012 Update studies.

In 2008, a Power System Master Plan (PSMP) was developed by the consultant SNC - Lavalin of Canada for the Government of Tanzania, through TANESCO, to provide a fundamentally new plan to guide the development of the power system in Tanzania for the next 25 years. The study provided a detailed assessment of load demand projections, available options for meeting the demand and requirements for a new higher voltage backbone transmission system for the country.

The Plan was updated in 2009 by MEM and TANESCO with the technical support from the SNC - Lavalin consultant which reviewed the progress and challenges encountered during the first year of implementation. The 2012 Update was conducted by technical staffs from MEM, TANESCO, President's Office - Planning Commission, Ministry of Finance, TPDC, EWURA, REA and NBS. The Plan has also incorporated comments from various stakeholders. This PSMP 2016 Update was also conducted by the same technical team with technical assistance from Japan International Cooperation Agency (JICA). The PSMP 2016 Update covers the following main components:

a) Revised load forecast based on the current situation and updated expectations;
b) Reassessment of the short-term, mid-term and long-term generation plan;
c) Update of the transmission plan to reflect the update in plans for connecting presently isolated regions and increased generation capacities;
d) Environmental and social considerations for proposed projects; and
e) Economic and financial analysis

1.2 Scope of the work

The following five primary components underlie the PSMP 2016 Update study:

a) Confirmation of planning criterion;
b) Load forecast update including the collection of past and future power demand in all regions;
c) Generation plan update, including updating and confirming data on all generation sources, existing and future options;
d) Transmission plan update, including ongoing additions and reinforcement to the existing system, taking into account the interconnection of presently isolated areas to the national grid, and options for import from neighboring countries;
e) Mitigation measures on environmental and social impact from planned power development projects;
f) Investment plans and financial analysis on planned power projects; and
g) Preparing a new PSMP 2016 Update report.

1.3 Information collected for the PSMP 2016 Update

Load forecast data

a) Historical peak demand at branch, sub-station, grid and national levels;
b) Historical energy sales by category of load and by region and substation; and
c) Historical transmission and distribution losses, energy production, energy purchases and energy exports;

d) The information on the accelerated electrification scheme and its implementation status;

e) Current and recent electricity forecasts

f) Historical performance of the national economy up to year 2015; and

g) Information on expectations for the growth of the national economy and the individual sectors.

Hydrological data

a) Existing hydrological data from1940 to date reference hydrology from TANESCO's stations;

b) Data on reservoirs and hydro plants from TANESCO;

c) All meteorological/synoptic records to date from The Tanzania Meteorological Agency;

d) All stream flow and reservoir water level records to date from Ministry of Water; and

e) Estimates/studies of water abstraction amounts – including information from the Ministry of Water.

System planning

a) Existing system operating and maintenance data;

b) Fuel types, prices, volume and characteristics;

c) Generation and transmission expansion planning criteria used in previous studies;

d) Inventory and characteristics of existing and committed units including hydro units, simple cycle gas turbine units, combined cycle units and others (solar, wind, etc.); Inventory and characteristics of transmission facilities including transmission lines and substations;

e) Transmission system current configuration and short- term plans; and

f) Previous study reports on identified new generation options and transmission.

The overall update program consisted of data update and validation, analyses and report writing. The detailed scope of work was as follows:

Load forecasts

a) Initial update of load forecast based on updated consumption data;

b) Collection of regional power demand in the past, present and future;

c) Review of updated load forecast;

d) Confirmation of schedule for interconnection of presently isolated regions; and

e) Adjustments and finalization of forecast study.

Generation planning

a) Review / update and finalize generation and planning criteria;

b) Update hydro generation study using updated hydrological records;

c) Review and update list of new generation candidates, and finalizes plant characteristics for use in the plan; and

d) Prepare preferred new generation plan, based on new base case forecast, short term generation commitments, retirement dates.

Transmission planning

a) To distribute regional load into respective substations;

b) Update PSS/E files of system configuration and characteristics for 2015 conditions;

c) For the new base case generation plan develop 5-year plan components, for the mid-term (2020 and 2025) and for long term (2030, 2035 and 2040); and

d) Prepare estimates of investment costs.

1.4 Factors considered in the Update plan

The update plan has taken into account a broad spectrum of new information and planning criteria. Primary factors affecting the results, as compared with the 2016 PSMP Update, include:

Load forecast

a) The impact of current level of losses on the forecast;

b) The target of reaching 75 percent electrification of households by 2035;

c) Program for interconnection of remaining isolated systems; and

d) Emerging of high demands of power (Mtwara corridor) and Mining activities.

Generation options

a) Availability of resources to meet projected demand (eg. hydro, gas, coal, wind, etc.);

b) Lead time of projects (eg. hydro projects have very long lead time);

c) Contracts/Retirement of projects; and

d) Capital cost of the projects.

Transmission Plan

a) Concentrating on 220 and 400kV backbone voltage; and

b) Developing transmission plans in every interval of five years, while focusing in introduction of 400kV where necessary, instead of defining requirements for the whole horizon up to year 2040.

CHAPTER TWO

2 Power Demand Forecast

2.1 Background

This section provides estimate of the power demand in Tanzania over the study period from 2016 to 2040. The objectives of the load forecast activity were to provide set of forecasts for both short, mid and long terms for Tanzania Interconnected Power System, and the isolated systems. The forecast then forms the basis in the planning of generation and transmission facilities. This forecast study explicitly account for changed economic background, government development objectives in the power sector in addition to specific issues concerning the power demand.

2.2 National economy highlights

2.2.1 Population forecast

According to Tanzania national census of 2002 and 2012, the population trend is 2.9% per year from 1988 to 2002 and 2.7% per year from 2002 to 2012. It is considered that the future growth rate of the population is gradually going down comparing to the past trends. Therefore, the future population and the growth rate of Tanzania are approximately as follows:

Table 2-1: Population and growth rate forecasts of Tanzania

Unit 1000 persons

	2012~15	2015~20	2020~25	2025~30	2030~35	2035~40
Population	49,200	56,300	63,600	70,900	77,700	83,900
Growth rate (%)	2.7	2.7	2.5	2.2	1.9	1.5

Source: Study team projection based on the past NBS census
Note: Number of the population is at the end of the year

2.2.2 Foreign exchange rate

It is assumed that the current exchange rate with 2,200 TZS per US dollar (as of November 2016) and it will be devaluated a little bit in the future. According to foreign exchange theory, Tanzanian currency will be devaluated by 3% per year. It is also assumed that the foreign exchange rate after 2025 will be kept at the same level.

2.2.3 GDP

Tanzania has various strategic plans for future economic growth, these are: VISION 2025, FYDP (Five Year Development Plan), FYDPII and LTPP (Long Term Perspective Plan). These plans are summarized in Table 2-2.

Table 2-2: Prediction of GDP growth rates

Sources	Contents
VISION 2025	The target of GDP growth rate is 8% per year. The target of the GDP per capita should be $3000 per capita by 2025. This implies that Tanzania will become a middle income country by 2025.
FYDP	Economic growth rate from 2000 to 2010 was 7 % per year although the target was 8%. But in the first FYDP, the growth rate was targeted to be more than 10% from 2011 to 2025.
FYDP Ⅱ	In the second FYDP, economic renovation by industrialization policy will increase the GDP share of manufacturing sector from 8% to 19 % in Tanzania from 2016 to 2021.
LTPP	LTPP has three periods, short, medium and long term as follows. Short (2010 – 2015) Intend to construct infrastructure and energy supply Medium (2015 – 2020) Will facilitate the growth of natural gas industry and agroindustry Long (2020 – 2025) Will increase manufacturing, services and export industries

Note: FYDP: Five Year Development Plan 2011-2016 and FYDP Ⅱ is a plan for 2016/17 – 2020/21.
LTPP: Long Term Perspective Plan

By considering the above government economic strategies, the following scenarios are assumed.

HIGH scenario: After 2025, the high economic growth by developing natural gas and the related industries will be achieved in line with the economic development policies in Vision 2025.

BASE scenario: It is assumed that the current economic growth is driven by the main two factors; higher population growth and increasing labor productivity. After the year of 2025 the population growth rate will gradually go down and the economy will be more stable than the current growth rate.

LOW scenario: The domestic economic conditions are assumed to be the same as the BASE scenario, however, due to busting the international political and economic conflicts, the international economy will not be encouraging. The conflicts will give negative impacts on Tanzanian economy.

When the above preconditions are considered, the GDP growth rates for each scenario are assumed as follows:

Table 2-3: Real GDP growth rate by each scenario

Unit: %

	2013/15	2015/20	2020/25	2025/30	2030/35	2035/40
HIGH	7.0	8.0	8.0	8.0~10.0	8.0~10.0	8.0~10.0
BASE	7.0	7.0	7.0	6.0	6.0	5.0
LOW	7.0	6.0	6.0	5.0	5.0	4.0

Note: The GDP growth rate in above table are set by Task Force Team after discussion with MOF, Planning commission and other relevant organizations.

2.2.4 Crude oil price

According to the recent international oil price trend, it is predicted that the crude oil price will not be increased drastically but it will be gradually increased in future. In this PSMP, WTI price which represents the world oil prices is predicted as below in Table 2-4.

Table 2-4: WTI price prediction

	2014	2015	2016	2017	2018	2019	2020	2025	2030	2035	2040
WTI price (USD/bbl)	100	50	50	68	70	75	80	89	100	112	125

Source: IEEJ (2015)
Note: All prices in the table is at 2015 price.

2.3 Issue related to the load forecast

2.3.1 The electric energy ratio

In this PSMP, "Electric energy ratio" is used which is different from "Electrification rate". Electric energy ratio is defined by electric energy consumption share in all kinds of final energy consumption (Total Final Energy Consumption). Electric energy ratios in some countries and regions are shown in the Table 2-5.

Table 2-5: Electric energy ratios in some countries and regions

Unit: %

Country/region	1980	1990	2000	2009
USA	13.3	17.5	19.5	21.4
Japan	19.0	21.5	23.5	25.6
Africa (Average)	14.9	17.7	19.9	20.8
Asia (Average)	11.7	14.0	18.4	21.7

Source: IEEJ (2012)
Note: Electric energy ratio (%)＝ Electric energy consumption in a country (toe) / Final energy consumption (toe）

Electric energy ratio also can be defined by economic sectors such as Industry, Commercial & Services, Government and Residential sectors. Due to Tanzania's energy consumption pattern which is dominated by fuel woods, the Study proposes the following electric energy ratio prediction as shown in Table 2-6.

Table 2-6: Sectoral electric energy ratio prediction

Unit %

Sector	2012	2015	2020	2025	2030	2035	2040
Industry	6.7	7.4	8.5	9.9	11.5	13.3	15.4
Commercial	4.1	5.0	7.1	9.9	13.9	19.5	27.3
Residential	1.2	1.5	2.1	2.9	4.1	5.7	8.0
Total	2.1	2.3	3.1	4.3	5.6	7.4	9.6

Source: Team estimation
Note: Electric energy ratio= Electric energy consumption（toe）/Final energy consumption (toe)

2.3.2 Electrification rate estimation

Estimation of electrification rate is based on IEA standard. It is “Access” method defined by the following equations.

*Power accessible population = Σ accessible village * Population in the village*
*Electrification rate = Power accessible population / Total population * 100.*

Due to rural electrification programs which are ongoing, electrification rate reached 41% in 2015. Government has targeted to have the electrification rate of 50% by 2020. Under the conditions, the electrification rate is 64% in 2025, 76% in 2030, and 90% in 2035.

2.3.3 Transmission and Distribution (T/D) loss rate

Transmission and Distribution (T/D) loss rates in the following table is calculated by actual T/D energy loss over dispatched energy. T/D loss rates from 2001 to 2015 are the actual as recorded, and after 2016 the T/D losses are calculated based on the loss reduction target set by TANESCO. The figure shows that there is the improvement of T/D losses after 2016, and it will reach 11.4% by year 2025 and it will remain the same after year 2026.

Table 2-7: Transmission and Distribution loss rate

Unit ％

Year	loss rate	Year	loss rate	Year	loss rate	Year	loss rate
2001	26.0	2008	20.1	2015	17.5	2022	11.9
2002	23.9	2009	20.0	2016	16.5	2023	11.7
2003	22.1	2010	19.8	2017	15.5	2025	11.4
2004	24.1	2011	21.4	2018	14.5	2030	11.4
2005	25.8	2012	21.9	2019	13.7	2035	11.4
2006	25.0	2013	21.2	2020	12.4	2040	11.4
2007	20.2	2014	18.0	2021	12.2		

Source: TANESCO.
Note: T/D Loss rate = T/D energy loss / Dispatched electric energy,
Dispatch electric energy = Final electric energy demand + T/D loss

2.3.4 Load factor

Actual peak demand and actual power generation data obtained from TANESCO were used to calculate the load factor by using the following equation.

*Load factor = Generation (MWh) / (24 hours ＊365 days) / Peak demand (MW) *100*

Where, Generation = Final electric energy consumption ＋T/D loss + Own use

As shown in Table 2-8, future load factors are predicted by assuming that it will reach 70% after 2030.

Table 2-8: Load factor forecast

Unit %

Year	load factor	Year	load factor	Year	load factor	Year	load factor
2001	63.4	2009	70.0	2017	71.0	2025	70.0
2002	65.5	2010	70.0	2018	70.0	2026	70.0
2003	63.8	2011	70.0	2019	70.0	2027	70.0
2004	65.3	2012	76.0	2020	70.0	2028	70.0
2005	75.5	2013	71.0	2021	70.0	2030	70.0
2006	67.5	2014	74.5	2022	70.0	2035	70.0
2007	69.6	2015	74.0	2023	70.0	2040	70.0
2008	69.5	2016	72.0	2024	70.0		

Source: TANESCO and Team compilation

Note: The future value of 70% is the target of TANESCO

2.3.5 Un-constrain demand

Currently, recorded power demand does not represent the actual demand due to unmet demand because of insufficient power supply. Therefore, un-constrained demand should be taken into account to capture the actual power demand. The un-constrained demand is calculated by adding a potential factor to constrained demand (recorded data) as follows:

Un-constrain demand ＝ Constrain demand ×(1 ＋Potential factor)

Potential factor =1- Actual demand recorded / Forecasted demand in PSMP2012 Update

The un-constrained demands are applied to industry, commercial & services, agriculture and residential sectors. It is not applied to governmental and gold mining power sectors because their demands are not constrained. The potential factors of constrained demands from 2000 to 2015 are the actual ones and from 2016 to 2040 are the estimated ones where the target is set to reach 0 in 2020. The actual and estimated potential factors are shown in Table 2-9.

Table 2-9: Potential factors

Year	Potential factor	Year	Potential factor
2000- 2013	0.10	2017	0.15
2014	0.18	2018	0.10
2015	0.25	2019	0.05
2016	0.20	2020 -2040	0

Note: Potential factor to be '0' after 2020 means that the power shortage is eliminated.

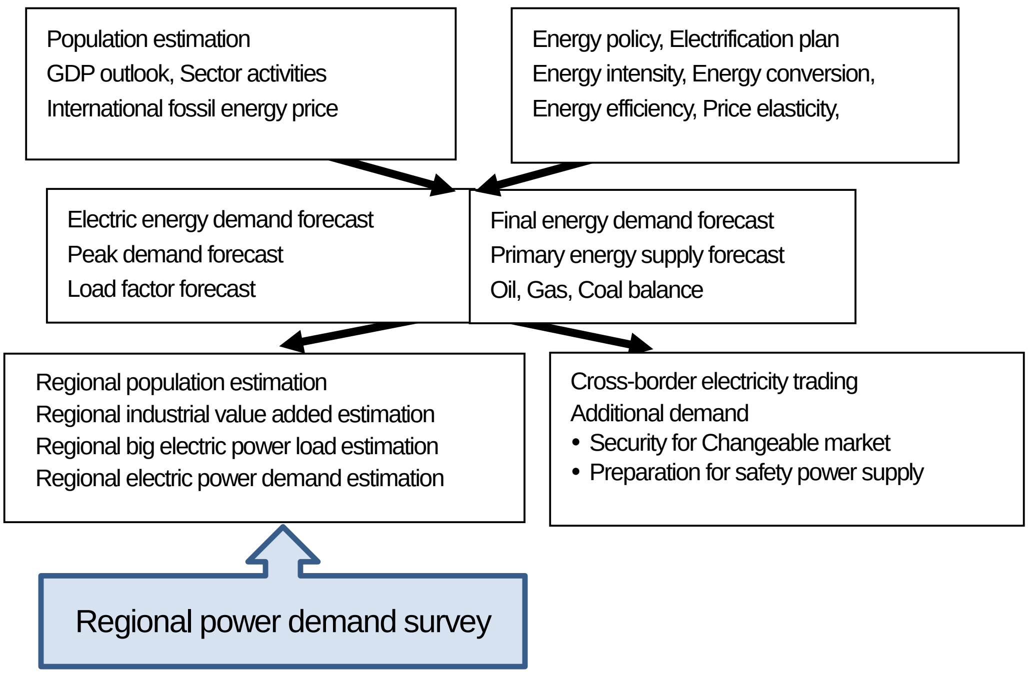
2.3.6 Energy efficiency and conservation (EE&C) for power demand

Energy efficiency and conservation refers to measures aimed at reducing energy consumption without sacrificing productivity, level of service or increasing costs. Energy efficiency and conservation (EE&C) applies to all sectors. In PSMP2016 Update, the target effect rate is set to reach 0.5% per year after 2026 assuming that EE&C in Tanzania will be gradually disseminated in the country. The effect rate is accumulated in the forecasted period.

2.4 Methodology of demand forecasts

The final energy and power demand for each sector are forecasted for 25years. Then, it is accumulated to obtain country wide final energy and power demand. After that, primary energy consumption in power sector is calculated. The outline of the demand forecast flow is as follows:

Figure 2-1: Outline of demand forecast flow



For establishing the forecasting equations, the future energy consumption intensities for each sector in relation to GDP are determined. Energy consumption intensity for residential sector is correlated to energy consumption per capita. These intensities are estimated by using the past trends.

Future demands are calculated by using the following procedures.

Table 2-10: Procedures of fuel energy & electric power demand forecasts

(1) Forecast total final energy consumption by sector
(2) Forecast electric power and fuel energy demand by sector
(3) Sum up all power and fuel energy demand in the whole country
(4) Estimate Transmission and Distribution loss and Load factor
(5) Estimate peak demand, power generation, export and additional demands
(6) Estimate domestic fuel energy consumption
(7) Estimate power and fuel energy consumption per GDP, and per capita
(8) Forecast regional power demand

2.5 Domestic Power Demand Forecasts

2.5.1 Power demand forecasts by scenario case

Using the above preconditions and method, the dispatched electric energy demands of Tanzania are shown in Table 2-11.

Table 2-11: Power demand forecasts (Dispatched energy)

Unit GWh

Year	High	Base	Low
2015	6,310	6,310	6,310
2016	7,870	7,820	7,640
2017	9,070	8,970	8,650
2018	10,460	10,270	9,780
2019	12,040	11,740	11,060
2020	13,840	13,440	12,470
2025	24,640	22,430	19,450
2030	45,270	36,000	29,250
2035	82,830	57,340	43,660
2040	145,470	87,890	63,090
2040/2015	13.4 %	11.1 %	9.6 %

The peak power demand forecasts of Tanzania are shown in Table 2-12

Table 2-12: Peak power demand forecasts

Unit MW

Year	High	Base	Low
2015	974	974	974
2016	1,280	1,270	1,250
2017	1,480	1,460	1,410
2018	1,700	1,680	1,600
2019	1,960	1,920	1,800
2020	2,260	2,190	2,030
2025	4,020	3,660	3,170
2030	7,380	5,870	4,770
2035	13,510	9,350	7,120
2040	23,720	14,330	10,290
2040/2015	13.6 %	11.4 %	9.9 %

2.6 Power demand including export and additional demand

The government of Tanzania has a policy of accelerating industrial development that triggers expansion of power generation capacity up to 4,915MW by year 2020. Comparing the high case peak demand of 2,260MW in 2020 and the generation capacity target of 4,915MW, the gap between the demand and the generation target is huge.

The demand forecast should be increased to meet Government Target, therefore, some additional demands such as power export, industrial renovation and backup for captive generators for large scale industries are added outside the econometric model. However, should industrial development fail to match increasing power supply infrastructure related to accelerated generation capacity, this may trigger increase in electricity supply cost due to idle capacity.

The details of the selected factories and mining sites are as follows;

Table 2-13: Additional power demand by rural factories and mining sites

Unit: MW

Year	Geita : Gold Mining Co.	Mara : Two Gold mining Co.*	Njombe: Iron Smelting	Mtwara : DANGOTE	Industrial renovation	Total
2015	28	9		34		71
2016	28	9		34		71
2017	28	9		34		71
2018	28	9		34		71
2019	28	9		34		71
2020	45	22	337	67	570	1041
2021	45	22	337	67	570	1041
2022	45	22	337	67	570	1041
2023	45	22	337	67	570	1041
2024	45	22	337	67	570	1041
2025	45	22	337	67	570	1041
2030	45	22	337	67	570	1041
2035	45	22	337	67	570	1041
2040	45	22	337	67	570	1041

Source: MEM、TANESCO and Regional demand survey

Note: * Mara Two Gold mining are “Buhemba Gold Mining” and “Kiabakari Gold Mining”

The total power demand and capacity including domestic demand, export and additional power demands are as the following table.

Table 2-14: Domestic, export and additional demands of Tanzania

Unit: MW

Cases		Demand items	Unit	2015	2020	2025	2030	2035	2040
Base	Peak demand	Domestic demand	MW	974	2,190	3,659	5,872	9,351	14,332
		Additional demand	MW	71	1,041	1,041	1,041	1,041	1,041
		Export (Inc. Loss)	MW	0	685	677	677	677	677
		Total	MW	1,045	3,916	5,377	7,590	11,069	16,050
	Installed capacity	Domestic demand	MW	1,267	2,847	4,757	7,633	12,156	18,631
	(Peak*1.3)	Additional demand	MW	92	1,353	1,353	1,353	1,353	1,353
		Export (Inc. Loss)	MW	0	890	880	880	880	880
		Total	MW	1,359	5,091	6,991	9,867	14,389	20,865
High	Peak demand	Domestic demand	MW	974	2,256	4,017	7,381	13,508	23,724
		Additional demand	MW	71	1,041	1,041	1,041	1,041	1,041
		Export (Inc. Loss)	MW	0	685	677	677	677	677
		Total	MW	1,045	3,981	5,736	9,100	15,226	25,443
	Installed capacity	Domestic demand	MW	1,267	2,932	5,223	9,596	17,560	30,842
	(Peak*1.3)	Additional demand	MW	92	1,353	1,353	1,353	1,353	1,353
		Export (Inc. Loss)	MW	0	890	880	880	880	880
		Total	MW	1,359	5,176	7,456	11,829	19,794	33,075
Low	Peak demand	Domestic demand	MW	974	2,035	3,172	4,769	7,120	10,289
		Additional demand	MW	71	1,041	1,041	1,041	1,041	1,041
		Export (Inc. Loss)	MW	0	685	677	677	677	677
		Total	MW	1,045	3,760	4,891	6,487	8,838	12,007
	Installed capacity	Domestic demand	MW	1,267	2,645	4,124	6,199	9,256	13,376
	(Peak*1.3)	Additional demand	MW	92	1,353	1,353	1,353	1,353	1,353
		Export (Inc. Loss)	MW	0	890	880	880	880	880
		Total	MW	1,359	4,889	6,358	8,433	11,490	15,609

Source: Analysis by the Task Force Team

Note: Total installed generation capacity in Base case is more than 4,920 MW in 2020.

The growth rate of the above total power demand and capacity are shown in Table 2-15. The growth rates of peak demand and capacity from year 2015 to 2020 are comparatively higher than others due to accelerated industrial development.

Table 2-15: Growth rate of the above total power demand and capacity

Unit: %

Cases		Demand items	2010/15	2015/20	2020/25	2025/30	2030/35	2035/40	2015/40
Base	Peak demand	Domestic demand	3.4	17.6	10.8	9.9	9.8	8.9	11.4
		Additional demand	0.0	71.1	0.0	0.0	0.0	0.0	11.3
		Export (Inc. Loss)	0.0	0.0	-0.2	0.0	0.0	0.0	0.0
		Total	0.0	30.2	6.5	7.1	7.8	7.7	11.5
	Installed capacity	Domestic demand	3.4	17.6	10.8	9.9	9.8	8.9	11.4
	(Peak*1.3)	Additional demand	0.0	71.1	0.0	0.0	0.0	0.0	11.3
		Export (Inc. Loss)	0.0	0.0	-0.2	0.0	0.0	0.0	0.0
		Total	0.0	30.2	6.5	7.1	7.8	7.7	11.5
High	Peak demand	Domestic demand	3.4	18.3	12.2	12.9	12.8	11.9	13.6
		Additional demand	0.0	71.1	0.0	0.0	0.0	0.0	11.3
		Export (Inc. Loss)	0.0	0.0	-0.2	0.0	0.0	0.0	0.0
		Total	0.0	30.7	7.6	9.7	10.8	10.8	13.6
	Installed capacity	Domestic demand	3.4	18.3	12.2	12.9	12.8	11.9	13.6
	(Peak*1.3)	Additional demand	0.0	71.1	0.0	0.0	0.0	0.0	11.3
		Export (Inc. Loss)	0.0	0.0	-0.2	0.0	0.0	0.0	0.0
		Total	0.0	30.7	7.6	9.7	10.8	10.8	13.6
Low	Peak demand	Domestic demand	3.4	15.9	9.3	8.5	8.3	7.6	9.9
		Additional demand	0.0	71.1	0.0	0.0	0.0	0.0	11.3
		Export (Inc. Loss)	0.0	0.0	-0.2	0.0	0.0	0.0	0.0
		Total	0.0	29.2	5.4	5.8	6.4	6.3	10.3
	Installed capacity	Domestic demand	3.4	15.9	9.3	8.5	8.3	7.6	9.9
	(Peak*1.3)	Additional demand	0.0	71.1	0.0	0.0	0.0	0.0	11.3
		Export (Inc. Loss)	0.0	0.0	-0.2	0.0	0.0	0.0	0.0
		Total	0.0	29.2	5.4	5.8	6.4	6.3	10.3

Source：Analysis by the Task Force Team

Note: Export growth rate is flat from 2020 to 2040, so the growth rate is 0

2.7 Power Demand Growth Factors

The power demand growths of Tanzania are expected in aspects of industry and residential sectors. The following table shows the main factors for the rapid power demand growth in

Tanzania from 2016 up to 2040.

Table 2-16: Main factors for power demand growth

1	The past GDP growth rate of Tanzania was average 7% per year, and the future GDP growth rate will be continued with the same GDP growth rate. Gas development, establishment of transportation infrastructure, increase of Foreign Direct Investment, level of education, construction of communication facilities and construction of modern households are major drivers for continued GDP growth. The power demand growth rates for industrial and commercial sectors are expected to reach 18% per year from 2015 to 2020 while the growth rates are 11% for industry and 13% for commercial sector afterward.
2	Gas intensive business will be promoted by the development of gas infrastructure such as chemical, LNG and transportation industries. Such industries consume a lot of electric power for their production activities.
3	Currently, wood and charcoal is the main source of energy in rural area in Tanzania. According to IEA database 2013, the share of the wood based energy in total final energy consumption is around 80%. In the future, wood and charcoal will be replaced by electric power, gas and petroleum products in line with urbanization of Tanzania. Therefore, the power consumption in residential sector will increases a lot. The share of wood and charcoal in final energy consumption will decrease up to 49% in 2040. The growth rate of power demand in residential sector will increase with average 11% per year from 2015 to 2040.
4	Since the electrification rate of Tanzania in 2015 is 41%, there is a room for increasing the electrification rate. The future electrification rates are assumed to be more than 50% in 2020 and 90% in 2035. Power consumption per capita is 137 kWh in 2016, it is rather small compared to other developing countries such as Kenya, Ghana and Zambia. In the future, it will become 240 kWh / capita in 2020 and 1,050 kWh / capita in 2040.
5	Currently, power supply in Tanzania cannot meet the demand. Such imbalance has to be solved as soon as possible. During the period when the shortage is gradually relieved, power demand will grow at higher rate than normal. In PSMP2016, it is assumed that the power shortage will be relieved toward the year 2020.

2.8 Annual power demand forecast

Energy demands, peak demand and power consumption per capita are as the following tables.

2.8.1 Power demand

Table 2-17: Power demand (Base)

Base case 2015-2030		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
T/D loss	S%	17.5	16.5	15.5	14.5	13.7	12.4	12.2	11.9	11.7	11.4	11.4	11.4	11.4	11.4	11.4	11.4
Own use ratio to Generation	S%	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
T/D loss (GWh)	GWh	1,080	1,290	1,390	1,500	1,610	1,670	1,810	1,960	2,130	2,310	2,560	2,810	3,090	3,400	3,740	4,100
Own use	GWh	130	190	210	240	280	320	350	390	430	480	530	580	640	710	780	850
Load Factor	%	74.0	72.0	71.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Generation	MW	1,000	1,270	1,480	1,720	1,970	2,240	2,480	2,750	3,050	3,380	3,740	4,120	4,530	4,980	5,470	6,010
Installed capacity	MW	1,500	1,590	1,850	2,150	2,460	2,800	3,100	3,440	3,810	4,220	4,680	5,150	5,660	6,220	6,840	7,510
Power energy demand	GWh	6,320	7,860	9,010	10,320	11,810	13,430	14,890	16,490	18,270	20,230	22,440	24,680	27,140	29,830	32,780	36,000
Peak power demand	MW	974	1,250	1,450	1,680	1,930	2,190	2,430	2,690	2,980	3,300	3,660	4,030	4,430	4,860	5,340	5,870

Base case 2031-2040		2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2015/20	2020/25	2025/30	2030/35	2035/40	2015/40
T/D loss	S%	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	-6.7	-1.7	0.0	0.0	0.0	-1.7
Own use ratio to Generation	S%	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0	0.0	0.0	0.0	0.0	0.0
T/D loss (GWh)	GWh	4,510	4,950	5,430	5,960	6,540	7,120	7,760	8,450	9,200	10,020	9.1	9.0	9.9	9.8	8.9	9.3
Own use	GWh	940	1,030	1,130	1,240	1,360	1,480	1,610	1,760	1,910	2,080	19.7	10.8	9.9	9.8	8.9	11.8
Load Factor	%	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	-1.1	0.0	0.0	0.0	0.0	-0.2
Generation	MW	6,600	7,240	7,950	8,720	9,570	10,420	11,360	12,370	13,470	14,660	17.6	10.8	9.9	9.8	8.9	11.4
Installed capacity	MW	8,250	9,050	9,940	10,900	11,960	13,030	14,190	15,460	16,840	18,330	13.3	10.8	9.9	9.8	8.9	10.5
Power energy demand	GWh	39,540	43,410	47,640	52,270	57,340	62,480	68,060	74,130	80,720	87,880	16.3	10.8	9.9	9.8	8.9	11.1
Peak power demand	MW	6,450	7,080	7,770	8,520	9,350	10,190	11,100	12,090	13,160	14,330	17.6	10.8	9.9	9.8	8.9	11.4

Source: Study results of PSMP2016

2.8.2 Sectoral power demand and contribution

Table 2-18: Sectoral power demand and contribution (Base)

Unit: GWh Contribution: %

Base 2015-2030	Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total	GWh	6,320	7,860	9,010	10,320	11,790	13,440	14,880	16,480	18,270	20,220	22,430	24,670	27,130	29,840	32,780	36,000
Agriculture.Fishery	GWh	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10
Industry	GWh	2,410	3,160	3,650	4,210	4,850	5,590	6,210	6,900	7,680	8,540	9,510	10,440	11,450	12,570	13,790	15,140
Commercial & Services	GWh	300	340	400	480	570	680	770	870	1,000	1,130	1,290	1,450	1,640	1,850	2,090	2,350
Zanzibar	GWh	340	400	460	520	580	650	710	780	850	920	990	1,050	1,110	1,180	1,240	1,310
Gold	GWh	200	200	200	200	200	210	210	210	210	210	210	210	220	220	220	220
Residential	GWh	1,990	2,470	2,910	3,410	3,980	4,640	5,170	5,760	6,400	7,110	7,870	8,710	9,620	10,610	11,690	12,870
T/D loss	GWh	1,080	1,290	1,390	1,500	1,610	1,670	1,810	1,960	2,130	2,310	2,560	2,810	3,090	3,400	3,740	4,100
Total	S%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture.Fishery	S%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Industry	S%	38.1	40.2	40.5	40.8	41.1	41.6	41.7	41.9	42.0	42.2	42.4	42.3	42.2	42.1	42.1	42.1
Commercial & Services	S%	4.7	4.3	4.4	4.7	4.8	5.1	5.2	5.3	5.5	5.6	5.8	5.9	6.0	6.2	6.4	6.5
Zanzibar	S%	5.4	5.1	5.1	5.0	4.9	4.8	4.8	4.7	4.7	4.5	4.4	4.3	4.1	4.0	3.8	3.6
Gold	S%	3.2	2.5	2.2	1.9	1.7	1.6	1.4	1.3	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6
Residential	S%	31.5	31.4	32.3	33.0	33.8	34.5	34.7	35.0	35.0	35.2	35.1	35.3	35.5	35.6	35.7	35.8
T/D loss	S%	17.1	16.4	15.4	14.5	13.7	12.4	12.2	11.9	11.7	11.4	11.4	11.4	11.4	11.4	11.4	11.4

Base 2031-2040	Unit	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2015/20	2020/25	2025/30	2030/35	2035/40	2015/40
Total	GWh	39,550	43,400	47,630	52,260	57,340	62,470	68,060	74,130	80,710	87,890	16.3	10.8	9.9	9.8	8.9	11.1
Agriculture.Fishery	GWh	10	10	10	10	10	20	20	20	20	30	0.0	0.0	0.0	0.0	24.6	0.0
Industry	GWh	16,640	18,270	20,070	22,060	24,240	26,330	28,610	31,100	33,790	36,730	18.3	11.2	9.7	9.9	8.7	11.5
Commercial & Services	GWh	2,650	2,990	3,370	3,800	4,280	4,790	5,350	5,980	6,680	7,470	17.8	13.7	12.7	12.7	11.8	13.7
Zanzibar	GWh	1,380	1,440	1,510	1,580	1,650	1,700	1,760	1,810	1,870	1,920	13.8	8.8	5.8	4.7	3.1	7.2
Gold	GWh	220	220	220	220	230	230	230	230	230	230	1.0	0.0	0.9	0.9	0.0	0.6
Residential	GWh	14,140	15,520	17,020	18,630	20,390	22,280	24,330	26,540	28,920	31,490	18.4	11.1	10.3	9.6	9.1	11.7
T/D loss	GWh	4,510	4,950	5,430	5,960	6,540	7,120	7,760	8,450	9,200	10,020	9.1	8.9	9.9	9.8	8.9	9.3
Total	S%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0						
Agriculture.Fishery	S%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
Industry	S%	42.1	42.1	42.1	42.2	42.3	42.1	42.0	42.0	41.9	41.8						
Commercial & Services	S%	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5						
Zanzibar	S%	3.5	3.3	3.2	3.0	2.9	2.7	2.6	2.4	2.3	2.2						
Gold	S%	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3						
Residential	S%	35.8	35.8	35.7	35.6	35.6	35.7	35.7	35.8	35.8	35.8						
T/D loss	S%	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4						

Source: Study results of PSMP2016

2.8.3 Big power consumers and new projects in Tanzanian regions

Table 2-19: Big power consumers by regional survey

		Unit	2015	2020	2021	2022	2023	2024	2025
2	Arusha	MW	23.0	26.0	26.0	26.0	26.0	26.0	26.0
7	Dar es Salaam	MW	128.0	155.0	158.0	163.0	166.0	167.0	172.0
1	Dodoma	MW	28.0	31.0	31.0	31.0	31.0	31.0	31.0
11	Iringa +Njombe	MW	12.3	15.8	15.8	15.8	15.8	15.8	15.8
18	Kagera	MW	12.0	8.0	8.0	8.0	10.0	13.0	14.0
16	Kigoma	MW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Kilimanjaro	MW	6.0	10.0	10.0	10.0	10.0	10.0	10.0
8	Lindi	MW	1.0	2.0	2.0	2.0	2.0	2.0	2.0
21	Manyara	MW	1.8	3.1	3.1	3.1	3.1	3.1	3.1
20	Mara	MW	16.0	28.5	30.5	30.5	31.6	31.6	31.6
12	Mbeya	MW	17.7	28.7	29.7	29.7	29.7	30.0	30.0
5	Morogoro	MW	21.1	28.0	28.0	28.0	28.0	28.0	28.0
9	Mtwara	MW	4.0	5.0	6.0	7.0	8.0	9.0	10.0
19	Mwanza +Geita	MW	23.0	40.0	44.0	45.0	45.0	49.0	57.0
6	Pwani	MW	30.0	55.0	56.0	58.0	59.0	60.0	62.0
15	Rukwa +Katavi	MW	2.0	2.0	2.0	2.0	2.0	2.0	2.0
10	Ruvuma	MW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	Shinyanga+ Simiyu	MW	94.0	103.0	106.0	106.0	106.0	106.0	106.0
13	Singida	MW	2.0	3.0	3.0	3.0	3.0	3.0	3.0
14	Tabora	MW	2.0	2.0	2.0	2.0	2.0	2.0	2.0
4	Tanga	MW	32.0	57.0	57.0	57.0	57.0	57.0	57.0
22	Zanzibar	MW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	total	MW	455.9	603.0	618.0	627.0	635.1	645.4	662.4

Table 2-20: New projects by regional survey

	Region	Unit	2015	2020	2021	2022	2023	2024	2025
2	Arusha	MW	1.2	42.9	43.6	44.2	44.9	45.5	46.2
7	Dar es Salaam	MW	92.0	119.0	126.2	133.4	140.6	147.8	155.0
1	Dodoma	MW	0.0	15.3	15.3	15.3	15.3	15.3	15.3
11	Iringa +Njombe	MW	0.0	0.5	0.6	0.6	0.7	0.7	0.8
18	Kagera	MW	1.4	51.8	60.1	68.4	76.6	84.9	93.2
16	Kigoma	MW	0.0	11.5	12.9	14.3	15.7	17.1	18.5
3	Kilimanjaro	MW	4.6	14.6	14.6	14.6	14.6	14.6	14.6
8	Lindi	MW	0.0	8.9	9.8	10.8	11.8	12.7	13.7
21	Manyara	MW	7.0	16.0	16.0	16.0	16.0	16.0	16.0
20	Mara	MW	0.0	4.0	4.4	4.8	5.2	5.6	6.0
12	Mbeya	MW	15.0	51.0	55.0	59.0	63.0	67.0	71.0
5	Morogoro	MW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	Mtwara	MW	0.0	2.2	2.2	2.2	2.2	2.2	2.2
19	Mwanza +Geita	MW	7.5	54.0	58.1	62.3	66.4	70.6	74.7
6	Pwani	MW	1.8	32.0	42.6	53.2	63.8	74.4	85.0
15	Rukwa +Katavi	MW	1.7	13.8	15.0	16.2	17.4	18.6	19.8
10	Ruvuma	MW	0.0	2.5	4.0	5.5	7.0	8.5	10.0
17	Shinyanga+ Simiyu	MW	0.0	3.6	4.0	4.4	4.8	5.2	5.6
13	Singida	MW	0.3	0.7	0.7	0.7	0.7	0.7	0.7
14	Tabora	MW	0.0	15.0	16.7	18.4	20.1	21.8	23.5
4	Tanga	MW	10.0	20.0	20.0	20.0	20.0	20.0	20.0
22	Zanzibar	MW	7.0	10.0	10.0	10.0	10.0	10.0	10.0
	total	MW	149.5	489.1	531.6	574.1	616.7	659.2	701.7

Source: Regional demand survey conducted by BICO (Bureau for Industrial Cooperation) in October - December 2015

Note: The tables are the original data from the Regional survey

2.8.4 Regional population

Table 2-21: Regional population

Unit: 1000 person

	Region names	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Dodoma	2,234	2,281	2,329	2,376	2,424	2,472	2,519	2,567	2,613	2,660	2,706	2,752	2,798	2,843	2,887	2,932
2	Arusha	1,857	1,909	1,962	2,015	2,068	2,121	2,174	2,227	2,280	2,333	2,386	2,439	2,491	2,544	2,596	2,647
3	Kilimanjaro	1,739	1,770	1,801	1,832	1,863	1,893	1,924	1,954	1,984	2,014	2,044	2,073	2,101	2,130	2,158	2,186
4	Tanga	2,204	2,254	2,304	2,355	2,405	2,438	2,470	2,501	2,532	2,563	2,594	2,624	2,653	2,683	2,711	2,740
5	Morogoro	2,400	2,457	2,516	2,574	2,632	2,683	2,733	2,783	2,832	2,881	2,930	2,978	3,026	3,074	3,121	3,167
6	Pwani	1,181	1,207	1,233	1,260	1,286	1,312	1,338	1,364	1,390	1,416	1,441	1,467	1,492	1,517	1,541	1,566
7	Dar es Salaam	5,269	5,573	5,895	6,227	6,568	6,913	7,259	7,606	7,954	8,302	8,649	8,994	9,336	9,676	10,013	10,346
8	Lindi	892	900	909	917	925	933	941	949	956	963	971	978	985	991	998	1,005
9	Mtwara	1,324	1,340	1,357	1,373	1,389	1,405	1,421	1,436	1,451	1,466	1,481	1,496	1,510	1,524	1,538	1,552
10	Ruvuma	1,478	1,510	1,542	1,574	1,606	1,639	1,671	1,703	1,735	1,767	1,798	1,829	1,860	1,891	1,922	1,952
11	Iringa +Njombe	1,699	1,716	1,733	1,749	1,766	1,782	1,797	1,812	1,827	1,842	1,857	1,871	1,885	1,899	1,912	1,925
12	Mbeya	2,965	3,047	3,131	3,214	3,298	3,354	3,409	3,463	3,517	3,570	3,623	3,675	3,726	3,777	3,828	3,878
13	Singida	1,481	1,516	1,552	1,587	1,622	1,658	1,694	1,730	1,765	1,800	1,835	1,870	1,905	1,939	1,973	2,007
14	Tabora	2,527	2,602	2,679	2,757	2,834	2,911	2,988	3,064	3,141	3,218	3,294	3,371	3,447	3,523	3,599	3,674
15	Rukwa +Katavi	1,747	1,805	1,863	1,923	1,982	2,042	2,102	2,162	2,222	2,282	2,343	2,403	2,463	2,524	2,584	2,644
16	Kigoma	2,306	2,362	2,419	2,476	2,533	2,589	2,645	2,701	2,756	2,811	2,866	2,921	2,975	3,029	3,082	3,135
17	Shinyanga+ Simiyu	3,329	3,395	3,461	3,528	3,593	3,703	3,813	3,923	4,034	4,145	4,256	4,367	4,478	4,590	4,701	4,812
18	Kagera	2,733	2,820	2,911	3,002	3,093	3,151	3,209	3,266	3,322	3,378	3,434	3,489	3,543	3,597	3,651	3,704
19	Mwanza +Geita	4,962	5,105	5,252	5,370	5,464	5,690	5,919	6,151	6,386	6,624	6,865	7,109	7,354	7,602	7,852	8,096
20	Mara	1,894	1,941	1,989	2,037	2,085	2,134	2,183	2,232	2,280	2,328	2,376	2,424	2,472	2,519	2,566	2,613
21	Manyara	1,585	1,636	1,689	1,742	1,795	1,838	1,882	1,925	1,968	2,011	2,054	2,097	2,139	2,181	2,223	2,265
	Mainland total	47,807	49,146	50,527	51,888	53,235	54,660	56,089	57,518	58,948	60,377	61,802	63,225	64,642	66,053	67,457	68,846
22	Zanzibar total	1,439	1,483	1,528	1,577	1,626	1,679	1,709	1,740	1,771	1,804	1,836	1,870	1,904	1,938	1,974	2,024
	Total	49,246	50,629	52,055	53,465	54,861	56,339	57,798	59,258	60,720	62,180	63,639	65,094	66,545	67,991	69,431	70,869

	Region names	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2015/20	2020/25	2025/30	2030/35	2035/40	2015/40
1	Dodoma	2,975	3,019	3,061	3,104	3,146	3,187	3,228	3,268	3,308	3,347	2.0	1.8	1.6	1.4	1.3	1.6
2	Arusha	2,699	2,750	2,801	2,851	2,902	2,951	3,001	3,050	3,098	3,146	2.7	2.4	2.1	1.9	1.6	2.1
3	Kilimanjaro	2,213	2,240	2,267	2,293	2,319	2,345	2,370	2,395	2,420	2,444	1.7	1.5	1.4	1.2	1.1	1.4
4	Tanga	2,768	2,795	2,822	2,849	2,875	2,900	2,925	2,948	2,971	2,993	2.0	1.2	1.1	1.0	0.8	1.2
5	Morogoro	3,213	3,259	3,304	3,348	3,392	3,435	3,476	3,516	3,554	3,591	2.2	1.8	1.6	1.4	1.1	1.6
6	Pwani	1,590	1,614	1,638	1,662	1,685	1,707	1,729	1,750	1,771	1,790	2.1	1.9	1.7	1.5	1.2	1.7
7	Dar es Salaam	10,675	10,999	11,318	11,632	11,940	12,242	12,538	12,828	13,111	13,387	5.6	4.6	3.6	2.9	2.3	3.8
8	Lindi	1,011	1,018	1,024	1,030	1,036	1,042	1,048	1,053	1,059	1,064	0.9	0.8	0.7	0.6	0.5	0.7
9	Mtwara	1,565	1,578	1,591	1,604	1,617	1,629	1,641	1,653	1,665	1,676	1.2	1.1	0.9	0.8	0.7	0.9
10	Ruvuma	1,982	2,011	2,040	2,069	2,098	2,126	2,154	2,182	2,209	2,236	2.1	1.9	1.7	1.5	1.3	1.7
11	Iringa +Njombe	1,938	1,951	1,964	1,976	1,988	2,000	2,011	2,023	2,034	2,045	1.0	0.8	0.7	0.6	0.6	0.7
12	Mbeya	3,927	3,975	4,023	4,070	4,117	4,162	4,206	4,248	4,288	4,328	2.5	1.6	1.4	1.2	1.0	1.5
13	Singida	2,041	2,074	2,107	2,139	2,172	2,204	2,235	2,267	2,298	2,328	2.3	2.0	1.8	1.6	1.4	1.8
14	Tabora	3,749	3,824	3,898	3,972	4,045	4,118	4,190	4,262	4,333	4,404	2.9	2.5	2.2	1.9	1.7	2.2
15	Rukwa +Katavi	2,705	2,765	2,824	2,884	2,943	3,000	3,057	3,113	3,168	3,222	3.2	2.8	2.5	2.2	1.8	2.5
16	Kigoma	3,188	3,240	3,291	3,343	3,393	3,442	3,490	3,536	3,581	3,624	2.3	2.1	1.8	1.6	1.3	1.8
17	Shinyanga+ Simiyu	4,923	5,034	5,144	5,254	5,362	5,469	5,574	5,677	5,779	5,879	2.2	2.8	2.5	2.2	1.9	2.3
18	Kagera	3,756	3,808	3,859	3,910	3,960	4,008	4,055	4,100	4,144	4,186	2.9	1.7	1.5	1.3	1.1	1.7
19	Mwanza +Geita	8,334	8,566	8,791	9,010	9,221	9,427	9,625	9,816	10,001	10,179	2.8	3.8	3.4	2.6	2.0	2.9
20	Mara	2,659	2,705	2,751	2,796	2,841	2,885	2,929	2,973	3,016	3,058	2.4	2.2	1.9	1.7	1.5	1.9
21	Manyara	2,307	2,348	2,389	2,429	2,469	2,508	2,545	2,581	2,615	2,648	3.0	2.2	2.0	1.7	1.4	2.1
	Mainland total	70,218	71,572	72,908	74,225	75,520	76,788	78,027	79,239	80,421	81,575	2.7	2.5	2.2	1.9	1.6	2.2
22	Zanzibar total	2,052	2,082	2,111	2,141	2,172	2,202	2,231	2,260	2,288	2,315	3.1	1.8	2.0	1.4	1.3	1.9
	Total	72,270	73,654	75,019	76,366	77,692	78,990	80,258	81,498	82,709	83,891	2.7	2.5	2.2	1.9	1.5	2.2

Source: NBS for population census data in 2012

2.8.5 Regional electrification rate

Table 2-22: Regional electrification rate

Unit: %

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Dodoma	39.4	42.0	44.7	47.6	50.7	54.0	57.5	61.3	65.2	69.5	74.0	76.3	78.6	81.0	83.5	86.0
2	Arusha	47.2	50.3	53.5	57.0	60.7	64.7	68.9	73.3	78.1	83.2	88.6	89.7	90.8	91.9	93.0	94.1
3	Kilimanjaro	82.1	83.7	85.4	87.1	88.8	90.6	92.4	94.3	96.1	98.0	100.0	100.0	100.0	100.0	100.0	100.0
4	Tanga	35.0	37.3	39.7	42.3	45.1	48.0	51.1	54.5	58.0	61.8	65.8	68.6	71.5	74.6	77.8	81.1
5	Morogoro	42.2	44.9	47.8	51.0	54.3	57.8	61.6	65.6	69.8	74.4	79.2	81.1	83.0	84.9	86.9	89.0
6	Pwani	45.8	48.8	51.9	55.3	58.9	62.8	66.8	71.2	75.8	80.7	86.0	87.3	88.6	90.0	91.3	92.7
7	Dar es Salaam	89.9	90.9	91.9	92.9	93.8	94.8	95.9	96.9	97.9	98.9	100.0	100.0	100.0	100.0	100.0	100.0
8	Lindi	14.5	15.4	16.4	17.5	18.6	19.8	21.1	22.5	24.0	25.5	27.2	29.2	31.2	33.5	35.9	38.5
9	Mtwara	14.3	15.2	16.2	17.2	18.4	19.6	20.8	22.2	23.6	25.2	26.8	28.7	30.8	33.0	35.4	37.9
10	Ruvuma	19.4	20.6	22.0	23.4	24.9	26.6	28.3	30.1	32.1	34.2	36.4	39.0	41.8	44.8	48.0	51.5
11	Iringa +Njombe	30.0	32.0	34.1	36.3	38.6	41.2	43.8	46.7	49.7	53.0	56.4	59.7	63.2	67.0	70.9	75.1
12	Mbeya	38.6	41.1	43.7	46.6	49.6	52.8	56.3	59.9	63.8	68.0	72.4	74.8	77.2	79.8	82.4	85.1
13	Singida	24.1	25.6	27.3	29.1	31.0	33.0	35.1	37.4	39.8	42.4	45.2	48.4	51.9	55.6	59.6	63.9
14	Tabora	20.3	21.7	23.1	24.6	26.2	27.9	29.7	31.6	33.7	35.9	38.2	40.9	43.9	47.0	50.4	54.0
15	Rukwa +Katavi	8.1	8.6	9.2	9.8	10.4	11.1	11.8	12.6	13.4	14.3	15.2	16.3	17.5	18.7	20.1	21.5
16	Kigoma	29.6	31.5	33.6	35.8	38.1	40.6	43.2	46.0	49.0	52.2	55.6	59.0	62.5	66.3	70.3	74.6
17	Shinyanga+ Simiyu	24.1	25.6	27.3	29.1	31.0	33.0	35.1	37.4	39.8	42.4	45.2	48.4	51.9	55.6	59.6	63.9
18	Kagera	10.4	11.1	11.8	12.6	13.4	14.3	15.2	16.2	17.3	18.4	19.6	21.0	22.5	24.1	25.9	27.7
19	Mwanza +Geita	41.2	43.9	46.8	49.8	53.0	56.5	60.2	64.1	68.2	72.7	77.4	79.4	81.5	83.6	85.8	88.0
20	Mara	31.5	33.6	35.8	38.1	40.6	43.2	46.0	49.0	52.2	55.6	59.2	62.4	65.7	69.3	73.0	76.9
21	Manyara	45.4	48.3	51.5	54.8	58.4	62.2	66.2	70.5	75.1	80.0	85.2	86.6	88.0	89.4	90.8	92.3
22	Mainland total	39.0	41.0	43.2	45.4	47.8	50.3	53.0	55.7	58.7	61.7	65.0	67.0	69.1	71.3	73.5	75.9

		2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2015/20	2020/25	2025/30	2030/35	2035/40	2015/40
1	Dodoma	88.7	91.4	94.2	97.0	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	3.1	3.1	0.0	3.8
2	Arusha	95.3	96.4	97.6	98.8	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	1.2	1.2	0.0	3.1
3	Kilimanjaro	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	2.0	2.0	0.0	0.0	0.0	0.8
4	Tanga	84.6	88.2	92.0	95.9	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	4.3	4.3	0.0	4.3
5	Morogoro	91.1	93.2	95.4	97.7	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	2.4	2.4	0.0	3.5
6	Pwani	94.1	95.6	97.0	98.5	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	1.5	1.5	0.0	3.2
7	Dar es Salaam	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1.1	1.1	0.0	0.0	0.0	0.4
8	Lindi	41.2	44.2	47.4	50.8	54.4	57.8	61.4	65.3	69.4	73.8	6.5	6.5	7.2	7.2	6.3	6.7
9	Mtwara	40.6	43.5	46.7	50.0	53.6	57.0	60.7	64.6	68.8	73.2	6.5	6.5	7.2	7.2	6.4	6.8
10	Ruvuma	55.2	59.1	63.4	67.9	72.8	75.1	77.6	80.1	82.7	85.3	6.5	6.5	7.2	7.2	3.2	6.1
11	Iringa +Njombe	79.5	84.2	89.2	94.4	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	5.9	5.9	0.0	4.9
12	Mbeya	87.9	90.8	93.7	96.8	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	3.3	3.3	0.0	3.9
13	Singida	68.5	73.4	78.7	84.3	90.4	91.3	92.2	93.2	94.1	95.1	6.5	6.5	7.2	7.2	1.0	5.6
14	Tabora	57.9	62.1	66.5	71.3	76.4	78.5	80.6	82.8	85.1	87.4	6.5	6.5	7.2	7.2	2.7	6.0
15	Rukwa +Katavi	23.0	24.7	26.5	28.4	30.4	34.2	38.6	43.5	48.9	55.1	6.5	6.5	7.2	7.2	12.6	8.0
16	Kigoma	79.1	83.9	88.9	94.3	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	6.0	6.0	0.0	5.0
17	Shinyanga+ Simiyu	68.5	73.4	78.7	84.3	90.4	91.3	92.2	93.2	94.1	95.1	6.5	6.5	7.2	7.2	1.0	5.6
18	Kagera	29.7	31.8	34.1	36.6	39.2	43.0	47.3	51.9	57.0	62.6	6.5	6.5	7.2	7.2	9.8	7.4
19	Mwanza +Geita	90.3	92.6	95.0	97.5	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	2.6	2.6	0.0	3.6
20	Mara	81.1	85.4	90.0	94.9	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	5.4	5.4	0.0	4.7
21	Manyara	93.8	95.3	96.8	98.4	100.0	100.0	100.0	100.0	100.0	100.0	6.5	6.5	1.6	1.6	0.0	3.2
22	Mainland total	78.4	81.0	83.7	86.5	89.5	90.3	91.1	91.9	92.9	93.8	5.2	5.2	3.2	3.3	1.0	3.6

Source: Study results of Task Force Team

2.8.6 Regional power demand

Table 2-23: Regional power demand (Base case)

Unit: GWh

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Dodoma	132	158	179	204	232	270	291	314	341	369	401	441	485	533	586	644
2	Arusha	356	483	587	708	857	987	1,077	1,180	1,297	1,427	1,569	1,716	1,876	2,048	2,237	2,442
3	Kilimanjaro	157	199	226	266	316	348	368	391	417	444	473	513	556	603	653	708
4	Tanga	285	333	368	413	463	640	692	751	818	893	973	1,074	1,186	1,308	1,443	1,591
5	Morogoro	251	304	335	375	420	502	551	608	671	741	818	898	985	1,079	1,182	1,294
6	Pwani	158	257	309	368	426	482	569	674	788	915	1,062	1,165	1,278	1,402	1,538	1,687
7	Dar es Salaam	2,973	3,539	3,930	4,383	4,888	5,353	5,883	6,494	7,146	7,836	8,626	9,468	10,378	11,362	12,433	13,590
8	Lindi	17	31	44	58	72	95	107	120	135	151	168	186	206	228	253	280
9	Mtwara	43	58	53	68	77	94	109	127	148	171	197	219	244	272	303	337
10	Ruvuma	31	36	47	59	72	86	111	140	171	205	242	271	303	340	380	426
11	Iringa +Njombe	114	132	144	165	182	216	235	258	282	310	340	378	420	467	519	577
12	Mbeya	211	307	366	426	492	556	619	684	758	840	927	1,019	1,121	1,232	1,354	1,488
13	Singida	40	48	54	61	69	88	96	106	117	130	144	161	181	202	227	255
14	Tabora	125	175	242	304	373	441	501	567	642	725	815	922	1,043	1,179	1,333	1,508
15	Rukwa +Katavi	19	30	39	51	62	73	82	92	103	115	128	142	158	176	196	218
16	Kigoma	28	47	72	98	127	154	177	203	231	262	296	329	365	406	450	500
17	Shinyanga+ Simiyu	451	535	579	626	702	713	790	863	946	1,037	1,136	1,270	1,419	1,587	1,776	1,987
18	Kagera	62	109	152	196	263	260	304	353	418	494	567	626	691	764	844	933
19	Mwanza +Geita	307	415	528	631	741	938	1,071	1,199	1,335	1,524	1,776	1,963	2,168	2,394	2,644	2,917
20	Mara	159	190	222	257	295	387	439	482	541	595	655	728	810	900	1,001	1,113
21	Manyara	24	30	35	43	50	58	61	65	69	74	79	84	90	97	103	110
	Mainland total	5,942	7,417	8,510	9,759	11,181	12,740	14,134	15,670	17,373	19,258	21,394	23,574	25,963	28,576	31,455	34,606
22	Zanzibar	375	443	504	564	624	689	752	824	896	970	1,044	1,110	1,176	1,252	1,320	1,398
	Total	6,317	7,859	9,014	10,322	11,806	13,428	14,886	16,494	18,269	20,228	22,439	24,684	27,139	29,828	32,775	36,004

		2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2015/20	2020/25	2025/30	2030/35	2035/40	2015/40
1	Dodoma	708	780	857	943	1,037	1,125	1,210	1,301	1,400	1,506	15.4	8.2	9.9	10.0	7.8	10.2
2	Arusha	2,664	2,905	3,166	3,449	3,756	4,084	4,440	4,825	5,241	5,691	22.6	9.7	9.3	9.0	8.7	11.7
3	Kilimanjaro	768	833	903	979	1,063	1,152	1,250	1,355	1,469	1,593	17.2	6.4	8.4	8.5	8.4	9.7
4	Tanga	1,755	1,935	2,132	2,349	2,588	2,803	3,035	3,286	3,557	3,849	17.6	8.8	10.3	10.2	8.3	11.0
5	Morogoro	1,415	1,547	1,689	1,843	2,011	2,181	2,365	2,562	2,775	3,003	14.9	10.3	9.6	9.2	8.3	10.4
6	Pwani	1,853	2,036	2,239	2,463	2,709	2,944	3,199	3,477	3,779	4,110	24.9	17.1	9.7	9.9	8.7	13.9
7	Dar es Salaam	14,841	16,196	17,657	19,236	20,946	22,875	24,967	27,237	29,692	32,352	12.5	10.0	9.5	9.0	9.1	10.0
8	Lindi	311	344	382	424	471	519	572	632	697	770	40.5	12.1	10.7	10.9	10.4	16.4
9	Mtwara	376	419	467	521	580	646	720	803	896	999	16.8	16.0	11.4	11.5	11.5	13.4
10	Ruvuma	477	535	599	670	750	828	914	1,008	1,112	1,226	22.6	23.1	12.0	12.0	10.3	15.8
11	Iringa +Njombe	642	713	791	877	973	1,051	1,136	1,227	1,325	1,430	13.6	9.5	11.2	11.0	8.0	10.6
12	Mbeya	1,636	1,799	1,978	2,176	2,392	2,595	2,815	3,053	3,310	3,590	21.4	10.8	9.9	10.0	8.5	12.0
13	Singida	287	322	362	406	455	495	539	587	638	693	16.9	10.4	12.2	12.2	8.8	12.1
14	Tabora	1,704	1,926	2,174	2,453	2,767	3,066	3,398	3,764	4,167	4,611	28.8	13.1	13.1	12.9	10.8	15.5
15	Rukwa +Katavi	243	271	302	337	376	426	483	550	629	721	31.4	11.9	11.2	11.5	13.9	15.7
16	Kigoma	556	618	687	763	848	921	1,000	1,086	1,178	1,278	40.7	13.9	11.0	11.1	8.5	16.5
17	Shinyanga+ Simiyu	2,225	2,492	2,792	3,127	3,503	3,829	4,185	4,572	4,994	5,453	9.6	9.8	11.8	12.0	9.3	10.5
18	Kagera	1,033	1,144	1,268	1,407	1,560	1,724	1,908	2,115	2,347	2,610	33.0	16.9	10.5	10.8	10.8	16.1
19	Mwanza +Geita	3,219	3,549	3,912	4,310	4,746	5,168	5,625	6,120	6,656	7,238	25.1	13.6	10.4	10.2	8.8	13.5
20	Mara	1,237	1,375	1,528	1,697	1,884	2,047	2,224	2,415	2,622	2,846	19.5	11.1	11.2	11.1	8.6	12.2
21	Manyara	118	127	136	145	156	166	176	188	200	213	19.2	6.5	7.0	7.1	6.5	9.1
	Mainland total	38,068	41,866	46,022	50,577	55,571	60,648	66,159	72,164	78,682	85,783	16.5	10.9	10.1	9.9	9.1	11.3
22	Zanzibar	1,475	1,542	1,617	1,692	1,767	1,828	1,900	1,962	2,036	2,098	12.9	8.7	6.0	4.8	3.5	7.1
	Total	39,542	43,407	47,638	52,269	57,337	62,475	68,059	74,126	80,718	87,881	16.3	10.8	9.9	9.8	8.9	11.1

Source: Study results of Task Force Team

2.8.7 Regional peak demand

Table 2-24: Regional peak demand (Base)

Unit: MW

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Dodoma	20	25	29	33	38	44	47	51	56	60	65	72	79	87	96	105
2	Arusha	55	77	94	116	140	161	176	192	211	233	256	280	306	334	365	398
3	Kilimanjaro	24	32	36	43	52	57	60	64	68	72	77	84	91	98	107	115
4	Tanga	44	53	59	67	76	104	113	122	133	146	159	175	193	213	235	259
5	Morogoro	39	48	54	61	69	82	90	99	109	121	133	146	161	176	193	211
6	Pwani	24	41	50	60	69	79	93	110	129	149	173	190	208	229	251	275
7	Dar es Salaam	459	561	632	715	797	873	959	1,059	1,165	1,278	1,407	1,544	1,693	1,853	2,027	2,216
8	Lindi	3	5	7	9	12	16	17	20	22	25	27	30	34	37	41	46
9	Mtwara	7	9	8	11	13	15	18	21	24	28	32	36	40	44	49	55
10	Ruvuma	5	6	8	10	12	14	18	23	28	33	39	44	49	55	62	69
11	Iringa +Njombe	18	21	23	27	30	35	38	42	46	51	55	62	69	76	85	94
12	Mbeya	33	49	59	70	80	91	101	112	124	137	151	166	183	201	221	243
13	Singida	6	8	9	10	11	14	16	17	19	21	23	26	29	33	37	42
14	Tabora	19	28	39	50	61	72	82	93	105	118	133	150	170	192	217	246
15	Rukwa +Katavi	3	5	6	8	10	12	13	15	17	19	21	23	26	29	32	36
16	Kigoma	4	7	12	16	21	25	29	33	38	43	48	54	60	66	73	82
17	Shinyanga+ Simiyu	70	85	93	102	114	116	129	141	154	169	185	207	231	259	290	324
18	Kagera	10	17	24	32	43	42	50	58	68	81	92	102	113	125	138	152
19	Mwanza +Geita	47	66	85	103	121	153	175	195	218	249	290	320	354	390	431	476
20	Mara	24	30	36	42	48	63	72	79	88	97	107	119	132	147	163	181
21	Manyara	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17	18
	Mainland total	917	1,176	1,368	1,591	1,823	2,078	2,305	2,555	2,833	3,141	3,489	3,844	4,234	4,660	5,130	5,644
22	Zanzibar	58	70	81	92	102	112	123	134	146	158	170	181	192	204	215	228
	Total	974	1,246	1,449	1,683	1,925	2,190	2,428	2,690	2,979	3,299	3,659	4,025	4,426	4,864	5,345	5,872

		2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2015/20	2020/25	2025/30	2030/35	2035/40	2015/40
1	Dodoma	115	127	140	154	169	184	197	212	228	246	16.7	8.2	9.9	10.0	7.8	10.5
2	Arusha	434	474	516	562	613	666	724	787	855	928	24.0	9.7	9.3	9.0	8.7	12.0
3	Kilimanjaro	125	136	147	160	173	188	204	221	240	260	18.6	6.4	8.4	8.5	8.4	10.0
4	Tanga	286	316	348	383	422	457	495	536	580	628	18.9	8.8	10.3	10.2	8.3	11.2
5	Morogoro	231	252	275	301	328	356	386	418	453	490	16.1	10.3	9.6	9.2	8.3	10.7
6	Pwani	302	332	365	402	442	480	522	567	616	670	26.3	17.1	9.7	9.9	8.7	14.2
7	Dar es Salaam	2,420	2,641	2,880	3,137	3,416	3,730	4,072	4,442	4,842	5,276	13.7	10.0	9.5	9.0	9.1	10.3
8	Lindi	51	56	62	69	77	85	93	103	114	126	42.1	12.1	10.7	10.9	10.4	16.6
9	Mtwara	61	68	76	85	95	105	117	131	146	163	18.1	16.0	11.4	11.5	11.5	13.7
10	Ruvuma	78	87	98	109	122	135	149	164	181	200	23.9	23.1	12.0	12.0	10.3	16.1
11	Iringa +Njombe	105	116	129	143	159	171	185	200	216	233	14.9	9.5	11.2	11.0	8.0	10.9
12	Mbeya	267	293	323	355	390	423	459	498	540	586	22.7	10.8	9.9	10.0	8.5	12.3
13	Singida	47	53	59	66	74	81	88	96	104	113	18.2	10.4	12.2	12.2	8.8	12.3
14	Tabora	278	314	355	400	451	500	554	614	680	752	30.2	13.1	13.1	12.9	10.8	15.8
15	Rukwa +Katavi	40	44	49	55	61	69	79	90	103	118	32.8	11.9	11.2	11.5	13.9	16.0
16	Kigoma	91	101	112	124	138	150	163	177	192	208	42.3	13.9	11.0	11.1	8.5	16.8
17	Shinyanga+ Simiyu	363	406	455	510	571	624	682	746	814	889	10.8	9.8	11.8	12.0	9.3	10.7
18	Kagera	168	187	207	229	254	281	311	345	383	426	34.5	16.9	10.5	10.8	10.8	16.4
19	Mwanza +Geita	525	579	638	703	774	843	917	998	1,085	1,180	26.5	13.6	10.4	10.2	8.8	13.7
20	Mara	202	224	249	277	307	334	363	394	428	464	20.9	11.1	11.2	11.1	8.6	12.5
21	Manyara	19	21	22	24	25	27	29	31	33	35	20.5	6.5	7.0	7.1	6.5	9.4
	Mainland total	6,208	6,827	7,505	8,248	9,062	9,890	10,789	11,768	12,831	13,989	17.8	10.9	10.1	9.9	9.1	11.5
22	Zanzibar	240	251	264	276	288	298	310	320	332	342	14.2	8.7	6.0	4.8	3.5	7.4
	Total	6,448	7,079	7,769	8,524	9,351	10,188	11,099	12,088	13,163	14,332	17.6	10.8	9.9	9.8	8.9	11.4

Source: Study results of Task Force Team

2.8.8 Power consumption per capita

Table 2-25: Power consumption per capita (Base)

Unit: kWh /person

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Dodoma	59	69	77	86	96	109	115	122	131	139	148	160	173	187	203	220
2	Arusha	192	253	299	352	415	465	495	530	569	612	658	704	753	805	862	922
3	Kilimanjaro	90	113	126	145	170	184	191	200	210	221	232	248	265	283	303	324
4	Tanga	129	148	160	175	193	262	280	300	323	348	375	409	447	487	532	581
5	Morogoro	105	124	133	146	160	187	202	218	237	257	279	302	325	351	379	408
6	Pwani	134	213	251	292	331	367	425	494	567	646	737	794	857	924	998	1,077
7	Dar es Salaam	564	635	667	704	744	774	810	854	898	944	997	1,053	1,112	1,174	1,242	1,314
8	Lindi	19	34	48	63	78	102	114	127	141	157	174	191	209	230	253	279
9	Mtwara	32	44	39	49	56	67	77	89	102	117	133	146	162	178	197	217
10	Ruvuma	21	24	31	38	45	52	67	82	98	116	135	148	163	180	198	218
11	Iringa +Njombe	67	77	83	94	103	121	131	142	155	168	183	202	223	246	272	300
12	Mbeya	71	101	117	133	149	166	182	198	215	235	256	277	301	326	354	384
13	Singida	27	32	35	39	43	53	57	62	67	72	78	86	95	104	115	127
14	Tabora	49	67	90	110	132	152	168	185	204	225	248	274	303	335	371	410
15	Rukwa +Katavi	11	16	21	26	31	36	39	42	46	50	55	59	64	70	76	83
16	Kigoma	12	20	30	40	50	60	67	75	84	93	103	113	123	134	146	160
17	Shinyanga+ Simiyu	135	158	167	177	195	193	207	220	234	250	267	291	317	346	378	413
18	Kagera	23	39	52	65	85	83	95	108	126	146	165	179	195	212	231	252
19	Mwanza +Geita	62	81	101	117	136	165	181	195	209	230	259	276	295	315	337	360
20	Mara	84	98	112	126	141	181	201	216	237	256	275	300	328	357	390	426
21	Manyara	15	19	21	25	28	31	32	34	35	37	38	40	42	44	46	49
	Mainland total	124	151	168	188	210	233	252	272	295	319	346	373	402	433	466	503
22	Zanzibar	261	298	330	357	384	410	440	473	506	538	569	594	618	646	669	691
	Total	128	155	173	193	215	238	258	278	301	325	353	379	408	439	472	508

		2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2015/20	2020/25	2025/30	2030/35	2035/40	2015/40
1	Dodoma	238	258	280	304	330	353	375	398	423	450	13.1	6.3	7.6	8.5	6.4	8.5
2	Arusha	987	1,056	1,130	1,210	1,295	1,384	1,480	1,582	1,692	1,809	19.4	7.2	7.0	7.0	6.9	9.4
3	Kilimanjaro	347	372	398	427	458	491	527	566	607	652	15.3	4.8	6.9	7.2	7.3	8.2
4	Tanga	634	692	756	825	900	966	1,038	1,115	1,197	1,286	15.2	7.4	9.1	9.2	7.4	9.6
5	Morogoro	440	475	511	551	593	635	680	729	781	836	12.3	8.4	7.9	7.7	7.1	8.7
6	Pwani	1,165	1,261	1,367	1,482	1,608	1,724	1,850	1,987	2,134	2,296	22.3	15.0	7.9	8.3	7.4	12.0
7	Dar es Salaam	1,390	1,473	1,560	1,654	1,754	1,869	1,991	2,123	2,265	2,417	6.5	5.2	5.7	6.0	6.6	6.0
8	Lindi	307	338	373	412	454	498	546	600	659	724	39.3	11.2	9.9	10.3	9.8	15.6
9	Mtwara	240	265	294	325	359	397	439	486	538	596	15.5	14.8	10.3	10.6	10.7	12.3
10	Ruvuma	241	266	293	324	358	389	424	462	503	549	20.1	20.8	10.1	10.4	8.9	13.9
11	Iringa +Njombe	331	365	403	444	489	526	565	606	651	699	12.5	8.6	10.4	10.3	7.4	9.8
12	Mbeya	417	453	492	535	581	624	669	719	772	830	18.4	9.1	8.4	8.7	7.4	10.3
13	Singida	141	155	172	190	210	225	241	259	278	298	14.3	8.1	10.2	10.5	7.3	10.1
14	Tabora	455	504	558	618	684	745	811	883	962	1,047	25.2	10.3	10.6	10.8	8.9	13.0
15	Rukwa +Katavi	90	98	107	117	128	142	158	177	198	224	27.3	8.8	8.6	9.2	11.8	12.9
16	Kigoma	174	191	209	228	250	268	287	307	329	353	37.5	11.7	9.1	9.4	7.1	14.4
17	Shinyanga+ Simiyu	452	495	543	595	653	700	751	805	864	928	7.3	6.8	9.1	9.6	7.3	8.0
18	Kagera	275	300	329	360	394	430	471	516	566	623	29.3	14.9	8.8	9.4	9.6	14.1
19	Mwanza +Geita	386	414	445	478	515	548	584	623	666	711	21.7	9.4	6.8	7.4	6.7	10.3
20	Mara	465	508	555	607	663	710	759	812	869	930	16.7	8.7	9.1	9.3	7.0	10.1
21	Manyara	51	54	57	60	63	66	69	73	77	81	15.7	4.1	4.9	5.3	5.0	6.9
	Mainland total	542	585	631	681	736	790	848	911	978	1,052	13.4	8.2	7.7	7.9	7.4	8.9
22	Zanzibar	718	741	766	790	813	830	852	868	890	906	9.5	6.8	4.0	3.3	2.2	5.1
	Total	547	589	635	684	738	791	848	910	976	1,048	13.2	8.1	7.6	7.8	7.3	8.8

Source: Study results of Task Force Team

2.8.9 Power demand including export and additional demand

Table 2-26: Power energy demand including export and additional demand (Base)

			Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Additional demand (including transmission and distribution losses)	Geita : Gold Mining Co.		MW	28	28	28	28	28	45	45	45	45	45	45	45	45	45	45	45
	Mara :Two Gold mining Co.		MW	9	9	9	9	9	22	22	22	22	22	22	22	22	22	22	22
	Njombe :Iron Smelting		MW						337	337	337	337	337	337	337	337	337	337	337
	Mtwara : DANGOTE		MW	34	34	34	34	34	67	67	67	67	67	67	67	67	67	67	67
	Power supply for Security		MW						570	570	570	570	570	570	570	570	570	570	570
	Total		MW	71	71	71	71	71	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041
			Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Power export (MW)	Kenya (400kV)		MW						0	0	0	0	0	0	0	0	0	0	0
	Mozambique (400kV)		MW						200	200	200	200	200	200	200	200	200	200	200
	Uganda (220kV)		MW						100	100	100	100	100	100	100	100	100	100	100
	Malawi		MW						100	100	100	100	100	100	100	100	100	100	100
	Zambia (400kV)		MW						200	200	200	200	200	200	200	200	200	200	200
	Export Total (MW)		MW						600	600	600	600	600	600	600	600	600	600	600
	Export including losses (MW)		MW						685	683	681	679	677	677	677	677	677	677	677
Cases		Demand items	Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Base	Peak demand	Domestic demand	MW	974	1,246	1,449	1,683	1,925	2,190	2,428	2,690	2,979	3,299	3,659	4,025	4,426	4,864	5,345	5,872
		Additional demand	MW	71	71	71	71	71	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041
		Export (Inc. Loss)	MW	0	0	0	0	0	685	683	681	679	677	677	677	677	677	677	677
		Total	MW	1,045	1,317	1,520	1,754	1,996	3,916	4,152	4,412	4,700	5,017	5,377	5,744	6,144	6,583	7,063	7,590
	Installed capacity (Peak*1.3)	Domestic demand	MW	1,267	1,620	1,884	2,188	2,503	2,847	3,156	3,497	3,873	4,288	4,757	5,233	5,753	6,324	6,948	7,633
		Additional demand	MW	92	92	92	92	92	1,353	1,353	1,353	1,353	1,353	1,353	1,353	1,353	1,353	1,353	1,353
		Export (Inc. Loss)	MW	0	0	0	0	0	890	888	885	883	881	880	880	880	880	880	880
		Total	MW	1,359	1,712	1,976	2,281	2,595	5,091	5,397	5,736	6,109	6,522	6,991	7,467	7,987	8,557	9,182	9,867

			Unit	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2010/15	2015/20	2020/25	2025/30	2030/35	2035/40
Additional demand (including transmission and distribution losses)	Geita : Gold Mining Co.		MW	45	45	45	45	45	45	45	45	45	45	0.0	10.0	0.0	0.0	0.0	0.0
	Mara :Two Gold mining Co.		MW	22	22	22	22	22	22	22	22	22	22	0.0	19.6	0.0	0.0	0.0	0.0
	Njombe :Iron Smelting		MW	337	337	337	337	337	337	337	337	337	337	0.0	0.0	0.0	0.0	0.0	0.0
	Mtwara : DANGOTE		MW	67	67	67	67	67	67	67	67	67	67	0.0	14.5	0.0	0.0	0.0	0.0
	Power supply for Security		MW	570	570	570	570	570	570	570	570	570	570	0.0	0.0	0.0	0.0	0.0	0.0
	Total		MW	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	0.0	71.1	0.0	0.0	0.0	0.0
			Unit	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2010/15	2015/20	2020/25	2025/30	2030/35	2035/40
Power export (MW)	Kenya (400kV)		MW	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
	Mozambique (400kV)		MW	200	200	200	200	200	200	200	200	200	200	0.0	0.0	0.0	0.0	0.0	0.0
	Uganda (220kV)		MW	100	100	100	100	100	100	100	100	100	100	0.0	0.0	0.0	0.0	0.0	0.0
	Malawi		MW	100	100	100	100	100	100	100	100	100	100	0.0	0.0	0.0	0.0	0.0	0.0
	Zambia (400kV)		MW	200	200	200	200	200	200	200	200	200	200	0.0	0.0	0.0	0.0	0.0	0.0
	Export Total (MW)		MW	600	600	600	600	600	600	600	600	600	600	0.0	0.0	0.0	0.0	0.0	0.0
	Export including losses (MW)		MW	677	677	677	677	677	677	677	677	677	677	0.0	0.0	-0.2	0.0	0.0	0.0
Cases		Demand items	Unit	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2010/15	2015/20	2020/25	2025/30	2030/35	2035/40
Base	Peak demand	Domestic demand	MW	6,448	7,079	7,769	8,524	9,351	10,188	11,099	12,088	13,163	14,332	3.4	17.6	10.8	9.9	9.8	8.9
		Additional demand	MW	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	1,041	0.0	71.1	0.0	0.0	0.0	0.0
		Export (Inc. Loss)	MW	677	677	677	677	677	677	677	677	677	677	0.0	0.0	-0.2	0.0	0.0	0.0
		Total	MW	8,167	8,797	9,487	10,242	11,069	11,907	12,817	13,807	14,882	16,050	0.0	30.2	6.5	7.1	7.8	7.7
	Installed capacity (Peak*1.3)	Domestic demand	MW	8,383	9,202	10,099	11,081	12,156	13,245	14,429	15,715	17,113	18,631	3.4	17.6	10.8	9.9	9.8	8.9
		Additional demand	MW	1,353	1,353	1,353	1,353	1,353	1,353	1,353	1,353	1,353	1,353	0.0	71.1	0.0	0.0	0.0	0.0
		Export (Inc. Loss)	MW	880	880	880	880	880	880	880	880	880	880	0.0	0.0	-0.2	0.0	0.0	0.0
		Total	MW	10,617	11,436	12,333	13,315	14,389	15,479	16,662	17,949	19,346	20,865	0.0	30.2	6.5	7.1	7.8	7.7

Source: Study results of Task Force Team

Note: The installed capacity becomes more than 4,920 MW in 2020

2.8.10 Regional peak demand including additional demand, excluding export (Base)

Table 2-27: Regional peak demand including additional demand, excluding export (Base)

Unit: MW

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Dodoma	20	25	29	33	38	56	59	63	67	71	76	83	90	97	106	116
2	Arusha	55	77	94	116	140	205	219	235	254	275	298	321	347	375	405	438
3	Kilimanjaro	24	32	36	43	52	72	75	78	82	86	90	96	103	110	118	127
4	Tanga	44	53	59	67	76	133	141	150	160	172	185	201	219	239	261	286
5	Morogoro	39	48	54	61	69	104	112	121	131	143	155	168	182	197	214	232
6	Pwani	24	41	50	60	69	100	116	134	154	176	202	218	236	257	279	303
7	Dar es Salaam	459	561	632	715	797	1,113	1,197	1,295	1,400	1,510	1,637	1,773	1,920	2,080	2,253	2,440
8	Lindi	3	5	7	9	12	20	22	24	26	29	32	35	38	42	46	50
9	Mtwara	41	43	42	45	47	86	89	92	96	100	104	108	112	117	122	128
10	Ruvuma	5	6	8	10	12	18	23	28	33	39	46	51	56	62	69	76
11	Iringa +Njombe	18	21	23	27	30	382	385	388	392	397	401	408	415	422	431	441
12	Mbeya	33	49	59	70	80	116	126	136	148	162	176	191	207	225	245	267
13	Singida	6	8	9	10	11	18	20	21	23	25	27	30	33	37	41	46
14	Tabora	19	28	39	50	61	92	102	113	126	140	155	173	193	216	242	271
15	Rukwa +Katavi	3	5	6	8	10	15	17	18	20	22	24	27	29	32	36	39
16	Kigoma	4	7	12	16	21	32	36	40	45	51	56	62	68	74	82	90
17	Shinyanga+ Simiyu	70	85	93	102	114	148	161	172	185	200	216	238	263	290	322	357
18	Kagera	10	17	24	32	43	54	62	70	82	95	108	117	128	140	153	168
19	Mwanza +Geita	75	94	113	131	149	240	263	284	307	339	382	413	446	483	524	569
20	Mara	33	39	45	51	57	102	111	118	128	137	146	158	172	187	203	222
21	Manyara	4	5	6	7	8	12	12	13	14	14	15	16	17	18	19	20
	Mainland total	988	1,247	1,439	1,662	1,894	3,119	3,346	3,597	3,874	4,182	4,530	4,885	5,275	5,701	6,171	6,685
22	Zanzibar	58	70	81	92	102	112	123	134	146	158	170	181	192	204	215	228
	Total	1,045	1,317	1,520	1,754	1,996	3,231	3,469	3,731	4,020	4,340	4,700	5,066	5,467	5,905	6,386	6,913

		2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2010/15	2015/20	2020/25	2025/30	2030/35	2035/40	2015/40
1	Dodoma	126	138	150	164	180	194	208	222	238	256	4.6	22.5	6.3	8.7	9.2	7.3	10.7
2	Arusha	474	513	556	601	651	704	762	825	893	966	0.8	30.2	7.7	8.1	8.2	8.2	12.2
3	Kilimanjaro	137	147	158	171	184	199	215	232	250	270	-0.1	24.4	4.4	7.2	7.7	8.0	10.1
4	Tanga	312	342	374	410	449	483	521	562	606	653	1.4	24.8	6.8	9.1	9.4	7.8	11.4
5	Morogoro	252	273	296	321	349	376	406	438	473	510	2.0	21.9	8.3	8.4	8.5	7.9	10.9
6	Pwani	330	360	393	429	470	508	549	595	644	698	3.3	32.6	15.0	8.5	9.2	8.2	14.3
7	Dar es Salaam	2,643	2,862	3,098	3,354	3,631	3,945	4,287	4,657	5,057	5,491	5.5	19.4	8.0	8.3	8.3	8.6	10.4
8	Lindi	55	61	67	74	82	90	98	108	119	131	1.1	49.2	10.0	9.5	10.2	9.9	16.8
9	Mtwara	134	141	149	158	168	178	191	204	220	237	50.4	16.3	3.8	4.1	5.6	7.1	7.3
10	Ruvuma	85	94	105	117	130	143	157	172	189	208	3.1	30.1	20.8	10.7	11.2	9.9	16.3
11	Iringa +Njombe	451	463	476	490	506	518	532	547	563	580	-2.3	85.0	1.0	1.9	2.8	2.8	15.0
12	Mbeya	291	318	347	379	415	448	483	522	564	609	3.7	28.8	8.8	8.7	9.2	8.0	12.4
13	Singida	51	57	63	71	79	85	93	100	109	118	4.0	24.1	8.4	11.0	11.5	8.3	12.5
14	Tabora	303	340	382	428	480	529	583	644	710	783	0.3	36.7	11.0	11.8	12.1	10.3	16.0
15	Rukwa +Katavi	43	48	53	59	65	73	83	94	107	122	-2.8	39.4	9.8	10.0	10.7	13.4	16.2
16	Kigoma	99	109	121	133	147	159	172	186	201	217	6.6	49.4	11.9	9.8	10.4	8.1	17.0
17	Shinyanga+ Simiyu	396	440	490	545	607	660	718	782	851	925	2.6	16.3	7.8	10.6	11.2	8.8	10.9
18	Kagera	184	202	223	245	270	297	328	362	400	443	2.3	41.2	14.7	9.3	10.0	10.4	16.5
19	Mwanza +Geita	618	672	731	796	868	936	1,011	1,091	1,179	1,273	12.3	26.1	9.8	8.3	8.8	8.0	12.0
20	Mara	242	265	290	318	349	375	404	435	469	505	9.2	25.1	7.4	8.7	9.5	7.7	11.5
21	Manyara	21	22	24	25	27	29	30	32	34	36	3.4	26.5	4.6	5.8	6.3	6.1	9.5
	Mainland total	7,249	7,868	8,546	9,289	10,103	10,931	11,830	12,810	13,872	15,030	5.2	25.9	7.8	8.1	8.6	8.3	11.5
22	Zanzibar	240	251	264	276	288	298	310	320	332	342	0.3	14.2	8.7	6.0	4.8	3.5	7.4
	Total	7,490	8,120	8,810	9,565	10,392	11,230	12,140	13,129	14,205	15,373	4.9	25.3	7.8	8.0	8.5	8.1	11.4

Source: Study results of Task Force Team

CHAPTER THREE

3 GENERATION

Generation plan presents an assessment of generation sequencing that meet demand for the forecast period. A number of generation technologies have been evaluated to attain the recommended plans for development of power sector in the country. In identifying new power projects, the plan evaluate new power generation technologies, including a review of capital investment, project lead time, fuel costs and their availability, both locally and imported. In addition, confirmatory studies such as environmental assessment and project financing arrangement are key elements of the projects preparations and signals on the possibility of success for the identified projects. The generation plan considers the following power sources namely hydro, gas, coal, wind, geothermal and solar among others.

3.1 Existing Generation Plants

3.1.1 Hydro power plants

Existing hydro power plants are consisted of three reservoir type and eight run-of-river type plants as shown in Table 3-1(a) and (b).

3.1.2 Thermal power plants

The interconnected grid system is composed of several power plants, among those seven are gas fired plants, two are Heavy Fuel Oil (HFO) plants, two are Biomass plants, and one is Industrial Diesel Oil. Thermal power plants on average have an economic life span of twenty (20) years however; the life span can be extended by proper maintenance and interim replacement of major parts. Characteristics of the existing thermal power plants are shown in Table 3-2.

Table 3-1 (a): Existing Hydro Plant Characteristics (Owned by TANESCO)

Item			Hale	Nyumba Ya Mungu	New Pangani Falls	Kidatu	Mtera	Uwemba	Kihansi
			Hydro Power Plant						
Owner			TANESCO						
Plant Characteristic	River Basin		Pangani			Rufiji			
	Location	District	Korogwe	Mwanga	Muheza	Kilombero	Kilolo	Njombe	Kilombero
		Region	Tanga	Kilimanjaro	Tanga	Morogoro	Iringa	Njombe	Iringa
	Power Generation Type		Run-off-river	Reservoir	Run-off-river	Reservoir	Reservoir	Run-off-river	Run-off-river
	Installation Year		1964	1968	1995	1975 (2 units) 1980 (2 units)	1988	1991	1999 (1 unit) 2000 (2 units)
	Installed Capacity (MW)		21	8	68	204	80	0.843	180
	Number of Units		2	2	2	4	2	3	3
	Plant Discharge (m^3/s)		45.00	42.50	45.00	140.00	96.00	N/A	23.76
	Gross Head (m)		70.00	27.00	170.00	175.00	101.00	N/A	852.75
	Annual Energy Generation (GWh)		36.11	21.53	137.20	558.34	166.68	2.30	793.49
	Plant Factor (%)		20	31	23	31	24	31	50
Facility Characteristic	Dam (Main)	Type	Concrete gravity	Rock fill	Concrete gravity	Rock fill	Concrete buttress	N/A	Concrete gravity
		Height (m)	33.5	42	9	40	45	N/A	25
		Crest Length (m)	137	121	116.6	350	260	N/A	200
	Dam (Auxiliary)	Type	Rock fill	Rock fill	Earth fill	-	-	N/A	-
		Height (m)	7.77	N/A	9	-	-	N/A	-
		Crest Length (m)	246.9	N/A	315	-	-	N/A	-
	Reservoir	Full Water Level (masl)	342.44	688.91	177.50	450.00	698.50	N/A	1,146.00
		Low Water Level (masl)	342.44	679.15	176.00	433.00	690.00	N/A	1,141.00
		Active Storage (10^6 m^3)	0	600	0.8	125	3,200	N/A	1
	Headrace	Type	Tunnel	-	Tunnel	Tunnel	Tunnel	N/A	Tunnel
		Length (m)	2,050	-	1,050	9,600	70	N/A	2,250
		Diameter (m)	2.0 - 4.6	-	6.0 - 12.0	6.0 - 12.0	6.0	N/A	6.0 - 12.0
	Penstock	Type	Tunnel	N/A	Tunnel	Tunnel	Tunnel	N/A	Tunnel
		Length (m)	3.6	400	3	140	92	N/A	185
		Diameter (m)	1.8	2.69 - 3.85	2.4	4.7	3.2	N/A	1.1 - 2.0
	Powerhouse	Type	Underground	Surface	Underground	Underground	Underground	Surface	Underground
		Width (m)	12	15	12.5	N/A	14	7.8	N/A
		Depth (m)	30	43	40	N/A	48	13.6	N/A
		Height (m)	24	19	29	N/A	32	6.7	N/A
	Tailrace	Type	Tunnel	N/A	Tunnel	Tunnel	Tunnel	N/A	Tunnel
		Length (km)	N/A	N/A	1,200	1,000	10,323	N/A	2,740
		Diameter (m)	1.0 - 2.0	N/A	1.0 - 2.0	1.0 - 2.0	6.5 - 8.4	N/A	5.3
	Turbine	Type	Vertical Francis	Vertical Francis	Vertical Francis	Vertical Francis	Vertical Francis	N/A	Pelton
		Rated Output (MW/unit)	10.625	4.25	24	52.3 & 52.4	50	N/A	60
	Generator	Type	Synchronous 3 Phase	Synchronous 3 Phase	Synchronous 3 Phase	Synchronous 3 Phase	Synchronous 3 Phase	N/A	Synchronous 3 Phase
		Rated Output (MVA/unit)	12.5	4.7	40	60	45	N/A	71.5
		Rated Voltage (kV)	11	11	11	10.5	22	N/A	22

Note: Annual energy generation and plant factor are actual record in 2013.
New Pangani Falls and Kihansi hydro power plants are considered and operated as a run-off-river type, although these plants have ponds (small reservoirs).
Hale hydro power plant has no active storage capacity of reservoir due to full sedimentation.

Source: TANESCO and PSMP2012 Update

Table 3-1 (b): Hydro Plant Characteristics (Owned by SPP, Extisging or ongoing)

Item			Mwenga	Mapembasi	EA Power	Darakuta	Yovi	Tulila	Ikondo	Mbangamao
			Hydro Power Plant							
Owner			SPP							
			Mwenga Hydro Ltd.	Mapembasi Hydro Power Co., Ltd.	EA Power Ltd.	N/A	N/A	N/A	N/A	N/A
Plant Characteristic	River Basin		Rufiji		Lake Nyasa	N/A	Rufiji	Rufiji	Rufiji	N/A
	Location	District	Mufindi	Njombe	Tukuyu	Magugu	Kisanga	N/A	N/A	N/A
		Region	Iringa	Njombe	Mbeya	Manyara	Morogoro	Songea	N/A	Mbinga
	Power Generation Type		Run-of-river	Run-of-river	Run-of-river	Run-of-river	Run-of-river	Run-of-river	Run-of-river	Run-of-river
	Installation Year		2012	2019 (expected)	2019 (expected)	2015	2016	2015	2015	2014
	Installed Capacity (MW)		4	10	10	0.46	0.96	5	0.6	0.5
	Number of Units		1	3	2	N/A	1	2	3	1
	Plant Discharge (m^3/s)		8.00	30.00	N/A	N/A	N/A	N/A	N/A	N/A
	Gross Head (m)		62.00	36.00	N/A	N/A	N/A	N/A	N/A	N/A
	Annual Energy Generation (GWh)		17.10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Plant Factor (%)		49	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Facility Characteristic	Dam (Main)	Type	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Height (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Crest Length (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Dam (Auxiliary)	Type	-	-	-	-	-	-	-	-
		Height (m)	-	-	-	-	-	-	-	-
		Crest Length (m)	-	-	-	-	-	-	-	-
	Reservoir	Full Water Level (masl)	1,127.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Low Water Level (masl)	1,126.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Active Storage (10^6 m^3)	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Headrace	Type	N/A	Channel	N/A	N/A	N/A	N/A	N/A	N/A
		Length (m)	N/A	900	N/A	N/A	N/A	N/A	N/A	N/A
		Diameter (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Penstock	Type	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Length (m)	340	168 - 185	340	340	N/A	N/A	N/A	N/A
		Diameter (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Powerhouse	Type	N/A	Surface	N/A	N/A	N/A	N/A	N/A	N/A
		Width (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Depth (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Height (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Tailrace	Type	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Length (km)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Diameter (m)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Turbine	Type	Francis	Horizontal Francis	Horizontal Francis	N/A	N/A	N/A	N/A	N/A
		Rated Output (MW/unit)	N/A	3.238	5	N/A	N/A	N/A	N/A	N/A
	Generator	Type	Synchronous 3 Phase	Synchronous 3 Phase	N/A	N/A	N/A	N/A	N/A	N/A
		Rated Output (MVA/unit)	N/A	4.2	N/A	N/A	N/A	N/A	N/A	N/A
		Rated Voltage (kV)	6.6	6.3	N/A	N/A	N/A	N/A	N/A	N/A

Note: Annual energy generation and plant factor are actual record in 2013.
New Pangani Falls and Kihansi hydro power plants are considered and operated as a run-off-river type, although these plants have ponds (small reservoirs).
Hale hydro power plant has no active storage capacity of reservoir due to full sedimentation.

Source: TANESCO and PSMP2012 Update

Table 3-2: Existing Thermal Power Plants

Plant	Fuel	Units	Installed Capacity MW	Available Capacity MW	Station service %	Net Available Capacity MW	FOR %	Combined Outage Rate %	Maximum Plant Factor %	Available Energy GWh	Year Installed (Jan)	Nominal Service Life Years	Retirement Year (Dec)
IPP UNITS													
Songas 1	Gas	2	42.00	38.30	1.60	37.69	5	13	80	251	2004	20	2023
Songas 2	Gas	3	120.00	110.00	1.60	108.24	5	13	80	721	2005	20	2024
Songas 3	Gas	1	40.00	37.00	1.60	36.41	5	13	80	242	2006	20	2025
Tegeta IPTL	HFO	10	103.00	100.00	1.60	98.40	8	18	75	595	2002	20	2021
TPC	Biomass		17.00	17.00	1.60	16.73	5	13	50	70	2011	20	2030
TANWAT	Biomass		2.70	2.40	1.60	2.36	5	13	50	10	2010	20	2029
Subtotal			**324.70**	**304.70**		**299.83**				**1888**			
TANESCO													
Ubungo I	Gas	12	102.00	100.00	1.60	98.40	5	13	80	655	2007	20	2026
Tegeta GT	Gas	5	45.00	43.00	1.60	42.31	5	13	80	282	2009	20	2028
Ubungo II	Gas	3	105.00	100.00	1.60	98.40	5	13	80	655	2012	20	2031
Zuzu D	IDO	1	7	5.00	1.60	4.92	8	18	75	31	1980	20	2019
Nyakato	HFO	10	63.00	63.00	1.60	61.99	8	18	75	375	2013	20	2032
Kinyerezi-I	Gas	4	150.00	150.00	1.60	147.60	5	13	80	1034	2015	20	2035
Subtotal			**472.00**	**461.00**		**453.62**				**1998**			
TOTAL			**796.70**	**765.70**		**753.45**				**3886**			

Available energy (MWh) = Available capacity (MW) * 8.76*(100-FOR)*max plant factor/100
Small diesels assumed to stay in service to December 2012 as reserve
FOR = Forced Outage Rate

3.1.3 Retirement of Existing Plant

In the scheduling of new generation, existing generating units were assumed to be retired at the end of their normal "economic" service life except for hydroelectric plants which were assumed to remain in service. Assumed retirement dates are shown in Table 3-3.

Table 3-3: Existing Plant Retirement Dates (Interconnected System)

Plant name	Nominal Capacity MW	Normal service life – years	Installation year (January)	Retirement year (December)
HYDRO				
Mtera	80	50	1988	2038**
Kidatu	204	50	1975	2025**
Hale	21	50	1967	2017**
Kihansi	180	50	2000	2050**
Pangani Falls	68	50	1995	2045**
Nyumba Ya Mungu	8	50	1968	2018**
Mwenga	4	15*	2012	2027*
Uwemba	0.843	50	1991	2041
Yovi	0.95	15*	2016	2031
Tulila	5	20*	2015	2035
Ikondo	0.6(0.4)	20*	2015	2035
THERMAL				
Songas I (2 units)	40	20	2004	2024
Songas II (3 units)	120	20	2005	2025
Songas III (1 units)	40	20	2006	2026
Tegeta IPTL	100	25	2002	2022
Tegeta Gas Engine	45	20	2009	2029
Ubungo I	100	20	2007	2027
Ubungo II	105	20	2012	2032
Tanwat	2.7	20	2010	2029
Zuzu Diesel	7.44	20**	1980	2019
Nyakato	63	20	2013	To be operated as backup after 2021
Kinyerezi-I	150	20	2015	2035
TPC	17	20	2011	2030

Source: TANESCO and Team compilation

*Contractual period

** To be rehabilitated

3.2 Future Generation Options

3.2.1 Hydroelectric power

3.2.1.1 Hydrology and Hydro System Capability

The availability of reliable generation sequences at each candidate hydroelectric project is of major importance. It is important that updated hydrologic data is used for each PSMP update, and that the simulations reflect the optimum use of hydroelectric resources, taking into account the use of reservoirs in a mixed hydro-thermal system. In this Power System Master Plan Update, the energy generation of all new candidate hydroelectric projects, and existing plants, was re-estimated using revised and updated flow records. The re-estimate of generation values was made in two steps, updated hydrology and new generation simulations.

3.2.1.2 Hydrological Data Update

In PSMP, a generation expansion plan for 25 years will be compiled. Accordingly, for the hydro power generation capability used in generation planning tool (WASP[1]), it is desirable to use energy generation values or generating performance based on hydrological data over at least 25 years.

Concerning energy generation values, in the "Power System Master Plan 2009 Update (August 2009, SNC-LAVALIN International)", energy calculations for existing hydro power plants are conducted using flow records from 1995 to 2005. However, in consideration of the following points, it was decided not to use these values in PSMP2016 Update:

a) The flow records used in energy calculations are monthly data and do not have high accuracy.
b) The calculation results only show average annual energy generation over 11 years, but not monthly energy generation.
c) There are only calculation results for 11 years, which is not a sufficiently long period.

Accordingly, in this study, monthly energy generation capability was calculated by means of the following expression using monthly power generation performance. Table 3-4 shows monthly energy generation capability.

Calculation for large and medium-scale power plants

$E_{GCi} = E_{GRi} \times (1 - Ru)$

Where, E_{GCi} : Energy generation capability in "*i*" month (GWh)

E_{GRi} : Mean energy generation performance in "*i*" month (GWh) as shown in Table 3-4

Ru : Station use rate

= Average at existing hydro power plants = 0.79 (%)≈1 (%)

[1] Wien Automatic System Planning Package, a least cost generation planning software developed by International Atomic Energy Agency

Calculation for Small Power Project (SPP) hydro power plants

$E_{GCi} = E_{PRi}$

Where, E_{GCi} : Energy generation capability in "*i*" month (GWh)

E_{PRi} : Mean purchased energy in "*i*" month (GWh) as shown in Table 3-4

Table 3-4: Monthly Energy Generation Capability in Existing Hydro Power Plants from 1971 to 2010

Hydro Power Plant	Energy Generation Capability (GWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hale	4.22	3.81	3.76	4.03	5.38	5.55	4.80	4.62	4.00	3.73	4.32	4.21	52.43
Nyumba Ya Mungu	2.43	2.34	2.37	2.32	2.26	2.15	2.23	2.25	2.29	2.15	2.28	2.04	27.11
Kidatu	78.04	73.70	81.47	79.90	75.87	68.37	69.21	71.43	73.16	73.58	71.94	76.20	892.87
Mtera	27.63	26.62	28.52	22.51	25.56	25.15	27.30	32.41	34.04	34.85	32.44	28.17	345.20
Uwemba	0.29	0.23	0.30	0.30	0.30	0.21	0.20	0.18	0.14	0.14	0.11	0.20	2.60
New Pangani Falls	21.46	16.09	18.46	23.59	30.30	25.34	20.74	20.05	16.90	19.11	19.85	19.17	251.06
Kihansi	56.02	54.72	66.51	89.30	89.65	69.48	58.04	50.67	38.93	38.18	34.42	47.98	693.90
Mwenga SPP	1.20	1.22	2.02	2.11	2.38	1.81	1.38	1.40	0.98	0.90	0.65	1.05	17.10

Source: TANESCO

3.2.1.3 Hydropower Resources

Tanzania has comparatively abundant hydro power potential since its inland area has a high elevation above sea level, and there are precipitous rivers. Various studies on hydro power have been carried out over a long period of time, and hydro power potential in Tanzania is estimated as 38,000MW and about 190,000GWh/year[2].

For large and medium-scale hydro power projects, twenty three (23) projects with a total installed capacity of 4,765MW are identified as power development options in previous studies as shown in Table 3-5. Four (4) planned projects out of those, i.e. Rumakali, Rusumo, Ruhudji and Malagarasi Stage III, were committed projects in the PSMP2012 Update. However, only the Rusumo Project is at the stage of implementation, and in the process of bidding for contractors as of December 2016.

The outline of development plans for planned large and medium-scale hydro power projects is shown in Table 3-5, 3-5(1-5).

[2] Kihansi Hydro Power Development Project - Study Final Report (October 1990, JICA)

Table 3-5: Planned Hydro Power Projects

			Planned Project		Installed Capacity (MW)	Current Status of Studies (as of December 2016)	Rank
1	Large and medium-scale	Implementation	Rusumo		80.0	- F/S was completed in 2012 - ESIA Certificate was issued by NEMC in 2014 - Under bidding of contractor	A
2		Planning	Kakono		87.0	- F/S and ESIA study were completed in Sep-2014 - ESIA was approved by NEMC	B
3			Malagarasi Stage III		44.7	- F/S was completed in Sep-2011 - ESIA Certificate was issued by NEMC in 2014	B
4			Rumakali		222.0	- F/S and ESIA study were completed in May-1998	C
5			Ruhudji		358.0		C
6			Steiglers Gorge	Phase 1	1,048.0	- Pre-F/S was completed in 2012 - ESIA study commenced in Dec-2014	C
7				Phase 2	1,048.0		C
8			Songwe	Manolo (Lower)	177.9	- F/S was completed in Apr-2014 - ESIA study of Lower was completed in 2015 - NEMC is reviewing ESIA study report	B
9				Sofre (Middle)	158.9		B
10			Mpanga		160.0	- Pre-F/S was completed in Jun-2010 - ESIA Certificate was issued by NEMC in 2012	C
12			Masigira		118.0	- F/S was completed	C
13			Lower Kihansi Expansion		120.0	- Preliminary study was completed in Mar-1997	A
14			Upper Kihansi		47.0	- Pre-F/S was completed in Oct-1990 - ESIA study was conducted	C
15			Kikonge		300.0	- Reconnaissance study was completed in Feb-2014	C
16			Iringa	Ibosa	36.0	- Pre-F/S was completed in May-2013	C
17				Nginayo	52.0		C
18			Mnyera	Ruaha	60.3	- Pre-F/S was completed in Jun-2012 - ESIA study was completed in 2014 - NEMC reviewed ESIA study report	C
19				Mnyera	137.4		C
20				Kwanini	143.9		C
21				Pumbwe	122.9		C
22				Taveta	83.9		C
23				Kisingo	119.8		C
Total					4,765.1		

Note: MOU (Memorandum of Understanding), ESIA (Environmental and Social Impact Assessment), NEMC (National Environment Management Council), RUBADA (Rufiji Basin Development Authority), CRIDF (Climate Resilient Infrastructure Development Facility)
Source: TANESCO, RUBADA, Ministry of Water and PSMP2012 Update
Criteria for Ranking:

Rank	Description
A	F/S completed, ESIA approved, Financing closed, Bidding commenced
B	F/S completed, ESIA approved
C	Other than A and B

Table 3-5(1): Outline of Large and Medium-Scale Hydro Power Projects

Item			Planned Project					
			Rusumo	Kakono	Malagarasi Stage III	Rumakali	Masigira	Kikonge
Plant Characteristic	River Basin		Lake Victoria		Lake Tanganyika	Lake Nyasa		
		River Name	Kagera		Malagarasi	Rumakali	Ruhuhu	
	Location	District	Ngara	Karagwe, Kyerwa, Missenyi	N/A	Makete	N/A	Mbinga
		Region	Kagera	Kagera	Kigoma	Njombe	Iringa	Ruvuma
	Power Generation Type		Reservoir	Run-off-river	Pondage	Reservoir	Pondage	Reservoir
	Installed Capacity (MW)		80	87	44.7	222	118	300
	Number of Units		3	2	3	3	2	3
	Plant Discharge (m^3/s)		357.00	315.00	171.00	19.05	57.00	N/A
	Gross Head (m)		N/A	32.00	33.45	1,294.50	238.00	140.00
	Annual Energy Generation (GWh)		507.00	573.00	186.80	1,320.00	664.00	1,268.00
	Plant Factor (%)		64	75	48	68	64	48
Facility Characteristic	Dam (Main)	Type	Concrete gravity	Concrete gravity	Concrete gravity	Concrete gravity	Rock fill	Concrete faced rock fill
		Height (m)	15.3	51	18	72	35	120
		Crest Length (m)	177	435	670	780	700	N/A
	Dam (Auxiliary)	Type	-	Rock fill	-	Rock fill	-	-
		Height (m)	-	15	-	N/A	-	-
		Crest Length (m)	-	1,160	-	90	-	-
	Reservoir	Full Water Level (masl)	1,325.00	1,190.00	841.50	2,055.00	938.00	660.00
		Low Water Level (masl)	1,322.00	1,190.00	838.50	2,025.00	937.00	620.00
		Active Storage (10^6 m^3)	473.1	-	0.457	256	1.5	6,200
	Headrace	Type	Tunnel	-	Culvert	Tunnel	Tunnel	Tunnel
		Length (m)	610	-	1,098 x 2	4,300	1,700	2,500
		Diameter (m)	Width: 11.0 Height: 14.3	-	Width: 5.05 x 2 Height: 5.05 x 2	5.00	7.00	10.00
	Penstock	Type	Tunnel	Embedded in dam body	Buried	Tunnel	Tunnel	Surface
		Length (m)	N/A	N/A	41.5 x 3	3,100	270	256 x 3
		Diameter (m)	5.40	N/A	4.00 x 3	2.40, 2.20	3.40	4.00 x 3
	Powerhouse	Type	Surface	Surface	Surface	Underground	Underground	Surface
		Width (m)	35	30	19	14	N/A	20
		Length (m)	89	57	50	70	N/A	60
		Height (m)	53	17	38	23	N/A	N/A
	Tailrace	Type	Open channel	-	Open channel	Tunnel	Tunnel	Open channel
		Length (km)	268	-	135	3,000	500	11
		Diameter (m)	Width: 45.0	-	Width: 40.0	6.90	7.00	N/A
	Turbine	Type	Vertical Kaplan	Vertical Kaplan	Vertical Francis	Vertical Pelton	Francis	Vertical Francis
		Rated Output(MW/unit)	N/A	44.5	15.75	74	59	100
	Generator	Type	N/A	Synchronous 3 Phase	Synchronous 3 Phase	N/A	N/A	N/A
		Rated Output(MVA/unit)	N/A	52	17.5	82	N/A	110
		Rated Voltage (kV)	12	10 - 12	6 - 10	13.8	N/A	N/A
Data Source			(1)	(2)	(3)	(4)	(5), (6)	(7)

Source: (1) Regional Rusumo Falls Hydroelectric and Multipurpose Project - Power Generation Plant Final Feasibility Study Phase: Final Feasibility Design Interim Report Volume 1 (July 2011, SNC-LAVALIN International)
(2) Feasibility Study of Kakono Hydropower Project and Transmission Line - Draft Final Feasibility Report (September 2014, Norplan)
(3) Malagarasi Stage III Project - Power Plant Feasibility Study Final Report (September 2011, ESB International Ltd.)
(4) Tanzania Power VI Project Feasibility Studies for Rumakali Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)
(5) Tanzania Power VI Project Feasibility Studies for Hydropower Project - Interim Report No.2 Final Volume 1(March 1997, SwedPower and Norconsult)
(6) Power System Master Plan 2009 Update (August 2009, SNC-LAVALIN International)
(7) Ruhuhu Valley Multi-Purpose Scheme - Dams and Hydropower Report 'February 2014, Climate Resilient Infrastructure Development Facility)
(8) Detailed Design and Investment Preparation Project for the Songwe River Basin Development Programme - Update of the 2003 Feasibility Study : Main Report Volume 1 (April 2014, Lahmeyer International GmbH and ACE Consulting Engineers)
(9) Tanzania Power VI Project Feasibility Studies for Ruhudji Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)
(10) Kihansi Hydro Power Development Project Study Final Report (October 1990, JICA)
(11) Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao)
(12) Mpanga Hydropower Project - Project Proposal (June 2010, Sinohydro Corporation Ltd)
(13) Preliminary Feasibility Study on Iringa Hydropower Projects - Final Report (May 2013, K-water)
(14) Steiglers Gorge Hydropower Project Report and Proposal of Development (2012, Odebrecht)

Table 3-5(2): Outline of Large and Medium-Scale Hydro Power Projects

Item			Planned Project					
			Songwe Bipugu (Upper)		Songwe Sofre (Middle)		Songwe Manolo (Lower)	
Plant Characteristic	River Basin		Lake Nyasa					
		River Name	Songwe					
	Location	District	Ileje		Ileje		Ileje	
		Region	Mbeya		Mbeya		Mbeya	
	Power Generation Type		Reservoir	Run-off-river	Reservoir	Run-off-river	Reservoir	Run-off-river
	Installed Capacity (MW)		28.2	1.2	155.7	3.2	172.8	5.1
	Number of Units		3	2	3	2	3	3
	Plant Discharge (m^3/s)		50.10	2.60	60.00	4.00	70.00	6.00
	Gross Head (m)		75.00	62.00	315.00	106.00	293.50	108.00
	Annual Energy Generation (GWh)		100.00	5.00	572.00	15.00	671.00	15.00
	Plant Factor (%)		40	48	42	54	44	34
Facility Characteristic	Dam (Main)	Type	Concrete gravity		Concrete gravity		Concrete gravity	
		Height (m)	75		115		115	
		Crest Length (m)	231		457		460	
	Dam (Auxiliary)	Type	-		-		Earth fill	
		Height (m)	-		-		23	
		Crest Length (m)	-		-		223	
	Reservoir	Full Water Level (masl)	1,240.00		1,140.00		820.00	
		Low Water Level (masl)	1,220.00		1,100.00		790.00	
		Active Storage (10^6 m^3)	166.0		228.6		237.7	
	Headrace	Type	-	-	Tunnel	-	Tunnel	-
		Length (m)	-	-	3,780	-	90	-
		Diameter (m)	-	-	4.50	-	N/A	-
	Penstock	Type	Tunnel	Embedded in dam body	Tunnel	Embedded in dam body	Tunnel	Embedded in dam body
		Length (m)	210	N/A	330	N/A	270	N/A
		Diameter (m)	4.50	1.10	3.50 - 4.20	1.30	3.70	1.60
	Powerhouse	Type	Underground	Embedded in dam	Underground	Embedded in dam	Underground	Embedded in dam
		Width (m)	18	N/A	20	N/A	20	N/A
		Length (m)	71	N/A	67	N/A	67	N/A
		Height (m)	32	N/A	35	N/A	35	N/A
	Tailrace	Type	Tunnel	N/A	Tunnel	N/A	Tunnel	N/A
		Length (km)	70	N/A	1,220	N/A	5,217	N/A
		Diameter (m)	5.00	N/A	5.60	N/A	6.00	N/A
	Turbine	Type	Vertical Francis	Horizontal Francis	Vertical Francis	Horizontal Francis	Vertical Francis	Horizontal Francis
		Rated Output(MW/unit)	9.5	0.6	52.8	1.6	58.5	1.7
	Generator	Type	Synchronous 3 Phase	Synchronous 3 Phase	Synchronous 3 Phase	Synchronous 3 Phase	Synchronous 3 Phase	Synchronous 3 Phase
		Rated Output(MVA/unit)	12	0.75	65	2	72	2.1
		Rated Voltage (kV)	10.5	0.4	10.5	3.3	10.5	3.3
Data Source			(8)		(8)		(8)	

Source:
(1) Regional Rusumo Falls Hydroelectric and Multipurpose Project - Power Generation Plant Final Feasibility Study Phase: Final Feasibility Design Interim Report Volume 1 (July 2011, SNC-LAVALIN International)
(2) Feasibility Study of Kakono Hydropower Project and Transmission Line - Draft Final Feasibility Report (September 2014, Norplan)
(3) Malagarasi Stage III Project - Power Plant Feasibility Study Final Report (September 2011, ESB International Ltd.)
(4) Tanzania Power VI Project Feasibility Studies for Rumakali Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)
(5) Tanzania Power VI Project Feasibility Studies for Hydropower Project - Interim Report No.2 Final Volume 1(March 1997, SwedPower and Norconsult)
(6) Power System Master Plan 2009 Update (August 2009, SNC-LAVALIN International)
(7) Ruhuhu Valley Multi-Purpose Scheme - Dams and Hydropower Report 'February 2014, Climate Resilient Infrastructure Development Facility)
(8) Detailed Design and Investment Preparation Project for the Songwe River Basin Development Programme - Update of the 2003 Feasibility Study : Main Report Volume 1 (April 2014, Lahmeyer International GmbH and ACE Consulting Engineers)
(9) Tanzania Power VI Project Feasibility Studies for Ruhudji Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)
(10) Kihansi Hydro Power Development Project Study Final Report (October 1990, JICA)
(11) Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao)
(12) Mpanga Hydropower Project - Project Proposal (June 2010, Sinohydro Corporation Ltd)
(13) Preliminary Feasibility Study on Iringa Hydropower Projects - Final Report (May 2013, K-water)
(14) Steiglers Gorge Hydropower Project Report and Proposal of Development (2012, Odebrecht)

Table 3-5(3): Outline of Large and Medium-Scale Hydro Power Projects

Item			Planned Project: Ruhudji	Lower Kihansi Expansion	Upper Kihansi	Mnyera - Ruaha	Mnyera - Mnyera	Mnyera - Kwanini
Plant Characteristic	River Basin		Rufiji					
		River Name	Rhhudji	Kihansi		Mnyera		
	Location	District	N/A	N/A	N/A	N/A	N/A	N/A
		Region	Iringa	Morogoro	Morogoro	Morogoro	Morogoro	Morogoro
	Power Generation Type		Reservoir	Reservoir	Reservoir	Reservoir	Run-off-river	Run-off-river
	Installed Capacity (MW)		358	120	47	60.3	137.4	143.9
	Number of Units		4	2	1	2	2	2
	Plant Discharge (m^3/s)		54.40	16.60	25.70	67.00	103.20	105.00
	Gross Head (m)		765.00	853.50	221.50	110.00	155.00	160.00
	Annual Energy Generation (GWh)		2,000.00	69.00	335.70	290.83	662.26	693.79
	Plant Factor (%)		64	7	82	55	55	55
Facility Characteristic	Dam (Main)	Type	Rock fill	Concrete gravity	Rock fill	Concrete gravity	Concrete gravity	Concrete gravity
		Height (m)	70	24	95	N/A	N/A	N/A
		Crest Length (m)	810	165	583	N/A	N/A	N/A
	Dam (Auxiliary)	Type	Concrete gravity	-	-	-	-	-
		Height (m)	32	-	-	-	-	-
		Crest Length (m)	200	-	-	-	-	-
	Reservoir	Full Water Level (masl)	1,478.00	1,146.00	1,360.00	1,070.00	960.00	805.00
		Low Water Level (masl)	1,440.00	1,141.00	1,330.00	1,060.00	960.00	805.00
		Active Storage (10^6 m^3)	269.3	1.0	75.1	287.84	-	-
	Headrace	Type	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
		Length (m)	7,300	3,384	653	3,140	5,080	2,770
		Diameter (m)	6.70	6.20	3.30	6.80	8.20	N/A
	Penstock	Type	Tunnel	Tunnel	Surface	Tunnel	Tunnel	Tunnel
		Length (m)	1,070	125	510	N/A	N/A	N/A
		Diameter (m)	3.20	1.80	1.85 - 3.30	4.80	7.40	N/A
	Powerhouse	Type	Underground	Underground	Surface	Surface	Surface	Surface
		Width (m)	14	N/A	20	N/A	N/A	N/A
		Length (m)	73	N/A	23	N/A	N/A	N/A
		Height (m)	30	N/A	35	N/A	N/A	N/A
	Tailrace	Type	Tunnel	Tunnel	Tunnel	Open channel	Open channel	Open channel
		Length (km)	3,100	1,500	641	N/A	N/A	N/A
		Diameter (m)	7.70	6.60	4.00	N/A	N/A	N/A
	Turbine	Type	Vertical Pelton	Pelton	Vertical Francis	Vertical Francis	Vertical Francis	Vertical Francis
		Rated Output(MW/unit)	91	N/A	48	31.09	70.83	74.18
	Generator	Type	N/A	N/A	Synchronous 3 Phase	Synchronous	Synchronous	Synchronous
		Rated Output(MVA/unit)	N/A	N/A	53	33.50	76.34	79.95
		Rated Voltage (kV)	13.8	N/A	11	N/A	N/A	N/A
Data Source			(9)	(5), (6)	(10)	(11)	(11)	(11)

Source: (1) Regional Rusumo Falls Hydroelectric and Multipurpose Project - Power Generation Plant Final Feasibility Study Phase: Final Feasibility Design Interim Report Volume 1 (July 2011, SNC-LAVALIN International)
(2) Feasibility Study of Kakono Hydropower Project and Transmission Line - Draft Final Feasibility Report (September 2014, Norplan)
(3) Malagarasi Stage III Project - Power Plant Feasibility Study Final Report (September 2011, ESB International Ltd.)
(4) Tanzania Power VI Project Feasibility Studies for Rumakali Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)
(5) Tanzania Power VI Project Feasibility Studies for Hydropower Project - Interim Report No.2 Final Volume 1(March 1997, SwedPower and Norconsult)
(6) Power System Master Plan 2009 Update (August 2009, SNC-LAVALIN International)
(7) Ruhuhu Valley Multi-Purpose Scheme - Dams and Hydropower Report 'February 2014, Climate Resilient Infrastructure Development Facility)
(8) Detailed Design and Investment Preparation Project for the Songwe River Basin Development Programme - Update of the 2003 Feasibility Study : Main Report Volume 1 (April 2014, Lahmeyer International GmbH and ACE Consulting Engineers)
(9) Tanzania Power VI Project Feasibility Studies for Ruhudji Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)
(10) Kihansi Hydro Power Development Project Study Final Report (October 1990, JICA)
(11) Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao)
(12) Mpanga Hydropower Project - Project Proposal (June 2010, Sinohydro Corporation Ltd)
(13) Preliminary Feasibility Study on Iringa Hydropower Projects - Final Report (May 2013, K-water)
(14) Steiglers Gorge Hydropower Project Report and Proposal of Development (2012, Odebrecht)

Table 3-5(4): Outline of Large and Medium-Scale Hydro Power Projects

Item			Planned Project					
			Mnyera - Pumbwe	Mnyera - Taveta	Mnyera - Kisingo	Mpanga	Iringa - Ibosa	Iringa - Nginayo
Plant Characteristic	River Basin		Rufiji					
		River Name	Mnyera			Mpanga	Little Ruaha	
	Location	District	N/A	N/A	N/A	N/A	Iringa	Iringa
		Region	Morogoro	Morogoro	Morogoro	Morogoro	Iringa	Iringa
	Power Generation Type		Run-off-river	Run-off-river	Run-off-river	Reservoir	Run-off-river	Run-off-river
	Installed Capacity (MW)		122.9	83.9	119.8	160	36	52
	Number of Units		2	2	2	2	2	2
	Plant Discharge (m^3/s)		111.00	133.40	134.00	51.56	27.85	30.47
	Gross Head (m)		130.00	75.00	105.00	370.00	150.60	195.90
	Annual Energy Generation (GWh)		592.18	403.84	577.28	796.00	186.09	262.75
	Plant Factor (%)		55	55	55	57	59	58
Facility Characteristic	Dam (Main)	Type	Concrete gravity	Concrete gravity	Concrete gravity	Concrete faced rock fill	Concrete gravity	Concrete gravity
		Height (m)	N/A	N/A	N/A	55	5	5
		Crest Length (m)	N/A	N/A	N/A	250	50	50
	Dam (Auxiliary)	Type	-	-	-	-	-	-
		Height (m)	-	-	-	-	-	-
		Crest Length (m)	-	-	-	-	-	-
	Reservoir	Full Water Level (masl)	645.00	490.00	415.00	730.00	1,212.00	977.00
		Low Water Level (masl)	645.00	490.00	415.00	710.00	1,212.00	977.00
		Active Storage (10^6 m^3)	-	-	-	46.4	-	-
	Headrace	Type	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
		Length (m)	4,340	2,010	3,750	N/A	1,515	1,518
		Diameter (m)	8.40	N/A	N/A	5.00	4.00	4.00
	Penstock	Type	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
		Length (m)	N/A	N/A	N/A	N/A	1,054	1,105
		Diameter (m)	5.20	N/A	N/A	5.00	4.00	4.00
	Powerhouse	Type	Surface	Surface	Surface	Underground	Surface	Surface
		Width (m)	N/A	N/A	N/A	19	N/A	N/A
		Length (m)	N/A	N/A	N/A	73	N/A	N/A
		Height (m)	N/A	N/A	N/A	50	N/A	N/A
	Tailrace	Type	Open channel	Open channel	Open channel	Tunnel	N/A	N/A
		Length (km)	N/A	N/A	N/A	N/A	N/A	N/A
		Diameter (m)	N/A	N/A	N/A	N/A	N/A	N/A
	Turbine	Type	Vertical Francis	Vertical Francis	Vertical Francis	Francis	Francis	Francis
		Rated Output(MW/unit)	63.36	43.25	61.76	81.6	N/A	N/A
	Generator	Type	Synchronous	Synchronous	Synchronous	N/A	Synchronous 3 Phase	Synchronous 3 Phase
		Rated Output(MVA/unit)	68.28	46.62	66.56	N/A	21.16	30.60
		Rated Voltage (kV)	N/A	N/A	N/A	N/A	12	12
Data Source			(11)	(11)	(11)	(12)	(13)	(13)

Source: (1) Regional Rusumo Falls Hydroelectric and Multipurpose Project - Power Generation Plant Final Feasibility Study Phase: Final Feasibility Design Interim Report Volume 1 (July 2011, SNC-LAVALIN International)
(2) Feasibility Study of Kakono Hydropower Project and Transmission Line - Draft Final Feasibility Report (September 2014, Norplan)
(3) Malagarasi Stage III Project - Power Plant Feasibility Study Final Report (September 2011, ESB International Ltd.)
(4) Tanzania Power VI Project Feasibility Studies for Rumakali Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)
(5) Tanzania Power VI Project Feasibility Studies for Hydropower Project - Interim Report No.2 Final Volume 1(March 1997, SwedPower and Norconsult)
(6) Power System Master Plan 2009 Update (August 2009, SNC-LAVALIN International)
(7) Ruhuhu Valley Multi-Purpose Scheme - Dams and Hydropower Report 'February 2014, Climate Resilient Infrastructure Development Facility)
(8) Detailed Design and Investment Preparation Project for the Songwe River Basin Development Programme - Update of the 2003 Feasibility Study : Main Report Volume 1 (April 2014, Lahmeyer International GmbH and ACE Consulting Engineers)
(9) Tanzania Power VI Project Feasibility Studies for Ruhudji Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)
(10) Kihansi Hydro Power Development Project Study Final Report (October 1990, JICA)
(11) Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao)
(12) Mpanga Hydropower Project - Project Proposal (June 2010, Sinohydro Corporation Ltd)
(13) Preliminary Feasibility Study on Iringa Hydropower Projects - Final Report (May 2013, K-water)
(14) Steiglers Gorge Hydropower Project Report and Proposal of Development (2012, Odebrecht)

Table 3-5(5): Outline of Large and Medium-Scale Hydro Power Projects

Item			Planned Project: Steiglers Gorge Phase 1	Planned Project: Steiglers Gorge Phase 2
Plant Characteristic	River Basin		Rufiji	
		River Name	Rufiji	
	Location	District	N/A	
		Region	Pwani	
	Power Generation Type		Reservoir	
	Installed Capacity (MW)		1,048	1,048
	Number of Units		4	N/A
	Plant Discharge (m^3/s)		N/A	N/A
	Gross Head (m)		118.50	N/A
	Annual Energy Generation (GWh)		4,558.67	N/A
	Plant Factor (%)		50	N/A
Facility Characteristic	Dam (Main)	Type	Concrete faced rock fill	
		Height (m)	126	
		Crest Length (m)	700	
	Dam (Auxiliary)	Type	Rock fill & Earth fill	
		Height (m)	25 & 10	
		Crest Length (m)	2,200 & 16,700	
	Reservoir	Full Water Level (masl)	186.50	
		Low Water Level (masl)	163.00	
		Active Storage (10^6 m^3)	20,820	
	Headrace	Type	Tunnel	Tunnel
		Length (m)	N/A	N/A
		Diameter (m)	9.00 x 4	N/A
	Penstock	Type	Tunnel	Tunnel
		Length (m)	150.00 x 4	N/A
		Diameter (m)	9.00 x 4	N/A
	Powerhouse	Type	Underground	Underground
		Width (m)	22	N/A
		Length (m)	151	N/A
		Height (m)	51	N/A
	Tailrace	Type	Tunnel	Tunnel
		Length (km)	692, 784	N/A
		Diameter (m)	14.00 x 2	N/A
	Turbine	Type	Vertical Francis	N/A
		Rated Output(MW/unit)	267.40	N/A
	Generator	Type	Synchronous	N/A
		Rated Output(MVA/unit)	291.20	N/A
		Rated Voltage (kV)	13.8	N/A
Data Source			(14)	

Source:
(1) Regional Rusumo Falls Hydroelectric and Multipurpose Project - Power Generation Plant Final Feasibility Study Phase: Final Feasibility Design Interim Report Volume 1 (July 2011, SNC-LAVALIN International)
(2) Feasibility Study of Kakono Hydropower Project and Transmission Line - Draft Final Feasibility Report (September 2014, Norplan)
(3) Malagarasi Stage III Project - Power Plant Feasibility Study Final Report (September 2011, ESB International Ltd.)
(4) Tanzania Power VI Project Feasibility Studies for Rumakali Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)
(5) Tanzania Power VI Project Feasibility Studies for Hydropower Project - Interim Report No.2 Final Volume 1(March 1997, SwedPower and Norconsult)
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(7) Ruhuhu Valley Multi-Purpose Scheme - Dams and Hydropower Report (February 2014, Climate Resilient Infrastructure Development Facility)
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(10) Kihansi Hydro Power Development Project Study Final Report (October 1990, JICA)
(11) Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao)
(12) Mpanga Hydropower Project - Project Proposal (June 2010, Sinohydro Corporation Ltd)
(13) Preliminary Feasibility Study on Iringa Hydropower Projects - Final Report (May 2013, K-water)
(14) Steiglers Gorge Hydropower Project Report and Proposal of Development (2012, Odebrecht)

3.2.2 Thermal power resources

3.2.2.1 Committed and planned thermal projects

Table 3-6 shows the thermal power generation development candidates under planning and /or ongoing.

Table 3-6: Power development candidates (Thermal power)

Type	Plant	Capacity MW	Remarks	Rank
Gas	Kinyerezi I Extension	185	Simple cycle gas turbine	A
	Kinyerezi II	240	Combined cycle gas turbine	A
	Kinyerezi III	600	Simple and combined cycle gas turbine	C
	Kinyerezi IV	330	Combined cycle gas turbine	C
	Somanga Fungu (IPP)	320	Combined cycle gas turbine	B
	Somanga (TANESCO)	240	Combined cycle gas turbine	D
	Somanga (PPP)	300	Combined cycle gas turbine	C
	Bagamoyo (IPP)	200	Combined cycle gas turbine	D
	Mtwara (Gas engine, TANESCO)	18	Grid connection of existing gas engine	A
	Mtwara (TANESCO)	300	Combined cycle gas turbine	D
Coal	Mchuchuma I-IV	600	150MW x 4units, Subcritical	C
	Kiwira-I	200	Subcritical	C
	Kiwira-II	200	Subcritical	C
	Ngaka-I	200	Subcritical	D
	Ngaka-II	200	Subcritical	D

Source: TANESCO

Note: Criteria for Ranking

Rank	Description of Ranking
A	Financing Closed or Construction started
B	PPA (BOT/EPC) contract signed
C	F/S, pre-F/S completed
D	F/S, pre-F/S not completed

3.2.2.2 Variable thermal options

Model plants for variable thermal options were set concerning promising availability of primary energies such as natural gas and coal, construction cost and O&M cost components to be input for the power development planning software (WASP: Wien Automatic System Planning Package) were examined.

Concerning the WASP input specifications, reference was made to PSMP 2012, the EAC Regional Power System Master Plan and Grid Code Study (EAC Regional PSMP) implemented by SNC-Lavalin in 2011, and the EIA's Annual Energy Outlook 2014 (EIA-AEO2014).

3.2.2.2.1 Coal-fired thermal power stations

a) Subcritical pressure coal-fired thermal power stations

In southern Tanzania, it is planned to construct Kiwira I&II power station, Mchuchuma I~IV power station, and Ngaka I&II power station. Since facility capacity is currently planned to be

50~100 MW and the plant heat rate at project locations is 9,243~9,730 [kJ/kWh] in PSMP 2012, it is thought that subcritical pressure (Sub-C) power generation is being considered. Moreover, because Tanzania has no past record of introducing coal-fired thermal power stations, examination was first carried out on the main specifications for subcritical pressure coal-fired thermal power stations.

b) Super Critical pressure coal-fired thermal power stations

In Super Critical (SC) pressure facilities, it is known that the main steam pressure exceeds the critical pressure of water (22.064MPa) and that the main steam temperature exceeds the critical temperature of water (374°C) but is no higher than 566°C (1,000°F). In other countries such as Japan, USA, Germany, Russia, Republic of Korea and China this technology has contributed to higher generating efficiency since 1980s.

c) Ultra-supercritical pressure coal-fired thermal power stations

In ultra-supercritical (USC) pressure facilities, it is known that the main steam pressure exceeds the critical pressure of water (22.064MPa) and that the main steam temperature exceeds 593°C (1,100°F), which is higher than the critical temperature of water (374°C). In other countries such as Japan, Germany, Russia, Republic of Korea and China this technology was first introduced in the late 1990s and developments are now moving more in the direction of high temperature rather than high pressure. The top performance facilities now have main steam pressure of around 25MPa and main steam temperature of 610~620°C. In Tanzania, ultra-supercritical pressure facilities have not yet been introduced, however, because such facilities have better thermal efficiency than supercritical facilities and can make a contribution to reducing coal consumption and mitigating environmental loads, it is recommended that ample consideration also be given to the introduction of ultra-supercritical pressure facilities.

d) Advanced subcritical pressure coal-fired thermal power stations

In advanced subcritical (Advanced Sub-C) pressure facilities, generating efficiency on a par with that of ultra-supercritical pressure facilities can be obtained in small- to medium-capacity plants of 150-350 MW through increasing the steam temperature to 600°C. Usually, drum boilers are used in sub-critical facilities, however, higher temperatures have been made possible through adopting once-through boilers that are used in super critical (ultra super critical) facilities.

Since it is difficult to effectively raise efficiency by applying supercritical pressure to small- to medium-capacity plants, this type of facility is effective for developing nations, where transmission systems are too fragile to introduce supercritical pressure (500 MW or more in single units).

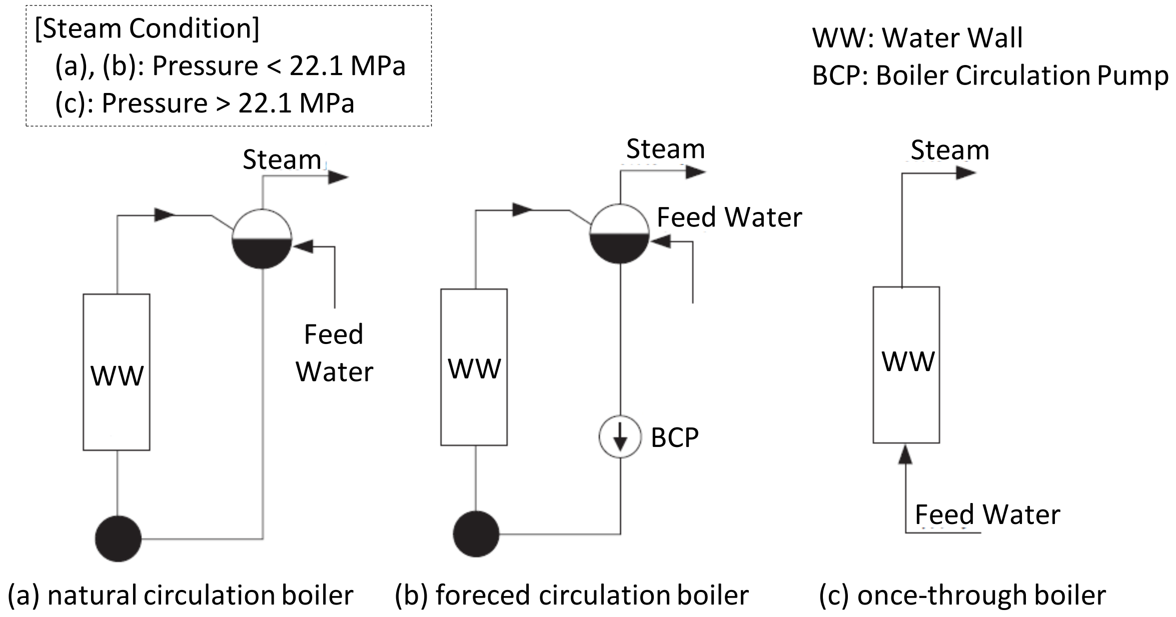
e) Differences between subcritical pressure boiler and Supercritical pressure boiler

A super critical pressure boiler is a boiler that operates at pressure higher than the critical pressure of the liquid (in this case water). In the case of water, a special state known as the critical point is adopted at critical pressure of 22.064MPa (218.3 atmospheric pressure) and critical temperature of 374.2°C.

When liquid water is heated at pressure below the critical pressure (i.e. sub-critical pressure), part of the water becomes steam (gas) containing air bubbles, and liquid and gas coexist. Meanwhile, at pressure higher than critical pressure (i.e. super critical pressure), there is no such co-existence of liquid and gas, but rather when heat is applied to the water (liquid), it instantaneously changes to steam (gas) at the critical temperature of 374.2°C. In other words, there is no “air bubble state inside water: coexistent field.”

In terms of boiler structure, whereas a sub-critical pressure boiler requires a drum for separating steam, a super critical pressure boiler is a once-through boiler.

Figure 3-1: Differences between subcritical pressure boiler (Drum boiler) and Supercritical pressure boiler (once-through boiler)



3.2.2.2.2 Gas-fired thermal power stations

a) Aero-derivative gas turbine thermal power stations

Aero-derivative gas turbines are characterized by small size, light weight and compactness, they quickly reach full load operation after activation, and they can respond to rapid starting and stopping. Also, they can be used for simple cycle operations, and it is easy to expand to combined cycle from simple cycle operation, and retrofit units. In Tanzania, there are SGT-800 gas turbines made by Siemens at Ubungo II gas-fired thermal power station and LM6000PF gas turbines made by GE at Kinyerezi I gas-fired thermal power station. Out of these, at Kinyerezi I gas-fired thermal power station, plans are being considered for combined operation in the future, however, it is first intended to introduce simple cycle gas turbines, but later to add waste heat recovery steam generator boilers and steam turbines and conduct combined operation according to the power demand and supply situation in Tanzania.

b) Heavy Duty gas turbine thermal power stations

Vigorous efforts are being made to improve the efficiency of power generating facilities and develop energy saving technologies and so on with a view to realizing more effective use of energy resources. In combined cycle facilities, since major improvements can be anticipated in overall plant efficiency thanks to higher temperature and performance of primary gas turbines, progress is being made in improving reliability and increasing the capacity and temperature of gas turbines. The latest heavy duty gas turbine (1,600°C J-class) possesses the highest thermal efficiency (61% or more) and power capacity (approximately 460 MW) in the world.

3.2.2.2.3 Selection of model units for variable candidates

Since the PSMP 2012 Update only indicates the maximum load and thermal efficiency (plant heat rate) at times of maximum load, it was decided to set the minimum load, and heat rate and operable scope at times of minimum load based on the specifications of gas turbines introduced to existing power sources. As specifications for candidate power sources for new development, out of aero-derivative gas turbines and heavy duty gas turbines, gas turbines (simple cycle and combined cycle) of varying capacity (small to large) were configured as the model units.

Similarly, concerning coal-fired model units, because the PSMP 2012 only indicates the maximum load and thermal efficiency (plant heat rate) at times of maximum load, typical power stations were configured as the model units. The coal-fired thermal power stations that are currently being implemented and formulated are based on the specifications of subcritical pressure coal-fired thermal power stations, however, the specifications of candidate power sources for new development are based on subcritical pressure coal-fired thermal power stations and ultra-supercritical coal-fired thermal power stations.

Concerning existing gas engine power stations, the minimum load, and heat rate and operable scope at times of minimum load were set based on gas engines introduced to existing power plants.

Concerning existing diesel power stations, because the equipment introduced to existing facilities is unknown, typical power stations were configured as the model units.

Moreover, when calculating the gas turbine heat rate, Thermoflow Co.'s GT Pro Master software was used based on the specifications of Gas Turbine World.

Table 3-7shows a list of model units for variable expansion candidates.

Table 3-7: Model Unit for variable expansion candidates

ID	Type	Unit Name	Unit Capacity [MW]	Minimum Load Capacity [%]	Minimum Load Heat Rate [kJ/kWh]	Maximum Load Heat Rate [kJ/kWh]	Possible Operation Range [%]	Remarks
1-1	Simple Cycle GT	GE: LM6000PF	43.4	30	16765	9813	0-100	
1-2	Simple Cycle GT	GE: 6FA	71.4	30	19876	11551	0-100	
1-3	Simple Cycle GT	GE: 9E	118.2	30	17586	11908	0-100	
1-4	Simple Cycle GT	MHI: M701G	309.1	30	16623	10338	0-100	
2-1	Combined Cycle GT	GE: LM6000PF (1on1)	56.5	60	7948	7537	60-100	GT:43.2MW, ST:13.3MW
2-2	Combined Cycle GT	GE: 106FA (1on1)	111.2	60	7967	7421	60-100	GT:71.1MW, ST:40.2MW
2-3	Combined Cycle GT	GE: 109E (1on1)	183.6	60	8360	7670	60-100	GT:117.8MW, ST:65.8MW
2-4	Combined Cycle GT	MHI: M701G (1on1)	471.2	60	7199	6766	60-100	GT:307.3MW, ST:163.9MW
3-1	Coal	Typical Sub-C PS	156	35	10089	8853	30-100	
3-2	Coal	Typical USC PS	700	30	10013	8540	30-100	
3-3	Coal	Advanced Sub-C PS	300	35	10079	8581	30-100	
4-1	Gas Engine	Wartsila: W20V34SG	8.74	50	9441	8390	0-100	
5-1	Diesel Engine	Typical Diesel Plant	4.5	25	11103	8669	50-100	
5-2	Diesel Engine	Typical Diesel Plant	10	25	10201	8346	50-100	

Source: Suppliers and Gas Turbine World 2012 GTW Handbook (2012)

3.2.3 Renewable energy and import

The table below shows the candidate of renewable energy and import projects which will be included in generation expansion plans.

Table 3-8: Possible candidates for power generation expansion (Renewable energy and import)

Project	Earliest Com. Year	Capacity	Cost	Rank
Mbeya Geothermal	2025	100MW (2025) 200MW (2026)	($4,362/kW)*1	D
Singida Wind	2018	50MW	$136M*2 ($2,720/kW)	C
	2019	75 (in 2019)- 200MW	($1,571/kW)*3	C
	2020	100MW	($1,571/kW)*3	C
Njombe Wind	2019	100MW	($1,571/kW)*3	D
Shinyanga/Simiyu Solar	2020	150MW	($1,200/kW)*3	D
Dodoma Solar	2019	50MW	($1,200/kW)*3	D
Import (Ethiopia)	2018 2020	200MW Max 400MW		A

Source: MEM, TANESCO and TGDC

*1: US-EIA "Updated Capital Cost Estimates for Electricity Generation Plants" (Apr.2013)

*2: Proposal from a developer

*3: International Energy Agency/ Nuclear Energy Agency "Projected cost of generating electricity" (2015 Edition)

Note: Criteria for Ranking

Rank	Description of Ranking
A	Financing Closed or Construction started
B	PPA (BOT/EPC) contract signed
C	F/S, pre-F/S completed
D	F/S, pre-F/S not completed

3.2.4 Nuclear energy

The potential for uranium deposits in Tanzania was identified in a countrywide airborne geophysical survey in the 1970´s. Further exploration between 1978 and 1982 resulted in the identification of surface mineralization and recognition of the potential for uranium deposits in Tanzania. Currently, there are about 20 companies engaged in exploration for uranium in Tanzania. Significant mineralization or deposits have been identified in the Dodoma area at Handa and Bahi North (Mantra Resources), in the Ruhuhu area near Lake Nyasa (Uranium Hunter, Atomic Minerals, and Western Metals). Nuclear generation could become an option, particularly when other indigenous resources are fully committed.

This technology has not been considered in this PSMP update because it is considered that nuclear generation could only be selected when:

a) The Government has finalized the policies on uranium and nuclear generation.

b) Human Capacity building on nuclear technology and other related matters.

It is considered that this resource would have been developed in Tanzania and available for power generation by 2040s subject to further studies and familiarization with this technology.

3.3 Methodology and preconditions

3.3.1 Method for compiling the least cost power generation development plan

In order to examine the least cost power generation development plan combining various types of power generation and development patterns, WASP (Wien Automatic System Planning Package, Version -IV), which is a power generation development planning software developed by the International Atomic Energy Agency (IAEA), was used.

WASP-IV can select the optimum power source development plan that satisfies constraints such as supply reliability (LOLP), reserve capacity, fuel limitation, and restriction on the amount of environmental pollutant emissions, etc. for the next 30 years. The optimum power source development plan refers to the plan in which the general cost discounted according to current prices becomes the minimum. The following paragraphs give an outline of the WASP calculation model.

The combination of all power generation plants (power generation development plan) that satisfy constraints and are added to the power system is evaluated based on objective functions composed of the following items:

i. Depreciable investment cost: Equipment and installation cost (I)
ii. Residual value of investment cost (S)
iii. Non-depreciable investment cost: Fuel store, replacement parts, etc. (L)
iv. Fuel cost (F)
v. Non-fuel operation and maintenance cost (M)
vi. Non-supplied power cost (O)

The cost function evaluated in WASP is expressed by the following formula:

$$B_j = \sum_{t=1}^{T} [\, \bar{I}_{j,t} - \bar{S}_{j,t} + \bar{L}_{j,t} + \bar{F}_{j,t} + \bar{M}_{j,t} + \bar{O}_{j,t} \,]$$

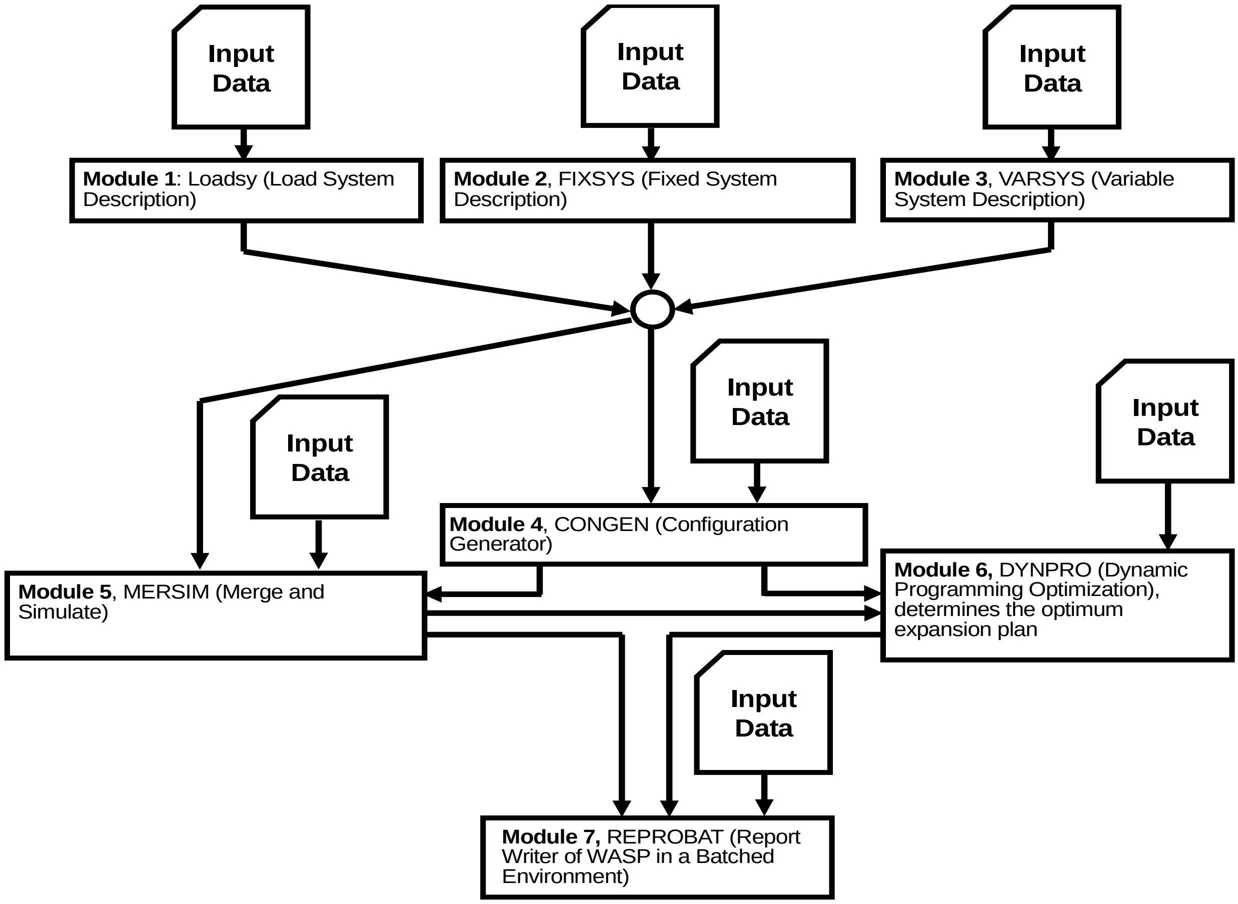
Where,

B_j : Cost function of the power source development plan j
t : Year of the power source development plan (1, 2, ... , T)
T : Term of the power source development plan (all years)

The bars above each symbol indicate prices that have been discounted at discount rate i by the set time. The optimum power source development plan is the plan at which the cost function Bj in all development plan candidates j becomes the minimum.

Figure 3-2 shows the simplified flowchart of WASP-IV indicating the flow of information and data files between various WASP modules.

Figure 3-2: WASP-IV Flowchart



Source: WASP IV User's Manual

Module 1: Loadsy (Load System Description), processes information describing period peak loads and load duration curves for the power system over the study period.

Module 2, FIXSYS (Fixed System Description), processes information describing the existing generation system and any predetermined additions or retirements, as well as information on any constraints imposed by the user on environmental emissions, fuel availability or electricity generation by some plants.

Module 3, VARSYS (Variable System Description), processes information describing the various generating plants which are to be considered as candidates for expanding the generation system.

Module 4, CONGEN (Configuration Generator), calculates all possible year-to-year combinations of expansion candidate additions which satisfy certain input constraints and which in combination with the fixed system can satisfy the loads. CONGEN also calculates the basic economic loading order of the combined list of FIXSYS and VARSYS plants.

Module 5, MERSIM (Merge and Simulate), considers all configurations put forward by CONGEN and uses probabilistic simulation of system operation to calculate the associated production costs, energy-not-served and system reliability for each configuration. In the process, any limitations imposed on some groups of plants for their environmental emissions, fuel availability or electricity generation are also taken into account. The dispatching of plants is determined in such a way that plant availability, maintenance requirement, spinning reserve requirements and all the group-limitations are satisfied with minimum cost. MERSIM can also be used to simulate the system operation for the best solution provided by the current DYNPRO run and in this mode of operation is called REMERSIM.

Module 6, DYNPRO (Dynamic Programming Optimization), determines the optimum expansion plan based on previously derived operating costs along with input information on capital costs, energy-not-served cost and economic parameters and reliability criteria.

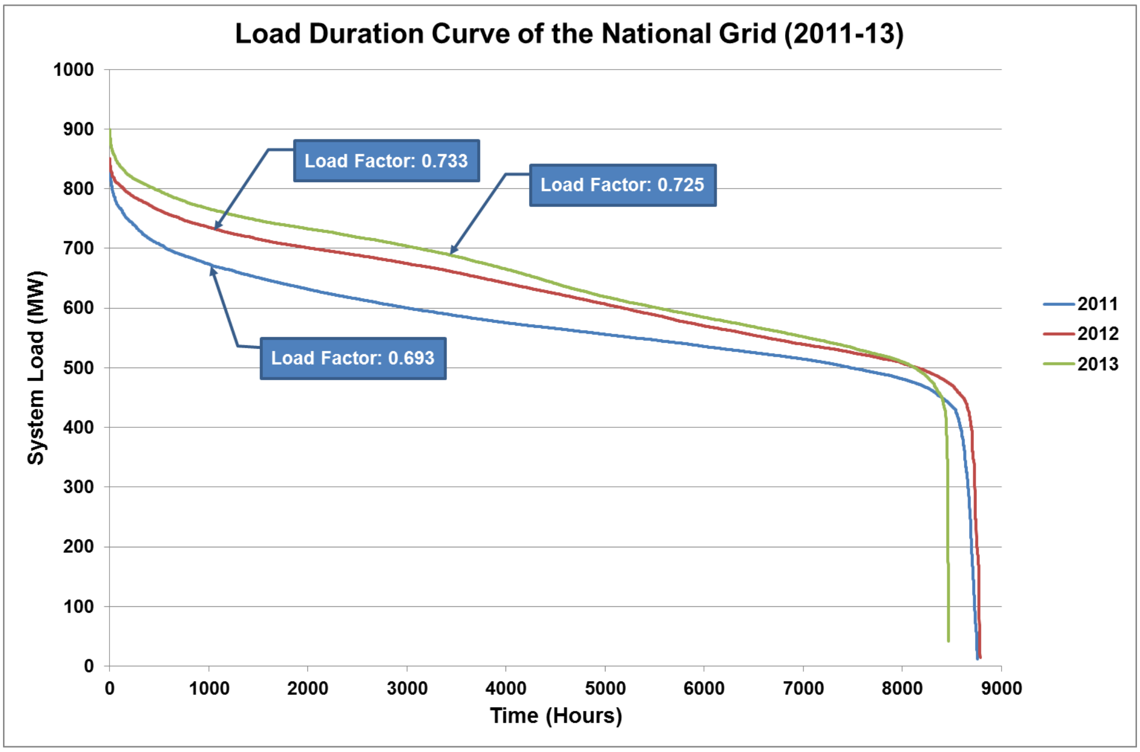
Module 7, REPROBAT (Report Writer of WASP in a Batched Environment), writes a report summarizing the total or partial results for the optimum or near optimum power system expansion plan and for fixed expansion schedules.

3.3.2 Examination conditions

3.3.2.1 Load Duration Curve

Figure 3-3 shows annual load duration curves in 2011, 2012 and 2013. Comparing hourly generation curves in the latest three years, 2013 seems to have less constraint in power supply than other two years. Therefore, load duration curve in 2013 will deemed as a typical load duration curve in Tanzania to be used for power generation planning.

Figure 3-3: Load duration curves in Tanzania



Source: TANESCO

3.3.2.2 Power demand forecast

In generation expansion planning, the base case of power demand forecast described in Chapter 2 of PSMP2016 Update is applied to meet the government target of achieving the generation capacity of at least 4,915MW by 2020. Table 3-9 shows the summary of the power demand forecast.

Table 3-9: Summary of power demand forecast

Cases		Demand items	Unit	2015	2020	2025	2030	2035	2040
Base	Peak demand	Domestic demand	MW	974	2,190	3,659	5,872	9,351	14,332
		Additional demand	MW	71	1,041	1,041	1,041	1,041	1,041
		Export (Inc. Loss)	MW	0	685	677	677	677	677
		Total	MW	1,045	3,916	5,377	7,590	11,069	16,050
	Installed capacity	Domestic demand	MW	1,267	2,847	4,757	7,633	12,156	18,631
	(Peak*1.3)	Additional demand	MW	92	1,353	1,353	1,353	1,353	1,353
		Export (Inc. Loss)	MW	0	890	880	880	880	880
		Total	MW	1,359	5,091	6,991	9,867	14,389	20,865
High	Peak demand	Domestic demand	MW	974	2,256	4,017	7,381	13,508	23,724
		Additional demand	MW	71	1,041	1,041	1,041	1,041	1,041
		Export (Inc. Loss)	MW	0	685	677	677	677	677
		Total	MW	1,045	3,981	5,736	9,100	15,226	25,443
	Installed capacity	Domestic demand	MW	1,267	2,932	5,223	9,596	17,560	30,842
	(Peak*1.3)	Additional demand	MW	92	1,353	1,353	1,353	1,353	1,353
		Export (Inc. Loss)	MW	0	890	880	880	880	880
		Total	MW	1,359	5,176	7,456	11,829	19,794	33,075
Low	Peak demand	Domestic demand	MW	974	2,035	3,172	4,769	7,120	10,289
		Additional demand	MW	71	1,041	1,041	1,041	1,041	1,041
		Export (Inc. Loss)	MW	0	685	677	677	677	677
		Total	MW	1,045	3,760	4,891	6,487	8,838	12,007
	Installed capacity	Domestic demand	MW	1,267	2,645	4,124	6,199	9,256	13,376
	(Peak*1.3)	Additional demand	MW	92	1,353	1,353	1,353	1,353	1,353
		Export (Inc. Loss)	MW	0	890	880	880	880	880
		Total	MW	1,359	4,889	6,358	8,433	11,490	15,609

Source: MEM, TANESCO and Regional demand data survey

3.3.2.3 Supply reliability standard

The LOLP (Loss Of Load Probability) is used as the indicator for evaluating the reliability of power supply, and the generation expansion plan which possesses the necessary reserve power for satisfying the target of LOLP is compiled. LOLP is widely applied as a standard of power supply reliability: NERC (North American Electric Reliability Corporation) adopts a LOLP of 1 day / 10 years, while PLN in Indonesia adopts 1 day / year, CEB (Ceylon Electricity Board) in Sri Lanka adopts 3 days/year and Kenya adopts 1day/year. In PSMP 2012 Update, the target of LOLP is set at 5 days / year.

In view of the above, the PSMP2016 Update adopts LOLP of 5 days / year as the target reliability standard.

3.3.2.4 Maximum allowable capacity of single unit power generator

In cases where generating equipment drops off the network due to accidents and so on, the frequency declines because power supply falls short of demand. The following formula is used to express the relationship between capacity drop and frequency drop.

$$\Delta F = -\frac{1}{K} \times \frac{\Delta P}{P} \times 100$$

Where,

- ΔF : System frequency fluctuation (Hz)
- ΔP : Output or load of the generator concerned (MW)
- P : Total load of system (MW)
- K : System constant (KG + KL) (%MW/0.1Hz)
- KG : Frequency characteristics of the generator (%MW/0.1Hz)
- KL : Frequency characteristics of the network (%MW/0.1Hz)

Single unit capacity of any new generator to be introduced to a grid should be so considered as not to cause any deviation from frequency operation standard even if it is shut down due to an unexpected break down.　Target system frequency range in Tanzania is set as follows.

Normal condition　　:　　49.50Hz～50.50 Hz (50Hz±1%)
Emergency condition :　　48.75Hz～51.25 Hz (50Hz±2.5%)

In case system frequency fluctuates beyond emergency range described above, under frequency relay installed in 33kV distribution network will be activated and some feeders will be cut off to reduce demand.　Currently, the largest single unit capacity in Tanzania is 60MW at Kihansi and 50MW at Kidatu hydro power stations. TANESCO has experienced system frequency drop up to 48.75Hz which is the lower limit of emergency range when a unit trip occurs at Kihansi or Kidatu during the night peak hours in rainy season. By using this situation system constant of Tanzanian power system is calculated as follows.

a. Situation of single unit trip

ΔF : System frequency drop (Hz) = 50.0-48.75 = 1.25Hz
ΔP : Capacity of unit dropped (MW) = 50MW　single unit of Kidatu
P : System load (MW) = 800MW

b. Calculation of system constant

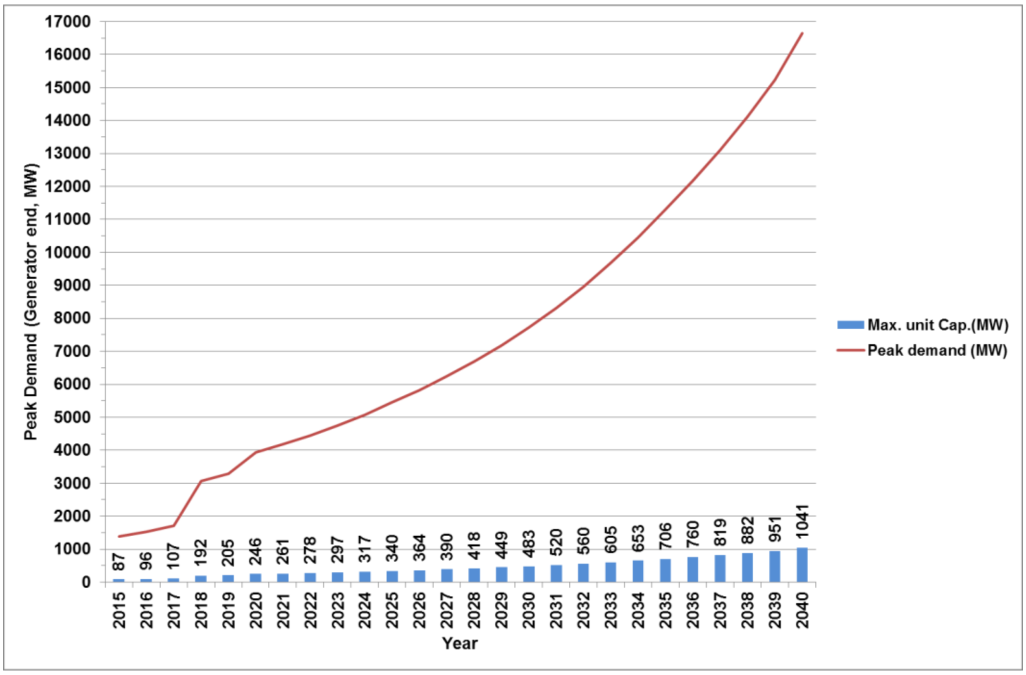
$$\Delta F = -\frac{1}{K} \times \frac{\Delta P}{P} \times 100$$

K = 5.0 %MW/Hz or K =0.5 %MW/0.1Hz

Assuming that allowable frequency drop is up to Δ1.25 Hz, maximum single unit capacity which system frequency can be maintained within the operational limit even if the unit drops is calculated by the following equation using the system constant described above with base case demand forecast results. The results of calculation is shown in Figure 3-4.

$$\Delta P = -\frac{\Delta F \times K \times P}{100}$$

Figure 3-4: Maximum allowable single unit capacity



Source: Study results

3.3.2.5 Fuel cost

Table 3-10 shows the natural gas and coal cost used for economic calculation for generation expansion planning.

Table 3-10: Fuel cost assumption

Type	PSMP 2012 Update	Current Price	PSMP2016 Update
Natural gas	Ubungo: US$ 0.64/mmBtu (US$0.68/GJ) Additional gas : US$3.01/mmBtu (US$ 3.18/GJ) Mnazi Bay: US$4.49/mmBtu (US$ 4.74/GJ)	**Ubungo:** Protected Gas US$ 0.6932/mmBtu (US$ 0.7365/GJ) **Additional Gas:** US$ 3.4494/mmBtu (US$ 3.6650/GJ) **Somanga:** US$ 0.6037/mmBtu (US$ 0.6414/GJ) **NNGIP:** (Kinyerezi I, Symbion & Ubungo II) - US$ 5.15/mmBtu (US$ 5.4719/GJ) **Mnazi Bay:** US$ 5.36/mmBtu (US$ 5.6950/GJ)	US$ 6.00/mmBtu
Coal	Ngaka: US$2.37/mmBtu (US$2.5/GJ) Mchuchuma: US$ 2.46/mmBtu (US$2.6/GJ or US$55/ton)	-	US$3.53/mmBtu (US$70/ton)

Source: PSMP2012 Update, NDC and TPDC

3.3.2.6 Outage rates

The plan assumes that there will be planned and forced outages at the generating plants. The Combined Outage Rates per year is a result of scheduled maintenance and forced outages. Table 3-11 below outlines the selected outage rates based on different technologies.

Table 3-11: Selected Outage Rates for Different Technologies

Generation type	Scheduled maintenance days per year	Forced outage in percent of time per year	Combined outage rate percent
Coal steam thermal	42	8	20
Gas turbine	28	5	13
Combined cycle gas turbine	21	5	11

Source: PSMP2012 Update and US-EIA "Updated Capital Cost Estimates for Electricity Generation Plants" (Apr.2013)
Remarks: Maintenance period and forced outage rates of hydro and renewable energy (solar and wind) are relatively short and low compared to thermal power plants. Therefore, they are not considered in generation planning.

3.3.2.7 Economic plant lifetime

The following economic plant lifetimes were used in determining average unit generation costs for preliminary comparisons, and for determining retirement dates for existing and future plants in the development of generation plans.

Table 3-12: Plant service lives

Generation type	Economic plant lifetime – years*
Gas turbines	20
Combined cycle gas turbines	20
Coal steam plants	25
Hydroelectric plant	50
Geothermal	20
Solar PV	20
Wind	20

Source: PSMP 2012 Update and experience of electric utilities

* Normally extended by major equipment replacement and maintenance

3.3.2.8 Operation and maintenance cost

Unit generation costs include allowances for operation and maintenance, interim replacement, and insurance. For thermal plants, the operation and maintenance cost is separated into fixed and variable costs, while for hydroelectric plants, O&M cost is considered as fixed cost.

Table 3-13: Selected operation and maintenance costs

Plant type	Unit size MW	Fixed O&M US$/kW-Month	Variable O&M US$/MWh
Coal steam thermal	All	4.17	6.50
Gas turbine	All	0.83	5.00
Combined cycle gas turbine	All	1.67	4.00
Hydroelectric-SPP (Run of river type)	All	37.72	-
Hydroelectric (Dam type)	All	2.60	-
Geothermal (Binary)	50	100.00	-
Solar PV	All	24.69	-
Wind	All	39.55	-

Source: PSMP2012 Update and US-EIA "Updated Capital Cost Estimates for Electricity Generation Plants" (Apr.2013)

3.3.2.9 Development cost

Capital costs for all candidate power plants are based on benchmarking of generic plants around the world, original capital costs from the PSMP2012 Update, and proposed developers' prices. These costs were then escalated from original sources to obtain costs on a common basis. Construction for both hydro, thermal and renewable are summarized in Table 3-14, Table 3-15 and Table 3-16, respectively.

Table 3-14: Construction costs for hydro projects

River Basin	Planned Projects	Installed Capacity (MW)	Annual Energy Generation (GWh)	Plant Factor (%)	Construction Cost (2014 Price)		Average Generation Cost (US cent/kWh)
					Amount (Million USD)	Unit Rate (USD/kW)	
Lake Victria	Rusumo	80.0	456.33	58	150.32	1,670	3.94
	Kakono	87.0	573.00	75	383.88	4,412	7.23
Lake Tanganyika	Malagarasi Stage III	44.7	168.12	43	165.20	3,696	10.74
Lake Nyasa	Rumakali	222.0	1,188.01	61	559.87	2,522	5.34
	Masigira	118.0	597.62	58	261.20	2,214	5.02
	Kikonge	300.0	1,141.20	43	670.68	2,236	6.75
	Songwe Manolo(Lower)	177.9	617.46	40	469.18	2,637	8.56
	Songwe Sofre (Middle)	158.9	528.38	38	468.28	2,947	9.88
	Songwe Bipugu (Upper)	29.4	94.56	37	200.57	6,822	22.36
Rufiji	Ruhudji	358.0	1,799.73	57	666.02	1,860	4.35
	Mnyera - Ruaha	60.3	290.83	55	255.08	4,230	9.49
	Mnyera - Mnyera	137.4	662.26	55	274.07	1,995	4.82
	Mnyera - Kwanini	143.9	693.79	55	164.12	1,141	3.03
	Mnyera - Pumbwe	122.9	592.18	55	219.15	1,783	4.38
	Mnyera - Taveta	83.9	403.84	55	205.75	2,452	5.79
	Mnyera - Kisingo	119.8	577.28	55	313.53	2,617	6.13
	Mpanga	160.0	796.00	57	420.23	2,626	5.95
	Lower Kihansi Expansion	120.0	62.10	6	220.75	1,840	41.88
	Upper Kihansi	47.0	213.35	52	519.89	11,061	25.26
	Iringa - Ibosa	36.0	186.09	59	123.06	3,418	7.27
	Iringa - Nginayo	52.0	262.75	58	125.46	2,413	5.43
	Steiglers Gorge Phase 1	1,048.0	4,558.67	50	2,455.99	2,344	6.15

Note: The construction cost does not include the interest during construction and transmission line and substation costs.
Steiglers Gorge Phase 2 Project is excluded because annual energy generation is not calculated in previous study report.

Table 3-15: Construction costs for thermal projects

Type	Name	Capacity (MW)	Heat Rate (kcal/kWh)	Construction Cost ($/kW)	Construction period
Simple cycle gas turbine	SGT1	70	2,759 (31.2%)	900	1 year
	SGT2	120	2,845 (30.2%)	900	1 year
	SGT3	300	2,470 (34.8%)	900	1 year
Combined cycle	CGT1	110	1,773 (48.5%)	1,200	2 years
	CGT2	185	1,832 (46.9%)	900	2 years
	CGT3	470	1,616 (53.2%)	900	2 years
Coal	SBCL Conventional sub-critical	150	2,115 (40.7%)	2,000	3 years
	ASBC Advanced sub-critical	300	2,050 (42.0%)	2,000	3 years
	USCL Ultra super critical	700	2,040 (42.2%)	2,000	3 years

Source: US-EIA "Updated Capital Cost Estimates for Electricity Generation Plants" (Apr.2013), Gas Turbine Worldwide Handbook and PSMP2012 Update

Table 3-16: Construction costs for renewable projects

Type	Name	Capacity (MW)	Construction Cost ($/kW)	Construction period
Geothermal	GEO	50	4,362*1	2 years
Solar PV, ground mounted	PV	100	1,200*2	1 year
Onshore wind	WIND	100	1,571*2	1 year

Source: *1 US-EIA "Updated Capital Cost Estimates for Electricity Generation Plants" (Apr.2013)

*2 International Energy Agency/ Nuclear Energy Agency "Projected cost of generating electricity" (2015 Edition)

3.4 Power development scenarios

3.4.1 Scenarios considered

The potential generation capacity determined from each energy resources is a basis for setting the scenarios. Potential of natural gas and its allocation for various purposes are shown in Table 3-17, Fig. 3-5 and 3-6.

Energy potential and possible generation capacity is described as follows.

a) Gas: Assuming that 20% of recoverable natural gas reserve (70% of 57.25Tcf=40.075Tcf) is allocated to power sector, 8.015 Tcf can be used for power generation. It can support around 8,000MW combined cycle power plants for 20 years.

b) Coal: Combined coal reserve in Mchuchuma, Ngaka, Kiwira, Mbeya and Rukwa is around 870mil.ton as shown in Table 3-18. It can support 9,900MW coal fired power plants for 30 years.

c) Hydro: Identified hydro potential with feasibility studies in Tanzania is approx. 4,700MW. The capacity of existing hydro power is 567MW.

d) If capacity of power development is calculated only from energy potential, generation mix will be Gas: 34%, Coal: 43% and Hydro: 23%. This is a basis of setting power development scenarios.

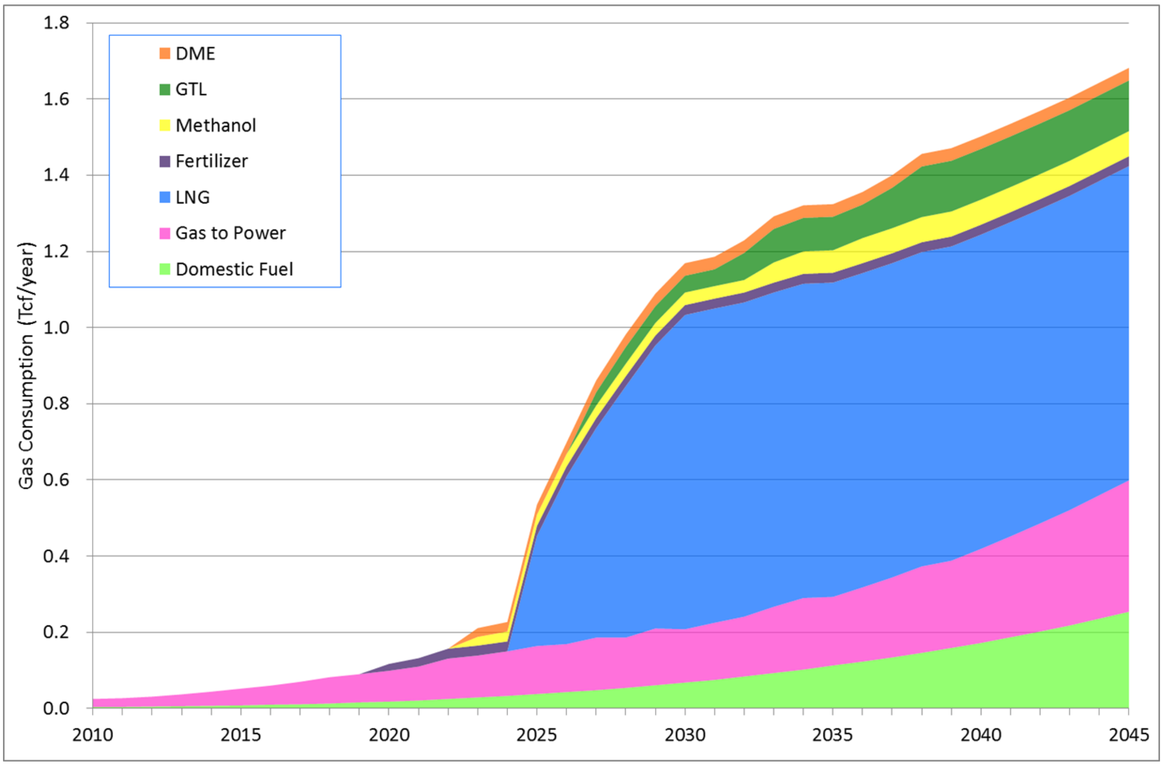
Six generation expansion scenarios which have different share of energy sources considering the energy potential described above are set as shown in Table 3-19.

Table 3-17: Natural gas reserve in Tanzania

Category	Gas Fields	Proven-Reserve	Probable-Resource
		P90	P50
		P1	P1+P2
Land/ Shallow Water	Songosongo	0.88	2.5
	Mnazi-bay	0.262	5
	Mkuranga		0.2
	Nyuni	0.045	0.07
	Ruvuma		0.178
	Ruvu		2.17
	Sub-total	**1.187**	**10.118**
Deep Water	Block 2		25.4
	Block 1,3 & 4		21.73
	Sub-total		**47.13**
Total			**57.25**

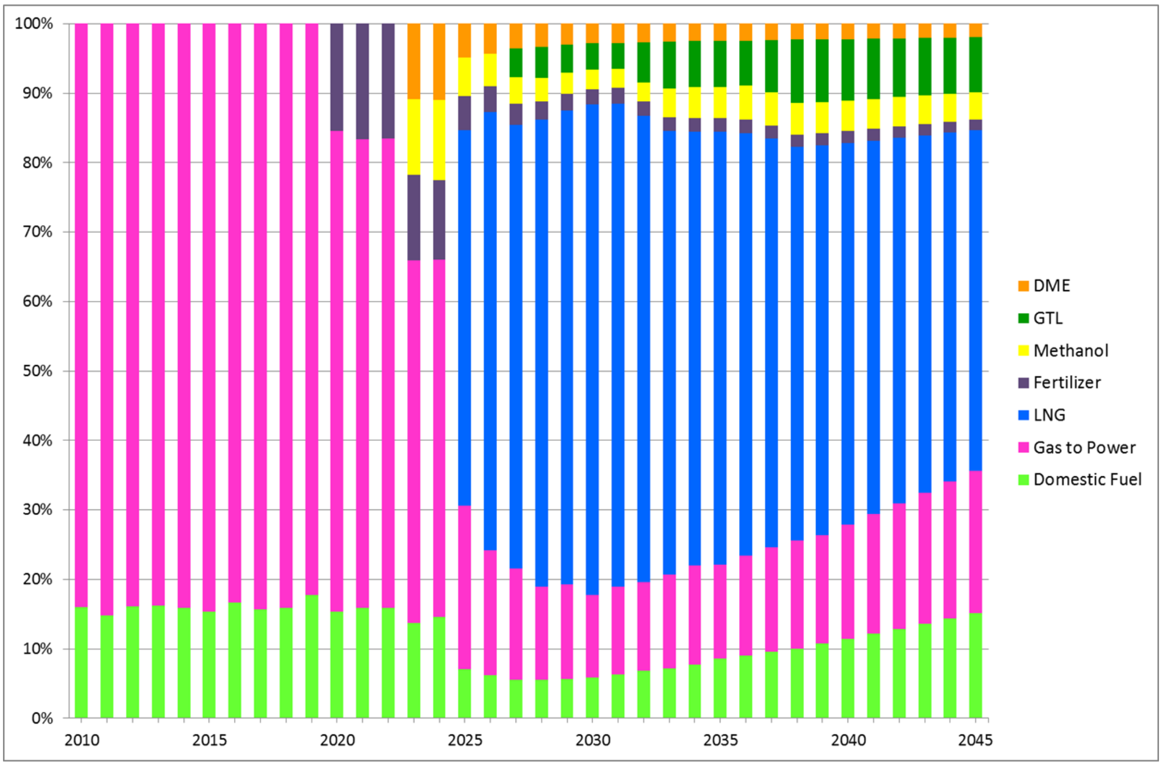
Source: TPDC

Figure 3-5: Gas Consumption Outlook: Base Case (NGUMP)



Source: Natural Gas Utilization Master Plan

Figure 3-6: Gas Consumption Share: Base Case (NGUMP)



Source: Natural Gas Utilization Master Plan

Table 3-18: Coal reserves in Tanzania

	National Development Corporation (NDC)			STAMICO	Others
Coal mine name	Mchuchuma	Katewaka	Ngaka	Kiwira - Ngoro - Kabulo - Maturi	- Mbeya *1 - Rukwa *2
Reserve	370mil.t	81.65mil.t	251mil.t	85mil.t	109mil.t *1 58mil.t *2
Production plan	3 mil.t/year	0.34 mil.t/year	3 mil.t/year	1.5mil.t/year	N/A
(for Generation)	(1.5 mil.t/y)	(For iron making)	(1.0mil.t/y)	(1.0mil.t/y)	N/A
(for Industry)	(1.5 mil.t/y)		(2.0mil.t/y)	(0.5mil.t/y)	N/A
Power development	600MW (150MWx4)	-	400MW (200MWx2)	400MW	*1: 300MW *2: 600MW

Source: NDC and STAMICO

Table 3-19: Power development scenarios

Scenarios	Generation Mix			
	Gas	Coal	Hydro	Renewable etc.
Scenario-1	50%	25%	20%	5%
Scenario-2	40%	35%	20%	5%
Scenario-3	35%	40%	20%	5%
Scenario-4	25%	50%	20%	5%
Scenario-5	50%	35%	10%	5%
Scenario-6	40%	30%	20%	10%

[Remarks] Renewable etc. includes solar, wind, biomass, geothermal and import

Generation expansion plans which correspond to six scenarios from Scenario-1 to 6 were analyzed by using WASP (Wien Automatic System Planning Package) software.

3.4.2 Items considered in formulating generation expansion plans

3.4.2.1 Generation mix

Generation mix was established to avoid dependence on single energy source and should be balanced to maintain the security of electricity supply.

3.4.2.2 Gas fired power

Availability of gas to power is the key for considering the share of gas fired power in generation mix. In NGUMP 2016, it is assumed that gas fired power accounts for 40% of energy generation by 2040 as a condition of estimating total gas demand.

3.4.2.3 Coal fired power

Financing for coal fired power plant is challenging because of the international pressure against coal fired power due to greenhouse gas emission. In addition, disposal of bottom and fly ash and gypsum (by-product of Flue Gas Desulfurizer) is also a constraint in developing coal fired power plant.

3.4.2.4 Hydro power

Seasonal variation of energy generated and vulnerability to climate change should be taken into consideration. Environmental impact, resettlement of people, and huge initial investment cost are also negative aspects of hydro power development. Still, hydro is the most economical source of power generation. Since hydro power is site specific, it is not possible to add “unknown” site to power development candidate. Therefore, maximum hydro capacity to be added will be limited to 4,700MW.

3.4.2.5 Geothermal

The challenges in developing geothermal resource are high upfront investment costs; long lead time from conception to production of electricity; capital intensive and high exploration cost and risk, inadequate capital resource to undertake necessary studies; remote location and limited infrastructures. Therefore, geothermal power plant included in the generation expansion plan is limited to the projects which have high possibility of development potential.

3.4.2.6 Other renewable energy

Generation cost of renewable energy, i.e. solar and wind, has dramatically dropped recently. In case of utility scale solar project, levellized generation cost is in the range[3] of US$54/MWh (United States) to US$181/MWh (Japan) at a 3% discount rate. However, generation output from solar and wind is intermittent and not stable. Moreover, daily load pattern in Tanzania is still “lighting peak” type, therefore, solar cannot be utilized during peak hours unless storage device is equipped[4]. In order to achieve reliable and stable power supply, development of conventional generation plants must be accompanied with the development of renewable energy plants to supplement and backup the fluctuation of renewable energy generation. Considering intermittent output and low utilization factor and of solar (10-15%) and wind (20-30%), contribution of such renewable energy generation to total energy generated is limited.

[3] International Energy Agency/ Nuclear Energy Agency “Projected cost of generating electricity” (2015 Edition)

[4] The largest storage device was commissioned in Japan in March 2016. It is consisted of NaS battery and power conditioning system with the output of 50MW and storage capacity of 300MWh. Procurement and installation cost for the storage system is approximately US$170 million.

3.5 Generation Plan Results

3.5.1 Optimum Generation Expansion Scenario

Optimum solutions obtained from WASP for each scenario are shown in Table 3-20. Scenario-2 is the most recommended through the evaluation of scenarios from the view point of total generation cost for 25years (from 2016 to 2040) which includes capital cost, operation and maintenance cost and fuel cost, energy balance and environmental aspect.

Table 3-20: Results of scenario comparison

Scenarios	Features	Cost* (million$)	Cost	Energy Balance	Environ ment	Order
Scenario-1	Gas:50%, Coal:25%, Hydro:20% Renewable and others:5%	58,664	3	3	2	3
Scenario-2	Gas:40%, Coal:35%, Hydro:20% Renewable and others:5%	57,462	2	1	3	1
Scenario-3	Gas:35%, Coal:40%, Hydro:20% Renewable and others:5%	57,098	2	1	4	2
Scenario-4	Gas:25%, Coal:50%, Hydro:20% Renewable and others:5%	56,368	1	3	5	5
Scenario-5	Gas:50%, Coal:35%, Hydro:10% Renewable and others:5%	58,576	3	5	4	6
Scenario-6	Gas:40%, Coal:30%, Hydro:20% Renewable and others:10%	72,049	5	1	1	4

[Remarks] Ranking order: 1 (best) to 5 (worst)

*Cost= Cumulative value of the following cost from 2015 to 2040

Investment Cost – Salvage Value +Fuel Cost+ O&M Cost

The following figures describe energy generated and capacity developed in six scenarios with the share of different type of fuel.

Figure 3-7: Energy generated

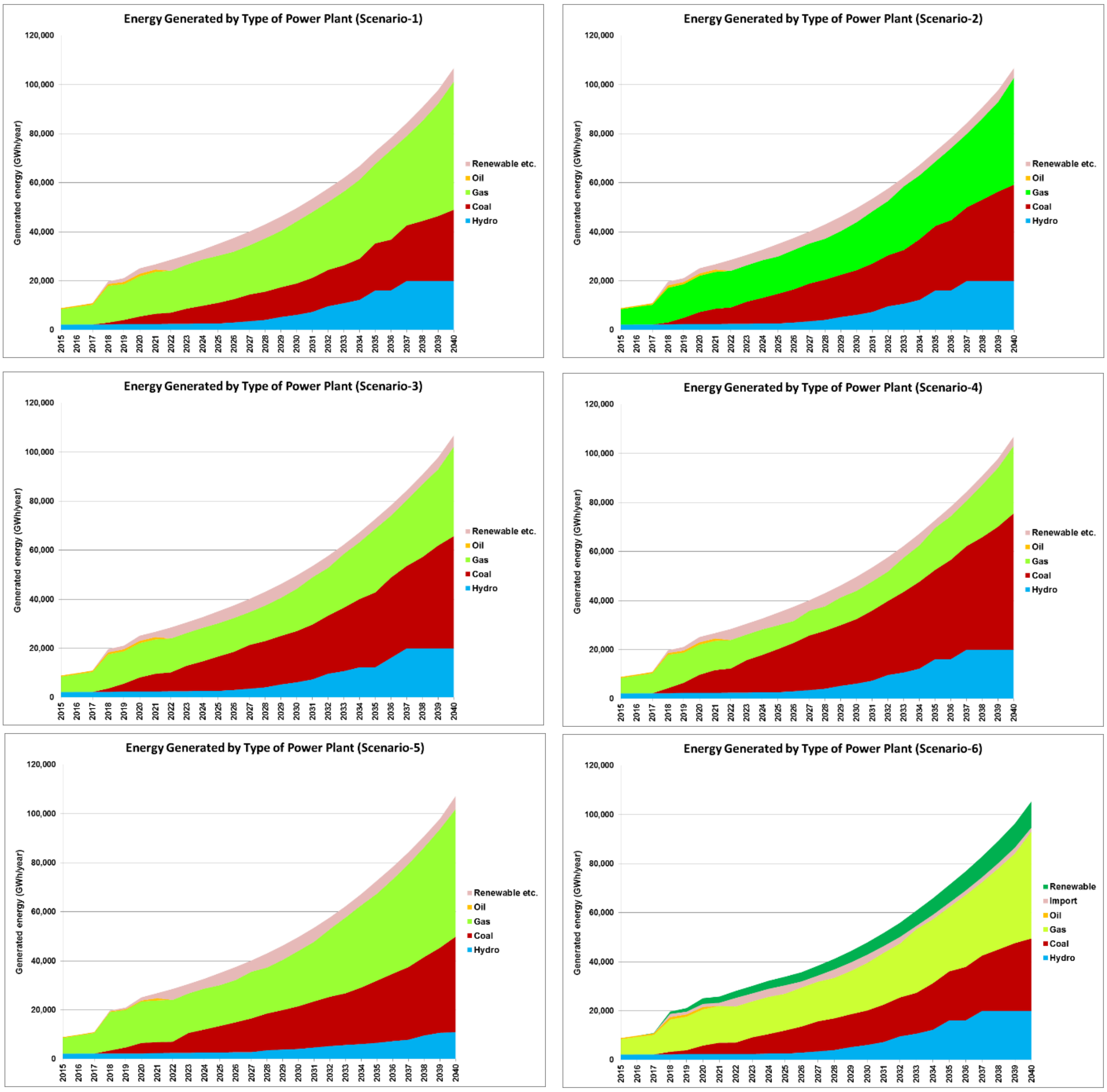


Figure 3-8: Share of energy generated

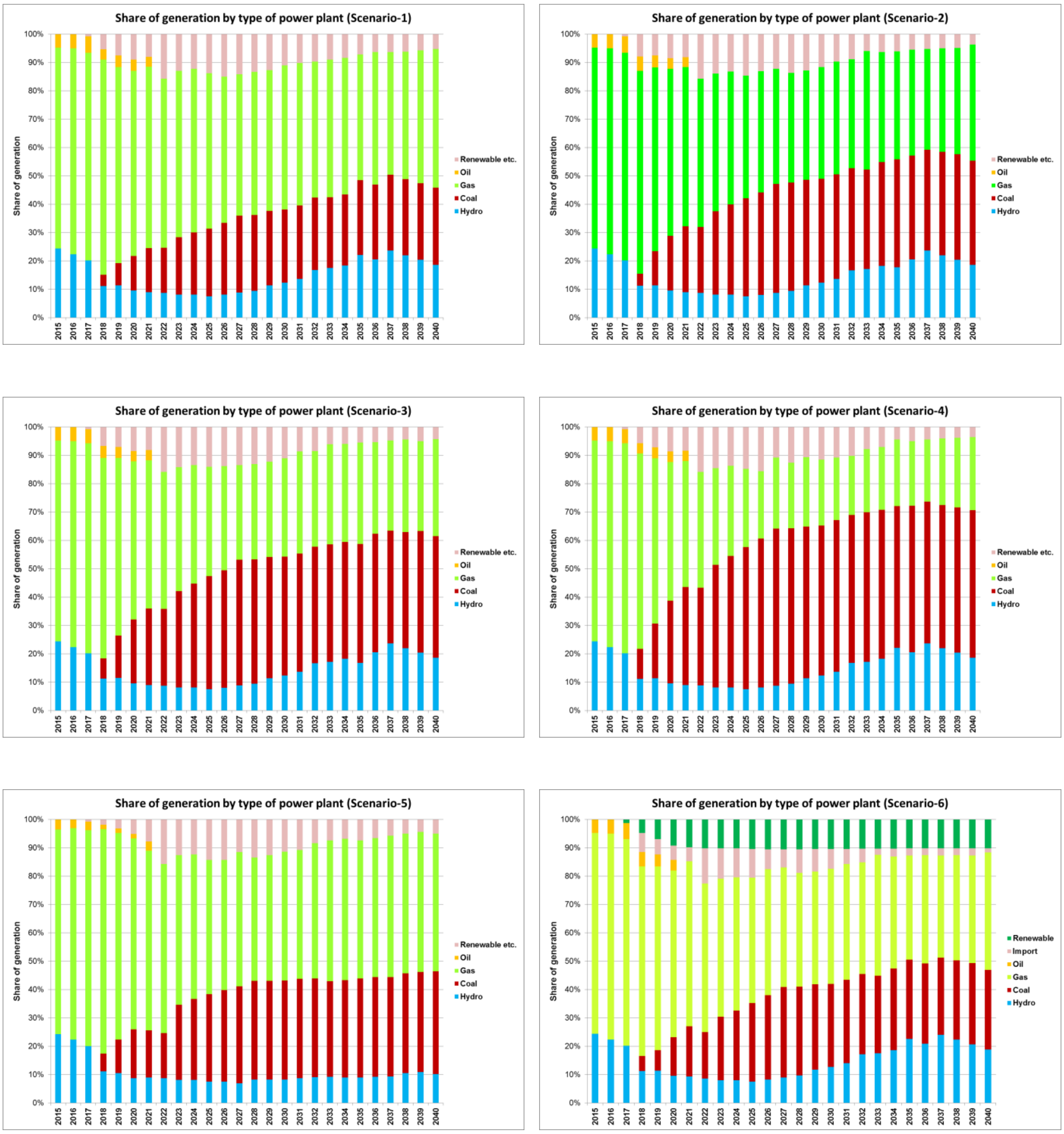


Figure 3-9: Generation capacity

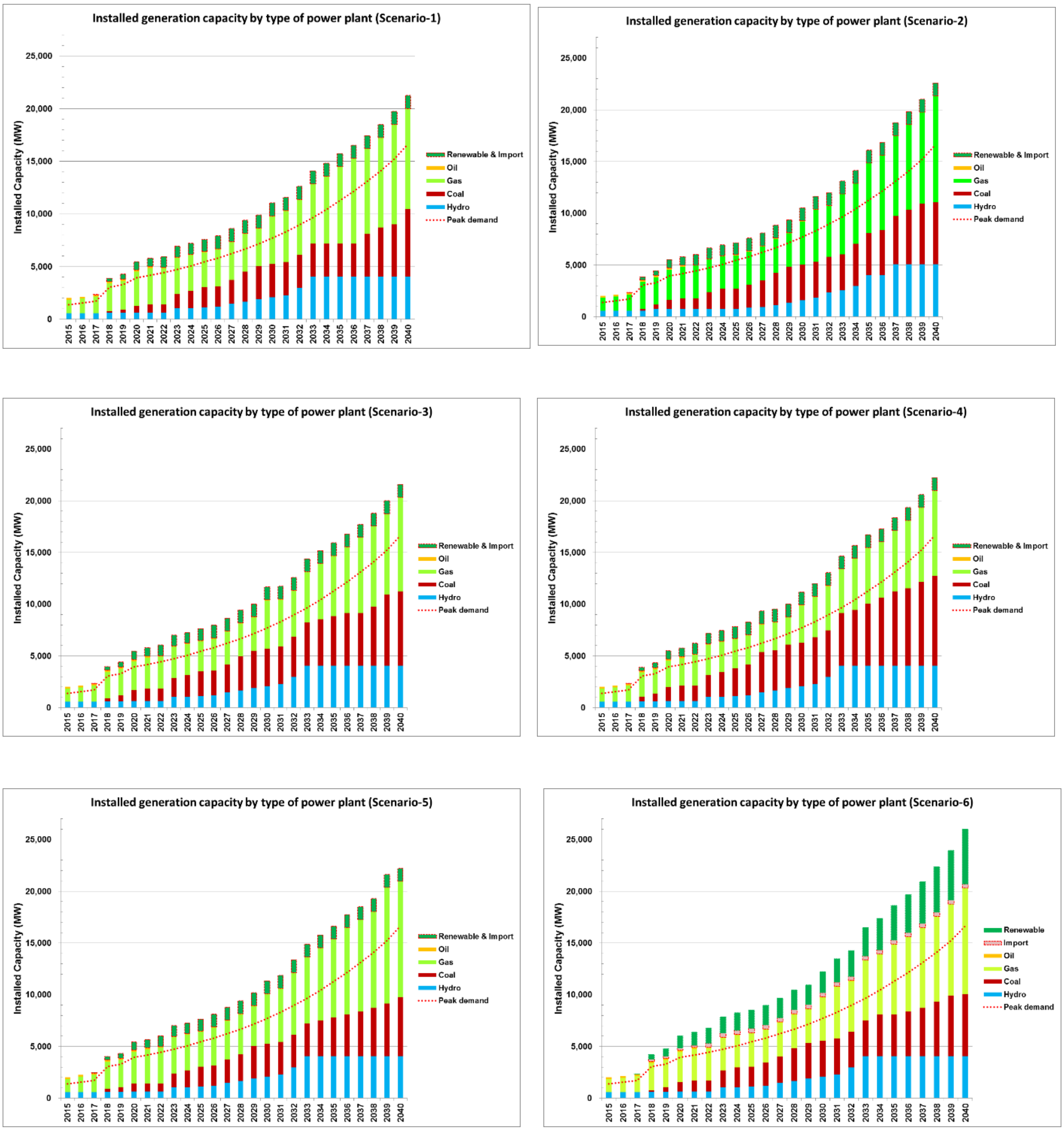
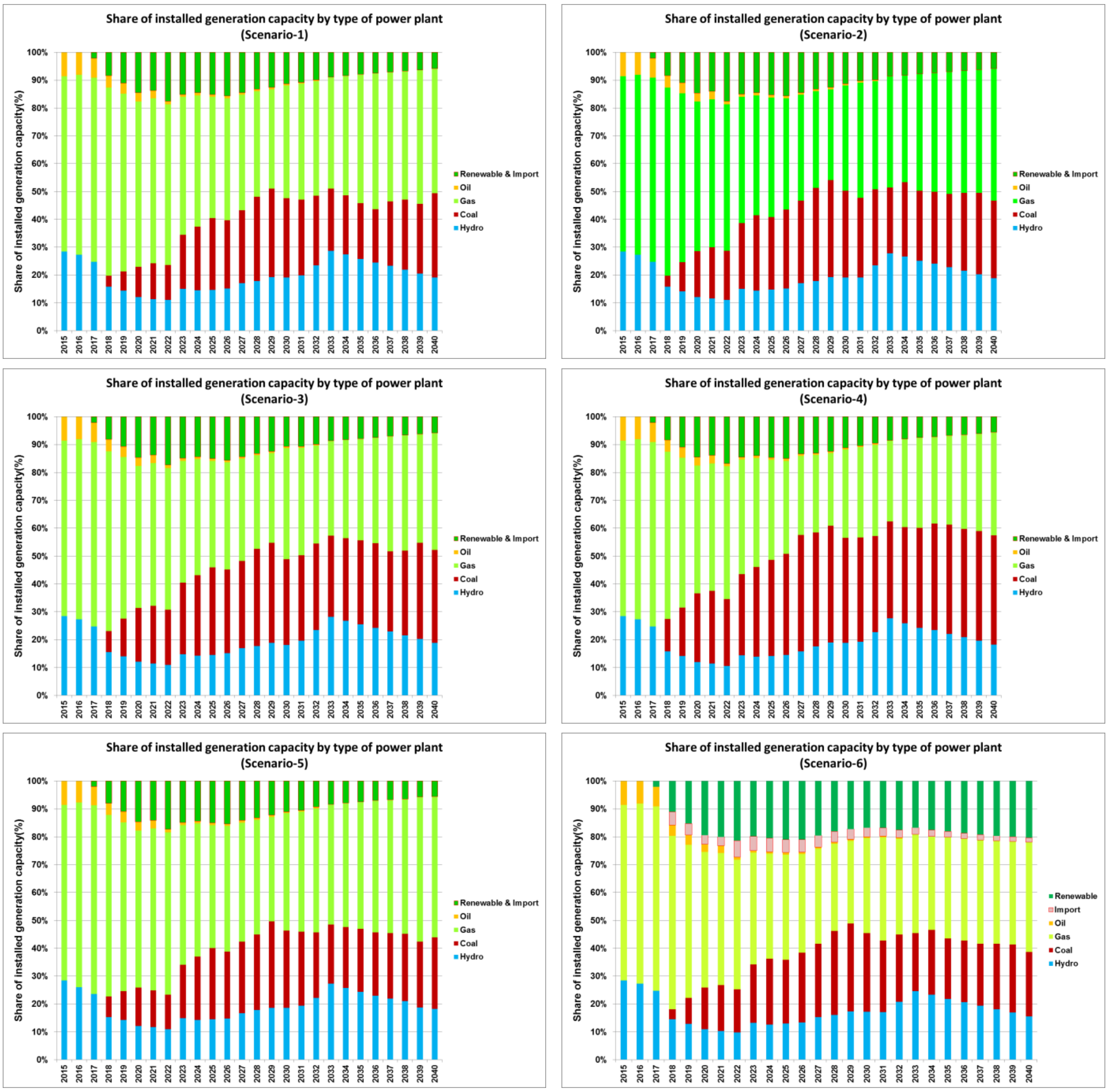


Figure 3-10: Share of generation capacity

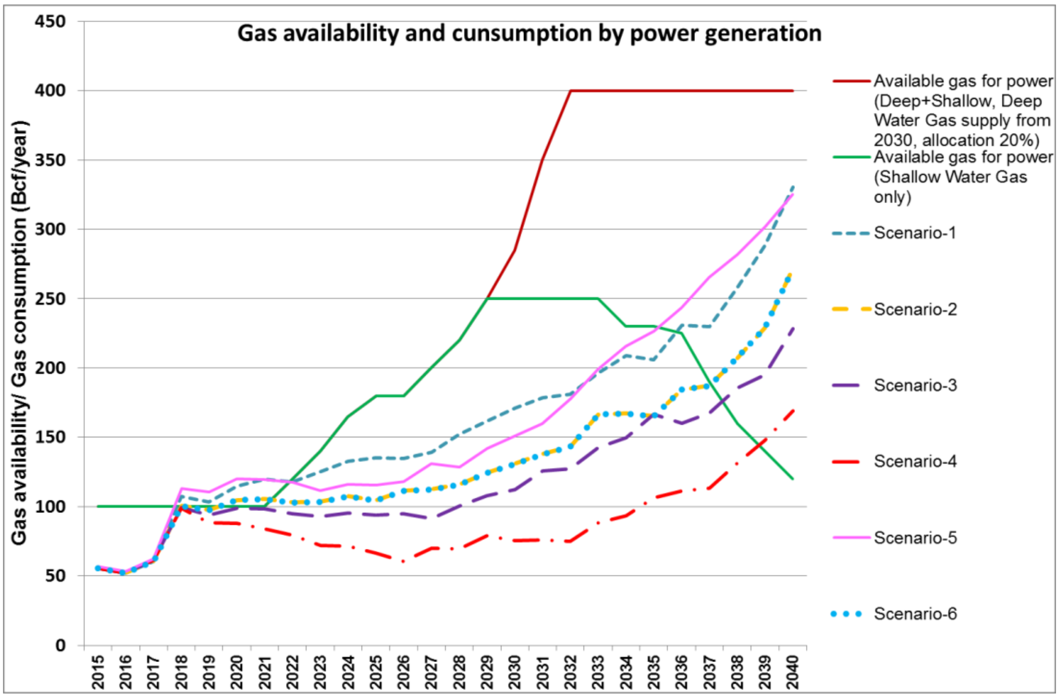


3.5.2 Observations

3.5.2.1 Natural gas demand and supply balance

Until deep water gas is developed, shallow water gas such as Songo Songo, Nyuni/Kiliwani, Mnazi Bay are the only source of natural gas for gas fired power plants. After the completion of a gas pipeline from Mtwara to Kinyerezi, constraint of pipeline capacity to deliver gas to power plants is relieved. Still, production capacity will be a bottleneck to deliver sufficient gas to power plants. Fig. 3-11 compares the capability of gas supply and demand by power for six scenarios. With accelerated production from shallow water gas fields, no serious shortage of gas to power will be anticipated as shown in Fig. 3-11.

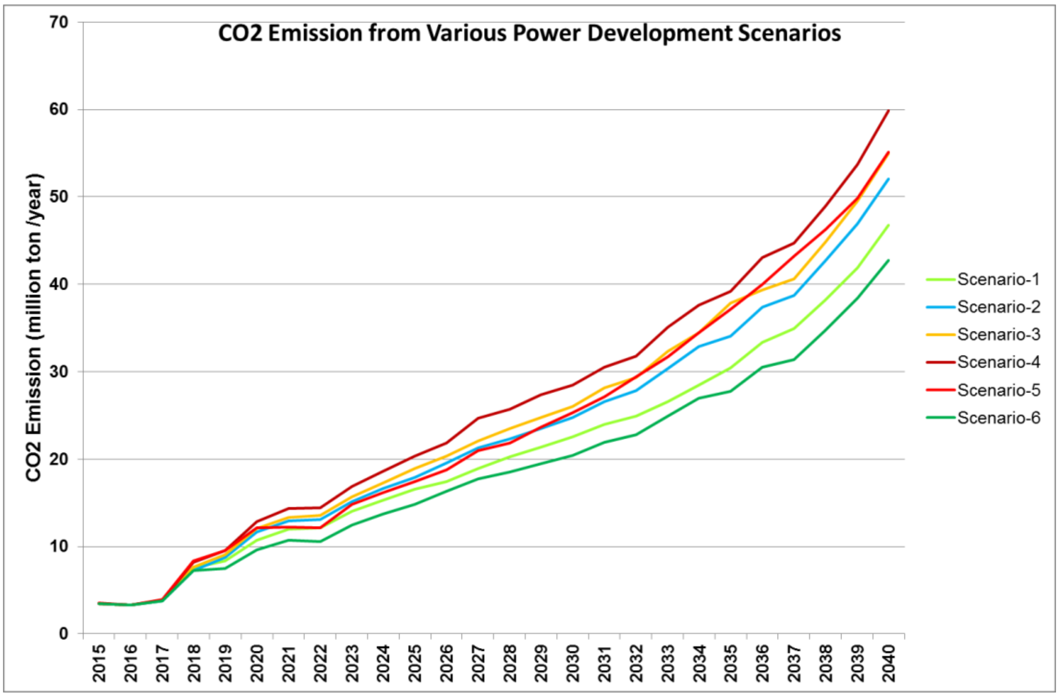
Figure 3-11: Natural gas demand and supply for power sector



3.5.2.2 Carbon dioxide emission

Fig. 3-12 shows the CO_2 emission from six power development scenarios. Scenario-4 which has the largest share of coal fired power plants emits more CO_2 than others. Compared with the lowest emission trend of Scenario-6, Scenario-6 generates 29% less CO_2 than Scenario-4 in 2040.

Figure 3-12: CO_2 emission in six power development scenarios



3.5.2.3 Optimal power development plan

The detailed results of Scenario-2 which was analyzed by WASP is shown in Table 3-21. Power development plan of Scenario-2 which includes the location and name of ongoing/planned projects is shown in Table 3-22.

Table 3-21: Least cost generation expansion plan by WASP (Scenario-2)

Scenario-2 Least Cost Generation Expansion Plan

Year	Fixed expansion		Variable expansion												LOLP%
	Plant	MW	Simple cycle GT			Combined cycle			Coal			GeoTh	Hydro		Target
			SGT1	SGT2	SGT3	CGT1	CGT2	CGT3	SBCL	ASBC	USCL	GEO1	DAM		
			70MW	120MW	310MW	110MW	185MW	470MW	150MW	300MW	700MW	50MW	Site Name	(MW)	=1.37%
2015	Kinyerezi-I	150				310									0.365
2016						110									0.657
2017	Kinyerezi-II	240													1.018
	Kinyerezi-I (Extension)	185													
	Singida Wind (50MW)	50													
2018	Import from Ethiopia (1st stage)	200				660	370		150						1.227
	Singida Wind (75MW)	75													
2019	Rusmo (Hydro)	30							300						0.704
	Lower Kihansi Expansion	120													
	Makambako Wind (100MW)	100													
	Dodoma solar (50MW)	50													
2020	Singida Wind (75MW) Extension	75				110	185		450						1.320
	Singida Wind (100MW)	100													
	Kishapu-Shinyanga Solar	150													
2021	Singida Wind (75MW) Extension	50				110			150						1.176
2022	Import from Ethiopia(2nd stage)	200				110									0.978
2023										600					0.215
2024										300			Malagarasi Stg-III	44.7	0.447
2025						220						100			1.203
2026										300		100	Iringa-Ibosa	36	1.342
													Iringa-Nginayo	52	
2027						220				300			Kakono	87	1.211
2028										600			Mnyera - Ruaha	60	0.699
													Songwe Manolo	88	
2029										300			Mnyera - Mnyera	137	1.227
													Mnyera - Kwanini	144	
2030								940					Mnyera - Pumbwe	123	0.308
													Mnyera - Taveta	84	
2031								940					Mnyera - Kisingo	120	0.143
													Mpanga	160	
2032													Ruhudji	358	0.374
													Masigira	118	
2033								940					Rumakali	222	0.132
2034										600			Kikonge	300	0.165
													Songwe Sofre	80	
													Upper Kihansi	47	
2035								940					Stieglers Gorge Ph-1	1,048	0.082
2036						110		470		300					0.157
2037						110		470		300			Stieglers Gorge Ph-2	1,048	0.129
2038								470		600					0.228
2039						110		470		600					0.385
2040								1410	150						0.583
Total addition (Number of units)						22	3	15	8	16	0	4		19	
Total addition (MW)		1,775				2,180	555	7,050	1,200	4,800	0	200		4,357	

Generation capacity in 2040		
Gas	10,253 MW	45.4%
Coal	6,000 MW	26.6%
Hydro	5,093 MW	22.5%
Renewable	850 MW	3.8%
Import	400 MW	1.8%
Total	22,595 MW	100%

Note: The table above is a result of WASP simulation. Future expansion projects which are not committed yet are deemed as “Variable Expansion Candidates”. WASP will select the type, capacity and year of operation for variable expansion candidates to formulate the least cost expansion plan.

Table 3-22: Optimal generation expansion plan (Scenario-2)

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	600	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

CHAPTER FOUR

4 TRANSMISSION EXPANSION PLAN

4.1 Introduction

This section provides the update to the transmission plan based upon the load forecast and the generation expansion plan presented in the previous chapters. Practically, the overall logical planning process that was used for conceptual primary transmission system planning update does not differ much from the previous Power System Master Plan of 2009 and 2012 Update.

An assessment of major power flows was conducted across widely separated geographical areas over the planning period up to the year 2040 in order to plan for reinforcement and new transmission lines. The assessment was done by calculating the ranges of major interface flows for critical system conditions, at discrete intervals of five years throughout the study period for the generation plans. These ranges of major interface power flows between geographic subsystems are based on a generation planning sequence, grid station load forecast, ranges of load levels and known operating constraints. This information led to a conceptual update design of the transmission additions or changes where it appeared necessary. Likewise, the information will provide an early feedback of transmission costs associated with the least cost generation update option.

After the simulation of load flow using generation data as an input to transmission plan, the results provided detail information for transmission system expansion/additions. Simulations were carried by an interval of 5 years starting from year 2020 to 2040.

4.1.1 Objectives

The main objective of this process is to identify a definitive near to mid-term plan (to year 2025) and an indicative long-range plan (to year 2040) for the transmission system expansion update. More specifically, transmission expansion plan objectives are:

a) Ensuring security of supply in the short term by coordinating electricity supply and demand;
b) Ensuring security of supply in the medium and long term by developing the National Grid;
c) Ensuring accessible transmission and distribution routes by means of good maintenance practices;
d) Determining the location, capacity, and type of the required power transmission development and upgrades over the planning horizon 2040;
e) Establishing the timing of the transmission upgrades across years 2020, 2025, 2030, 2035 and 2040; and
f) Estimating the capital cost and investment plan associated with the transmission line development and system upgrades.

In the context of a master plan, the transmission expansion determines the system upgrades that will allow the planned generation to serve the forecasted load. Additionally, a corresponding investment plan is developed to estimate the cost of the transmission expansion plan associated to the generation and sub- transmission/distribution plans which provide the basic input to financial and economic analysis.

The transmission plan chooses the system additions that are most economical, while satisfying a pre-defined set of technical criteria. Such criteria composed a set of rules that measure the system performance and compare several scenarios on a common technical basis, ensure the adequate operation of the power system under both normal and emergency conditions, once the infrastructure has been built.

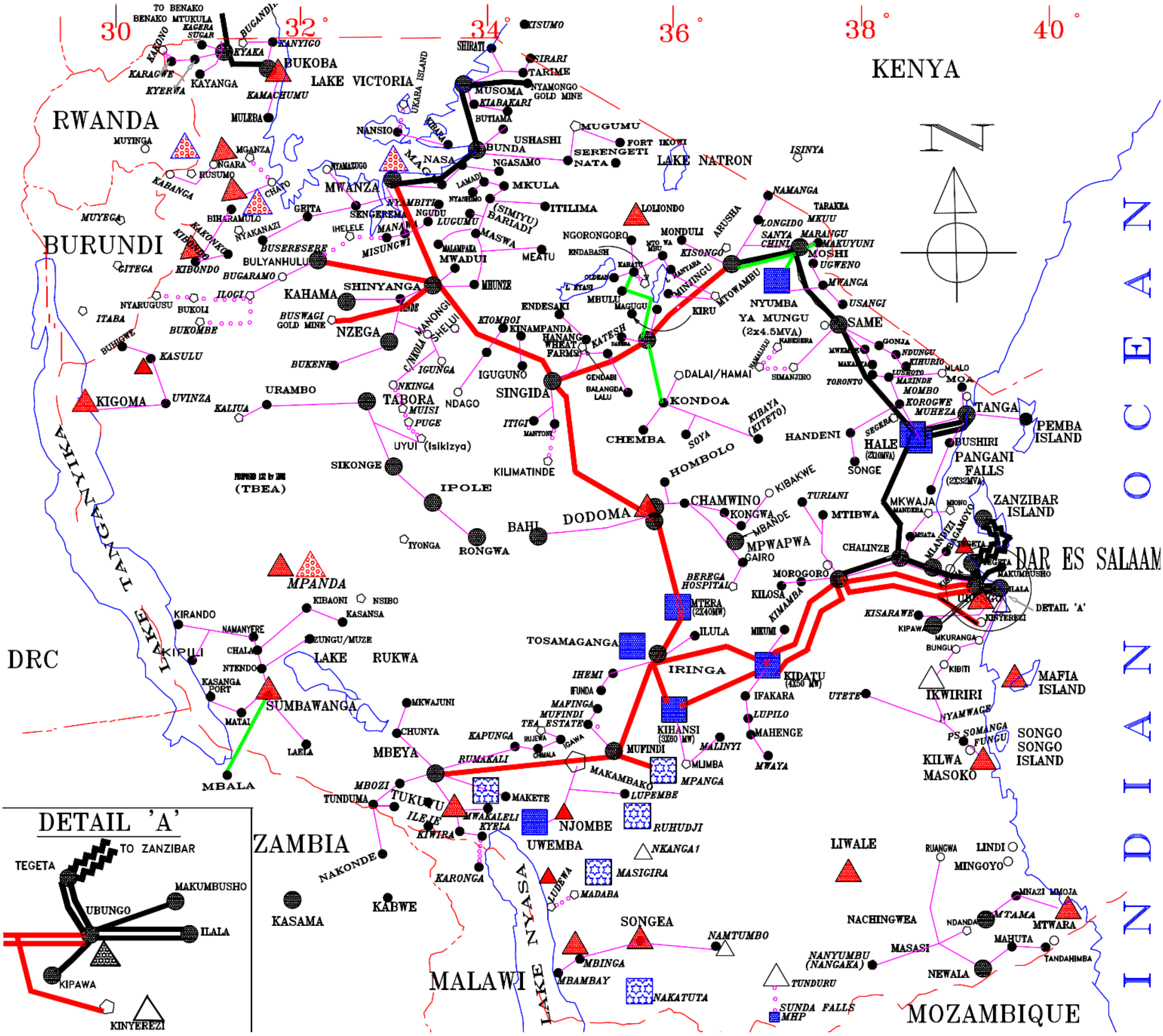
4.1.2 Existing Grid System

There are transmission and distribution lines of different voltage capacities all over the country. The transmission system is comprised of 647km of 400kV, 2,745 km of 220kV, 1,626 km of 132kV and 580 km of 66kV. The isolated centers away from the grid are served by generating units with an aggregate nominal capacity of 81.5 MW. TANESCO imports power from Uganda via 132kV and from Zambia through 66kV lines.

Simulation of the existing power system under peak load conditions revealed that the following portions of line, the Iringa – Dodoma – Singida 220kV line, the Chalinze – Hale – Arusha 132kV line and Ubungo – Kunduchi – Ras Kilomoni 132kV line and 132kV submarine cable from Ras Kilomoni (Mainland) to Ras Fumba (Zanzibar) had exceeded their thermal limits, therefore they could not transfer all the respective demanded power. This has resulted in the introduction of the 647km of 400kV Iringa – Shinyanga backbone project (in final stage of commissioning), 441 km of 400kV Dar es Salaam – Chalinze – Segera – Arusha and 64km of 220kV Segera – Tanga (are committed). While the reinforcement of 38 km of 132kV submarine cable from Ras Kilomoni to Zanzibar has been commissioned.

The proposed increase of power generation in Mbeya, Iringa and Dar es Salaam regions has necessitated the reinforcement of the 220kV lines to these areas so that power can be evacuated to the load centres. To this effect, 400kV lines of 336 km Chalinze – Dodoma and 292 km Iringa – Kisada – Mbeya are planned for construction just to mention the few as per Table 4-5, 4-6, 4-7, 4-8 and 4-9.

Figure 4-1: Existing Grid System



Source: TANESCO

Table 4-1: Parameters of the Existing Transmission Line System

As of November 2016

Rated Voltage (kV)	from	to	Route Length (km)	No. of Towers	No. of Circuits	Conductor		Year Commi-ssioned	Current Rating*1 (Amps)	Full Rating (MVA)	Normal Rating*2 (MVA)
						Code Name	Aluminum Sectional Area (mm^2)				
220	Morogoro	Ubungo 1st	172	456	1	Bluejay	564	1975	1,092	416	333
220	Kidatu	Mindu	116	279	1	Bluejay	564	1975	1,092	416	333
220	Mindu	Moro Dev.	12	41	1	Bluejay	564	1982	1,092	416	333
220	Kidatu	Iringa	160	441	1	Bison	350	1985	679	259	207
220	Iringa	Mufindi	130	336	1	Bison	350	1985	679	259	207
220	Iringa	Mtera	107	297	1	Bison	350	1985	679	259	207
220	Mtera	Dodoma	130	303	1	Bison	350	1985	679	259	207
220	Mufindi	Mbeya	220	544	1	Bison	350	1985	679	259	207
220	Dodoma	Singida	210	528	1	Bison	350	1988	679	259	207
220	Singida	Shinyanga	200	532	1	Bison	350	1988	679	259	207
220	Shinyanga	Mwanza	140	336	1	Bison	350	1988	679	259	207
220	Morogoro	Kidatu	130	328	1	Bluejay	564	1993	1,092	416	333
220	Morogoro	Ubungo 2nd	179	477	1	Bluejay	564	1995	1,092	416	333
220	Singida	Babati	150	424	1	Rail	483	1996	993	378	303
220	Babati	Arusha	162	433	1	Rail	483	1996	993	378	303
220	Kihansi	Iringa	95	277	1	Bluejay	564	1998	1,092	416	333
220	Kihansi	Escapmet	2	2	1	Pheasant	644	1998	1,187	452	362
220	Kihansi	Kidatu	180	529	1	Bluejay	564	1999	1,092	416	333
220	Shinyanga	Bulyanhulu	129	277	1	Bison	350	2000	679	259	207
220	Shinyanga	Buzwagi	108	237	1	Bison	350	2000	679	259	207
220	Kinyerezi	Ubungo-Pai	6	23	1	Bluejay	564	2016	1,092	416	333
220	Kinyerezi	Ubungo-Pai	6	23	1	Bluejay	564	2016	1,092	416	333
132	Ubungo	Mlandizi	37	334	1	Wolf	150	1963	406	93	74
132	Mlandizi	Chalinze	60		1	Wolf	150	1963	406	93	74
132	Chalinze	Hale	175	534	1	Wolf	150	1963	406	93	74
132	Chalinze	Morogoro	82	288	1	Wolf	150	1967	406	93	74
132	Hale	Tanga	60	389	1	Wolf	150	1971	406	93	74
132	Hale	Same	173	561	1	Wolf	150	1975	406	93	74
132	Same	Kiyungi	102	291	1	Wolf	150	1975	406	93	74
132	Ubungo	Tegeta	19	64	1	Wolf	150	1980	406	93	74
132	Tegeta	Zanzibar	38	-	1	XLPE Cu	95	1980	286	65	52
132	Kiyungi	Arusha (Njiro)	70	208	1	Wolf	150	1983	406	93	74
132	Mwanza	Musoma	210	628	1	Wolf	150	1989	406	93	74
132	Shinyanga	Tabora	203	587	1	Wolf	150	1989	406	93	74
132	Musoma	Nyamongo	90	238	1	Wolf	150	1989	406	93	74
132	Mtukula (Uganda)	Kyaka	30	85	1	Tiger	130	1992	361	83	66
132	Kyaka	Kibeta/Bukoba	54	157	1	Tiger	130	1992	361	83	66
132	Hale	Tanga	60	200	1	Hawk	241	1994	659	151	121
132	Pangani Falls	Hale	9	33	2	Hawk	241	1995	659	301	241
132	Ubungo	FZ III (Kipawa)	9	16	1	Wolf	150	2000	406	93	74
132	Ubungo	Makumbusho	7	37	1	Hawk	241	2010	659	151	121
132	Ubungo (II)	Tegeta	19	64	1	Wolf	150	2012	406	93	74
132	Ras Kilomoni	Zanzibar II	38	-	1	XLPE Cu	400	2013	640	146	117
132	Ubungo	Ilala	8	25	2	TACSR240	240	1999/2016	962	440	352
132	Kinyerezi	FZ II	4	16	1	Wolf	150	2016	406	93	74
132	Kiyungi	Njiro	70	300	1	Wolf	150	2016	406	93	74
66	Kiyungi	Arusha	78	625	1	Rabbit	50	1967	197	23	18
66	Nyumba Ya Mungu	Kiyungi	53	463	1	Rabbit	50	1968	197	23	18
66	Babati	Kondoa	85	251	1	Wolf	150	1999	406	46	37
66	Babati	Mbulu	85	192	1	Wolf	150	1999	406	46	37
66	Mbulu	Karatu	65	172	1	Wolf	150	1999	406	46	37
66	Mbala (Zambia)	Sumbawanga	120	569	1	Wolf	150	2001	406	46	37
66	Bunda	Kibara	60	300	1	Rabbit	50	2007	197	23	18
66	Kiyungi	Makuyuni	34	172	1	Wolf	150	2012	406	46	37

Note: *1 Source: SURAL catalogue
*2; Normal Rating
＝Full Rating x 80%

Voltage	Total Length	No. of Lines	Remarks
	Above Table	Above Table	
220kV	2,745	22	
132kV	1,626	24	(2 x submarine cables included)
66kV	580	8	
Total:	4,950	54	

Source: TANESCO

4.1.3 Development of New Interconnectors

Transmission capacity to other countries is an integrated and important part of a main grid that facilitates new renewable power generation and ensures security of supply domestically. It is necessary to increase the exchange capacity with other countries, both to ensure access through power trading.

The results from the operational experience in recent years lead to necessary adjustments of the plans for establishing new interconnectors in the coming five-year period. The countries project portfolio for interconnectors comprising of six projects: The new 400kV interconnector to Kenya, currently undergoing implementation phase, is scheduled for entering into operation in 2019. The connection point in the Grid is Arusha. Tanzania is planning another connection to Zambia at 400kV which is currently under preparation phase, scheduled to enter into operation in 2020 and the connection point in the Grid is Mbeya. Uganda and Tanzania are planning for the 220kV Masaka (Uganda) - Kyaka (Tanzania) interconnector, it is scheduled for operation by 2020.

Tanzania is also planning a new connection to Mozambique with a voltage of 400kV; Inter-Utility Memorandum of Understanding for the Construction of the Tanzania-Mozambique Interconnector and for Trade in Power and Telecoms (IUMOU) was signed between EDM (Electricidade de Mozambique) and TANESCO in 2015. Tanzania, Rwanda and Burundi are planning a 90MW hydro power plant project at Rusumo border, the project will enable the National grids of the three countries to be interconnected through 220kV transmission line. The last one involves Tanzania and Malawi, a total of 360MW hydro power plant project at Songwe border is planned, the project will enable the National grids of the two countries to be interconnected through 220kV transmission line by 2020. By year 2040, the Grid network (400kV and 220kV lines are shown in blue and red respectively) will be as per Fig. 4-2, 4-3 and 4-4.

Figure 4-2: Generation and Transmission Plan – Year 2020

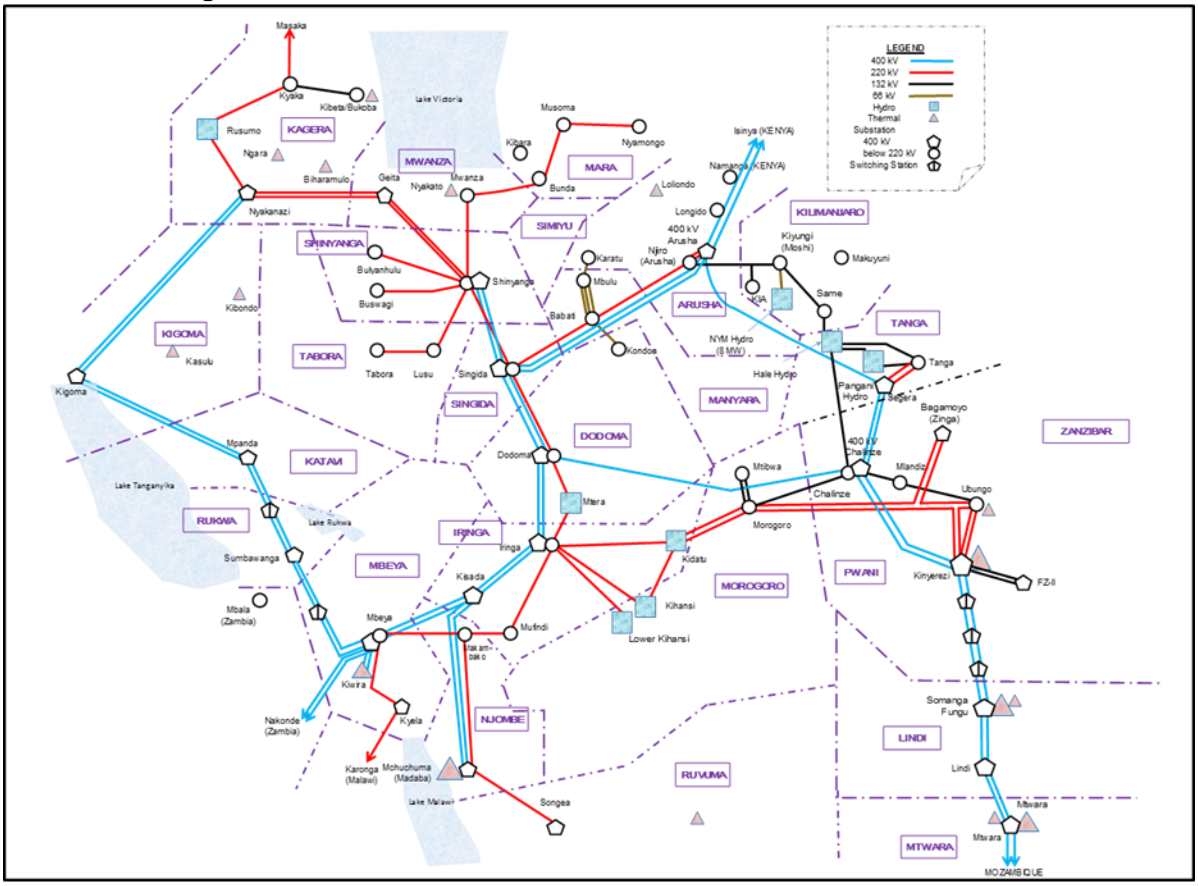


Figure 4-3: Generation and Transmission Plan – Year 2030

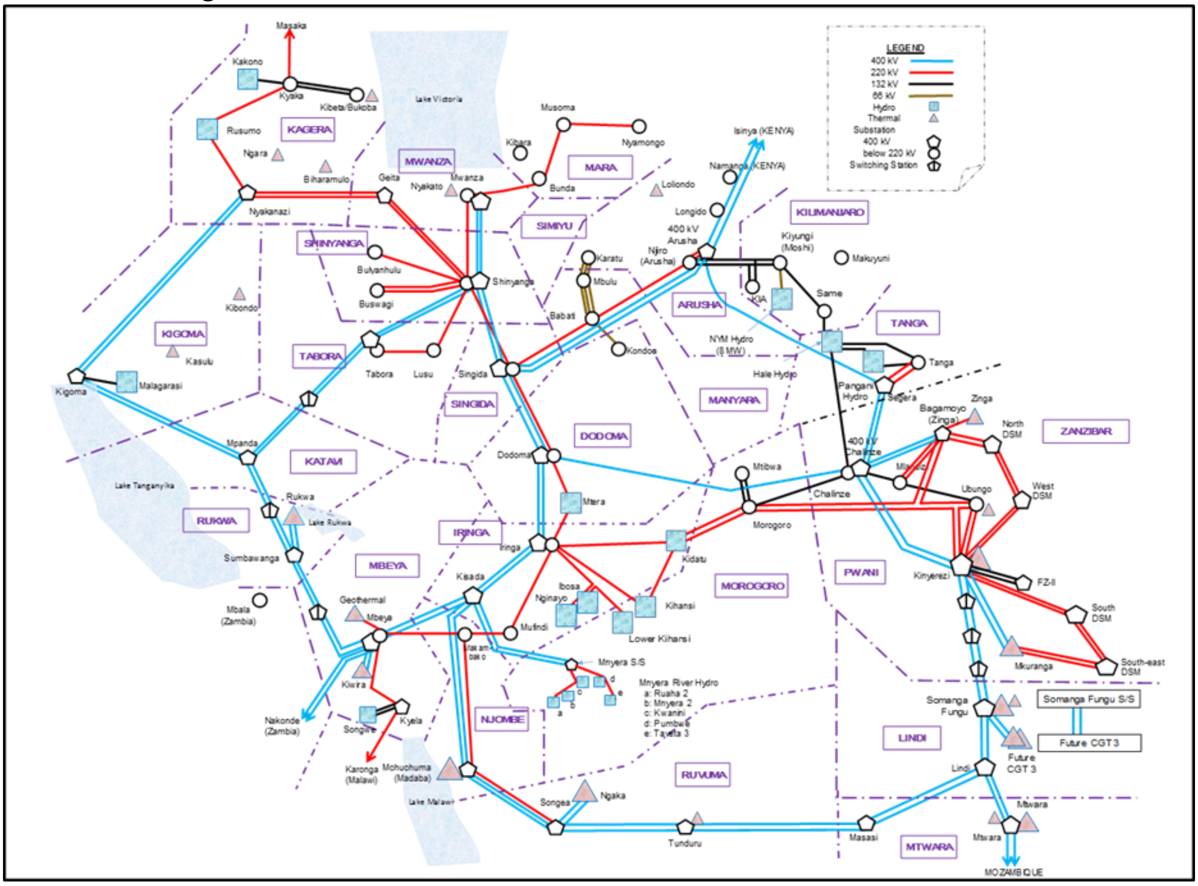
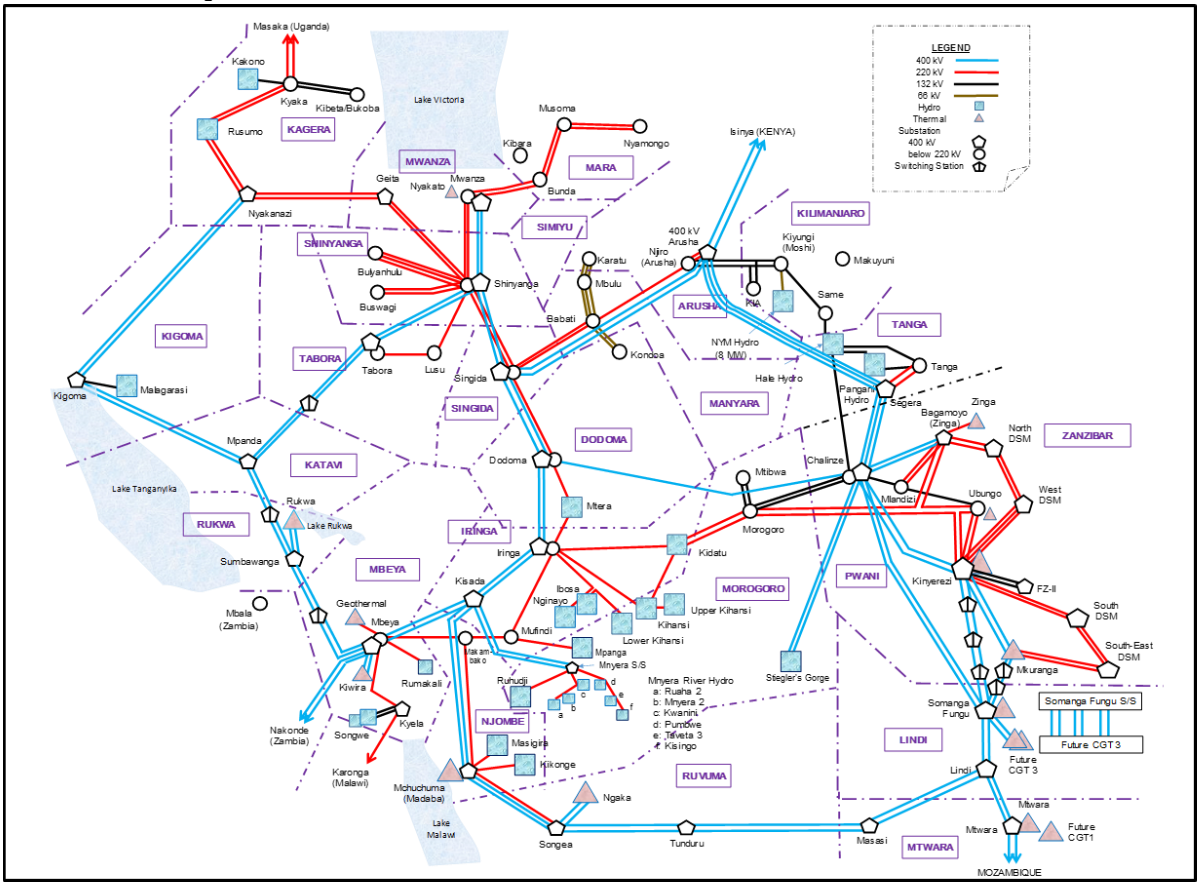


Figure 4-4: Generation and Transmission Plan – Year 2040



Source: Team compilation

Recommendation: Higher voltage would be recommended for 400kV lines from Mtwara to Dar es Salaam to reduce the number of lines.

4.1.4 Drivers for grid development

4.1.4.1 Security of supply is our top priority,

The Western, Northern and Lake Zones need new transmission capacity to secure a satisfactory supply, the South-West and Dar es Salaam areas also need transmission capacity to evacuate excess generated power to other load centers. In 2010, the government initiated several projects such as 400kV transmission lines (backbone), 220kV South-West project (Makambako – Madaba – Songea), 400kV North – East project (Dar es Salaam – Segera – Arusha) and 400kV Chalinze - Dodoma project and the 400kV North-West Grid (Nyakanazi – Kigoma – Mpanda – Sumbawanga – Mbeya), 400kV Kinyerezi – Somanga Fungu – Lindi - Mtwara and 400kV Songea –Tunduru – Masasi – Lindi - Mtwara. These projects are aimed at ensuring the security of power supply in the country and the implementation status are described in 4.1.3.

4.1.4.2 Renewable energy development

The government is determined to achieve its goals regarding new renewable generation in the most social economic efficient way. Several renewable energy projects are underway, such as solar, wind, small hydro and geothermal.

Since the potential for renewable in the country is abundant, it is important that all these developments are balanced, so that new generation is harmonized and adjusted to the implemented grid development plans as well as changes in consumption patterns. This applies both nationally and regionally, that is why the plans for a reinforced main grid include both domestic implementation measures and interconnector capacity to other countries. An increase in the generation from renewable energy will further increase variations in the grid power system between years with low precipitation and years with high precipitation; this requires an increase in the exchange capacity between Tanzania and other countries, both to secure access to energy in dry years, and ability to export surplus power during wet years.

4.1.4.3 Reliable grid creates value

The government will facilitate value creation by securing the necessary transmission capacity domestically, delivering power to the growing number of newly established enterprises, as well as facilitating increased power exchange internationally. Generally, in the entire country, the load forecast show that there will be high growth of power demand mainly due to increase of industrial activities, economic growth and in addition to that, the gas and coal discoveries made in recent years, will lead to higher levels of energy consumption. It is anticipated that the next generation main grid will comprise stronger connections between all regions, and contribute to more uniform electricity prices across the country during normal situations. This will provide producers and consumers alike with improved predictability, and facilitate value creation all over Tanzania.

4.1.4.4 The future of Tanzania is electric

The government‘s policy is to attain electrification rate of more than 50 percent by 2020 and more than 75 percent by 2033. In addition to that, the expectation in the long term is that the transport sector will be extensively electrified and industrial sector will grow up, in order to be able to facilitate these objectives; sufficient grid capacity must be developed.

4.2 Transmission Planning Criteria

Planning methodologies and criteria used in the Power System Master Plan Update Studies of 2012 were reviewed as appropriate and generally the same have been used in this update study. The planning of the transmission grid considers the operation of a power system under two possible situations, which are Normal operating conditions (N-0) and Contingency operating conditions (N-1).

4.2.1 Operating conditions

(i) Normal operating conditions (N-0)

The transmission infrastructure is entirely available (no equipment has been forced out of service).

(ii) Contingency operating conditions (N-1)

The main principal is that the main grid will be operated and scheduled based on the so called N-1 criterion. This means that under normal system conditions a fault in one single component (line or transformer) will have no influence on the general power supply. This criterion establishes security of supply as a stronger driving force in grid development. In this chapter, the study has set as target to rectify all known breaches of the planning criteria by 2040. The deadline has been predetermined to ensure that we also have the capacity to carry out investment projects related to additional priorities, therefore only outages of equipment rated at 220kV or above will be considered under the N-1 criteria. For each of these two operating conditions, the following criteria are applied to the analyses.

It should be noted that in most cases for this voltage class (220kV and above), the line thermal capability is not the main limiting factor for the amount of power transferred. Transfer limits are usually dictated by steady state stability, dynamic stability and voltage stability concerns.

4.2.2 System Voltage Criteria

The acceptable voltage range for operating the system based on factors such as equipment limitations and motor operation under normal and contingency conditions is as follows:

Condition	Acceptable Voltage Range
Normal System Conditions	95% - 105%
Contingency Conditions	90% - 110%

It is important to note that from an operational standpoint, healthy systems usually target a minimum voltage close to 1.0 per unit (pu) in the bulk system.

4.2.3 Equipment Thermal Loading Criteria

The transmission system shall be planned/designed to allow all transmission lines and equipment to operate within the following limits for the following defined conditions:

Condition	Thermal Loading Limit
Normal System Conditions	Defined Normal Load Capacity
System Design Contingencies of Long Duration (i.e. an outage involving the failure of a transformer)	Defined Normal Load Capacity
System Design Contingencies of Short Duration (i.e. not involving a transformer)	Defined Emergency Load Capacity (120% of normal rating for 10 hours per year)

4.3 Transmission and Substation Costs

4.3.1 Transmission voltage options

It is expected that the present 132kV and 220kV system voltage levels and the proposed 400kV line will be the main transmission technology of choice for the internal transmission expansion. Should a Direct Current (DC) voltage level be required, the range of 330kV to 500kV voltage standard used in other African countries and / or Alternative Current (AC) 700kV level are the next voltage above the 220kV voltage standard that will be considered in future. Series and shunt capacitors and static variance compensators (STATCOM) are used to improve the receiving end voltages on long and heavily loaded lines. These devices are still considered to delay or replace the need for new transmission lines where they appeared to be economical and practical.

4.3.2 Transmission Unit Costs

Transmission line and substation costs have been studied from TANESCO for recent planning studies and from actual transmission line projects in Tanzania. These costs are based on international competitive bidding. Table 4-2 lists the updated transmission line unit costs that were used in this update study. Unit costs for various substation components are summarized in Table 4-3. Costs for new switching substations include circuit breakers, disconnectors, switches, current and voltage transformers, relay buildings, structures and site preparation.

Table 4-2: Unit Cost of Transmission Lines

Unit Cost (1,000 USD/km)

Rated Voltage (kV)	PSMP 2016 Update		Kenya (Reference)
	Single Circuit	Double Circuit	Double Circuit
400	300 - 400	380 - 850	480
220	190 - 340	220 - 450	240
132	170 - 200	200 - 320	180

Source: Task Force Team using results of TANESCO projects, and Final Report on Development of a Power Generation and Transmission Master Plan, Kenya 2015 – 2035, May 2016 (www.erc.go.ke)

Table 4-3: Unit Cost of Substation per Bay[5]

Substation Cost 1,000,000 USD/bay		
132kV	220kV	400kV[6]
3.49	5.89	9.68

Source: TANESCO data, and Final Report on The Project for Preparation of Electricity Development Plan for Sustainable Geothermal Energy Development in Rwanda, March 2015, JICA

[5] One bay means the designated compartment where switchgear and buses are configured to interconnect a transmission line or a transformer. The costs include the switchgear, the buses, the structures, Control/Protection devices and site preparation. (Building is not included)

[6] For 400 kV cost, it represents two connections for 1-1/2 arrangement.

4.4 Grid Station Load Forecast

The grid substation load forecast updates are shown in Table 4-4. Individual existing and future grid substations were modelled in the load flow simulations in particular intervals of periods so that the corresponding total updated load forecasts in all regions were used as one of the inputs.

Table 4-4: Grid Substation Load forecast

AREA	Substation Load Distribution along 2020/2025/2030/2035/2040						
	BUS no	BUS Name	2020	2025	2030	2035	2040
Arusha	51211	Njiro	174.34	237.96	370.38	569.68	863.17
	50716	Karatu	13.12	17.91	27.88	42.88	64.97
Dar es Salaam	10311	Ubungo	641.04	435.85	502.98	499.40	522.61
	12202	South DSM		290.56	335.32	665.87	1,393.63
	12302	West DSM			335.32	665.87	1,045.22
	12002	North DSM		290.56	335.32	665.87	1,393.63
	12102	Sourth-east DSM		290.56	670.64	998.80	1,045.22
	11803	FZ2	267.10	181.60	209.58	208.08	217.75
Dodoma	80212	Dodoma	45.60	58.17	93.41	150.45	218.63
	50816	Kondoa	5.64	7.19	11.55	18.60	27.02
Iringa(Njombe)	60412	Iringa	155.63	22.82	38.80	65.38	96.06
	40112	Mufindi	118.24	17.33	29.47	49.67	72.98
	40115	Makambako	47.79	7.01	11.91	20.07	29.49
	60212	Kihansi	8.31	1.22	2.07	3.49	5.13
	40601	Mchuchuma	47.79	7.01	11.91	20.07	29.49
Kagera	90602	Nyakanazi	12.23	23.11	38.04	63.59	106.39
	90701	Rusomo	12.23	23.11	38.04	63.59	106.39
	91002	Kyaka	12.23	23.11	38.04	63.59	106.39
	91201	Kibeta	12.23	23.11	38.04	63.59	106.39
Kigoma	90402	Kigoma	29.11	48.33	81.59	138.34	208.43
Kilimanjaro	50311	Kiyungi	45.79	53.25	79.69	119.58	179.22
	51011	Same	3.32	3.86	5.77	8.66	12.99
	50313	KIA	16.59	19.29	28.87	43.32	64.94
Lindi	20201	Somanga	18.63	13.73	22.84	38.39	62.82
	20301	Lindi	0.00	13.73	22.84	38.39	62.82
Manyara	50116	Babati	9.22	11.33	15.85	22.33	30.60
	50916	Mbulu	1.26	1.54	2.16	3.04	4.17
Mara	30201	Bunda	18.12	20.29	34.47	58.39	88.17
	30301	Musoma	32.42	36.30	61.69	104.48	157.78
	30316	Nyamongo	44.82	50.18	85.28	144.43	218.11
Mbeya	40212	Mbeya	105.95	151.20	242.63	390.16	585.51
Morogoro	80111	Morogoro	70.84	99.04	156.53	243.36	363.40
	60112	Kidatu	21.48	30.03	47.47	73.80	110.20
	10411	Chalinze	24.22	44.00	69.84	111.76	169.30
	80401	Mtibwa	80.00	80.00	80.00	80.00	80.00
Mtwara	20401	Mtwara	84.47	32.08	27.50	47.31	81.49
	20501	Masasi			27.50	47.31	81.49
Mwanza(Geita)	30112	Mwanza	111.57	144.83	237.85	386.97	590.15
	30401	Geita	111.57	144.83	237.85	386.97	590.15
Pwani	10611	Mlandizi	35.55	58.30	92.58	148.65	225.56
	11402	Bagamoyo	75.55	98.30	132.58	188.65	265.56
	20101	Mkuranga		17.33	27.51	44.17	67.03
Rukwa(Katavi)	90301	Mpanda	6.99	10.45	17.79	30.68	58.76
	90101	Sumbawanga	6.99	10.45	17.79	30.68	58.76
Ruvuma	20701	Tunduru			34.73	61.20	100.00
	20902	Songea	16.30	39.47	34.73	61.20	100.00
Shinyanga (Simiyu)	70312	Shinyanga	40.52	55.60	97.21	171.36	266.77
	71010	Buzwagi	27.01	37.07	64.81	114.24	177.85
	70112	Bulyanhulu	67.53	92.66	162.02	285.61	444.61
Singida	80312	Singida	16.30	23.42	41.66	74.21	113.09
Tanga	51111	Tanga	60.55	79.35	129.74	211.02	313.85
	51302	Segera	60.55	79.35	129.74	211.02	313.85
Tabora	70401	Tabora	54.49	86.44	159.85	293.27	488.73
	70201	Lusu	29.34	46.54	86.08	157.92	263.16

4.5 Planned Transmission Line Projects

By TANESCO, the following transmission line projects are planned.

i. 400kV Backbone Project (BTLP)
   400kV: Iringa – Dodoma – Singida – Shinyanga

ii. 400/220 kV Project
   a. 400kV : Kinyerezi – Chalinze – Segera – Arusha
   b. 220kV : Kinyerezi – Ubungo (Cut-in)
   c. 220kV : Zinga – Kibaha (Cut-in)
   d. 220kV : Segera – Tanga

iii. 400kV ZTK Project
   a. 400kV: Singida – Arusha – Isinya (Kenya)
   b. 400kV: Iringa – Kisada – Mbeya – Nakonde (Zambia)

iv. 400kV Project
   400 kV: Chalinze – Dodoma

v. 220kV Project
   220kV: Makambako – Madaba – Songea

vi. 400kV Northeast Grid
   400kV: Mbeya – Sumbawanga – Mpanda – Kigoma – Nyakanazi

vii. 220kV Projects
   a. 220kV: Rusumo – Nyakanazi
   b. 220kV: Geita – Nyakanazi
   c. 220kV: Rusumo – Kyaka – Masaka (Uganda)

viii. 400kV Projects
   a. 400kV: Kinyerezi – Mkuranga – Somanga Fungu
   b. 400kV: Somanga Fungu – Lindi – Mtwara
   c. 400kV: Mtwara – Namialo (Mozambique)

ix. 400kV Project
   400kV: Songea –Tunduru – Masasi – Lindi

x. 220kV Project
   220kV: Mbeya – Kyela – Karonga (Malawi)

4.6 Transmission System Additions - Least Cost Expansion Plan

TANESCO planned the transmission projects as stated above. As a results of the analysis, PSMP2016 Update recommends the following additions of transmission system which satisfy transmission planning criteria.

4.6.1 Transmission lines additions

Table 4-5: Transmission System Additions from 2016 to 2020

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating*1 (Amps)	Full Rating (MVA)	Normal Rating*2 (MVA)
						Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				
400	Dodoma	Singida	Backbone Project	210	2	Bluejay	2	564	2016	1,092	3,026	2,421
400	Iringa	Dodoma	Backbone Project	237	2	Bluejay	2	564	2016	1,092	3,026	2,421
400	Singida	Shinyanga	Backbone Project	200	2	Bluejay	2	564	2016	1,092	3,026	2,421
220	Kinyerezi	Ubungo-Pai	Jacobson	8	1	Bluejay	2	564	2016	1,092	832	666
220	Ubungo-Pai	Kinyerezi	Jacobson	8	1	Bluejay	2	564	2016	1,092	832	666
132	Kinyerezi	FZ-II		5	1	Wolf	1	150	2016	406	93	74
132	Morogoro	Mtibwa	MCC, F/S completed	88	1	Hawk	1	242	2016	659	151	121
220	Wind Project	Singida		10	1	Bluejay	2	564	2017	1,092	832	666
400	Kin-Som SwS1	Kin-Som SwS2		53	2	Bluejay	8	564	2018	1,092	12,105	9,684
400	Kin-Som SwS2	Kin-Som SwS3		53	2	Bluejay	8	564	2018	1,092	12,105	9,684
400	Kin-Som SwS3	Somanga Fungu P/S	210 MW	53	2	Bluejay	8	564	2018	1,092	12,105	9,684
400	Kinyerezi	Kin-Som SwS1		53	2	Bluejay	8	564	2018	1,092	12,105	9,684
400	Kisada	Iringa		106	2	Bluejay	8	564	2018	1,092	12,105	9,684
400	Kisada	Madaba		243	2	Bluejay	8	564	2018	1,092	12,105	9,684
400	Muchuchuma P/S	Madaba	Total 1,800 MW	15	2	Bluejay	4	564	2018	1,092	6,052	4,842
220	Geita	Nyakanazi		130	2	Bluejay	2	564	2018	1,092	1,664	1,332
220	Madaba	Songea		171	1	Bluejay	2	564	2018	1,092	832	666
220	Makambako	Madaba		162	1	Bluejay	2	564	2018	1,092	832	666
220	Nyakanazi	Rusumo Falls P/S	30 MW	97	1	Bluejay	4	564	2018	1,092	1,664	1,332
220	Rusumo Falls P/S	Kyaka	30 MW	150	1	Bluejay	4	564	2018	1,092	1,664	1,332
220	Shinyanga	Geita		240	2	Bluejay	4	564	2018	1,092	3,329	2,663
400	Arusha	Singida		317	2	Bluejay	2	564	2019	1,092	3,026	2,421
400	Arusha	Isinya (Kenya)	up to Kenya border	114	2	Flint	3	375	2019	790	3,284	2,627
400	Lindi	Somanga Fungu		216	2	Bluejay	8	564	2019	1,092	12,105	9,684
400	Mtwara P/S	Lindi	400 MW	74	2	Bluejay	4	564	2019	1,092	6,052	4,842
220	Arusha	Njiro (Arusha existing)		5	2	Bluejay	4	564	2019	1,092	3,329	2,663
220	Iringa	Lower Kihansi P/S (Hydro)	(36+52+120) MW	120	1	Bluejay	2	564	2019	1,092	832	666
220	Solar I	Dodoma	50 MW	10	1	Bluejay	1	242	2019	1,092	416	333
132	Wind Project	Makambako	100 MW	10	1	Hawk	1	242	2019	659	151	121
400	Chalinze	Segera		175	1	Bluejay	4	564	2020	1,092	3,026	2,421
400	Chalinze	Dodoma		336	1	Bluejay	2	564	2020	1,092	1,513	1,210
400	Chalinze	Segera		175	1	Bluejay	4	564	2020	1,092	3,026	2,421
400	Kigoma	Mpanda		290	2	Bluejay	8	564	2020	1,092	12,105	9,684
400	Kinyerezi	Chalinze		138	2	Bluejay	4	564	2020	1,092	6,052	4,842
400	Kisada	Mbeya		186	2	Bluejay	8	564	2020	1,092	12,105	9,684
400	Kiwira P/S	Mbeya	400MW in 2020	110	2	Bluejay	8	564	2020	1,092	12,105	9,684
400	Mbea	Nakonde(Zambia)	up to Zambia border	93	2	Bluejay	2	564	2020	1,092	3,026	2,421
400	Mbe－Sum SwS	Sumbawanga		150	2	Bluejay	8	564	2020	1,092	12,105	9,684
400	Mbeya	Mbe－Sum SwS		150	2	Bluejay	8	564	2020	1,092	12,105	9,684
400	Mpanda	Mpa-Sum SwS		119	2	Bluejay	8	564	2020	1,092	12,105	9,684
400	Mpa-Sum SwS	Sumbawanga		119	2	Bluejay	8	564	2020	1,092	12,105	9,684
400	Mtwara	Namialo(Mozambique)	up to Mozambique border	51	2	Bluejay	2	564	2020	1,092	3,026	2,421
400	Nyakanazi	Kigoma		317	2	Bluejay	8	564	2020	1,092	12,105	9,684
400	Segera	Arusha		366	1	Bluejay	4	564	2020	1,092	3,026	2,421
400	Somanga Fungu P/S	Somanga P/S(PPP)	300MW	20	2	Bluejay	2	564	2020	1,092	3,026	2,421
220	Bagamoyo (Zinga)	Kibaha-Pai		45	1	Bluejay	1	564	2020	1,092	416	333
220	Bunda	Musona		60	1	Bluejay	4	564	2020	1,092	1,664	1,332
220	Kibaha-Pai	Bagamoyo (Zinga)		45	1	Bluejay	1	564	2020	1,092	416	333
220	Kinyerezi	Ubungo		12	2	Bluejay	1	564	2020	1,092	832	666
220	Kishapu Solar	Shinyanga	150 MW	10	1	Bluejay	1	382	2020	1,092	416	333
220	Kyaka	Masaka(Uganda)	up to Uganda border	30	1	Bluejay	2	564	2020	1,092	832	666
220	Kyela	Karonga(Malawi)	up to Malawi border	20	1	Bluejay	2	564	2020	1,092	832	666
220	Lusu	Tabora		139	1	Bluejay	2	564	2020	1,092	832	666
220	Mbeya	Kyela		106	1	Bluejay	2	564	2020	1,092	832	666
220	Musona	Nyamongo		90	1	Bluejay	4	564	2020	1,092	1,664	1,332
220	Mwanza	Bunda		150	1	Bluejay	4	564	2020	1,092	1,664	1,332
220	Segera	Tanga		76	2	Bluejay	2	564	2020	1,092	1,664	1,332
220	Shinyanga	Lusu		64	1	Bluejay	1	564	2020	1,092	416	333
132	Kinyerezi	FZ-II		5	2	Hawk	2	242	2020	659	603	482
132	Morogoro	Mtibwa		88	1	Hawk	1	242	2020	659	151	121
66	Babati	Mbulu		85	2	Wolf	2	150	2020	406	186	149

Note: *1 Source：SURAL catalogue
*2；Normal Rating＝Full Rating x 80%

Table 4-6: Transmission System additions from 2021 to 2025

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating*1 (Amps)	Full Rating (MVA)	Normal Rating*2 (MVA)
						Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				
400	Kinyerezi	Mkuranga P/S	300 MW	70	2	Bluejay	8	564	2022	1,092	12,105	9,684
400	Madaba	Songea		171	2	Bluejay	2	564	2023	1,092	3,026	2,421
400	Masasi	Lindi		141	2	Bluejay	4	564	2023	1,092	6,052	4,842
400	Ngaka P/S	Songea	600MW in 2023	37	2	Bluejay	4	564	2023	1,092	6,052	4,842
400	Songea	Tunduru		230	2	Bluejay	4	564	2023	1,092	6,052	4,842
400	Tunduru	Masasi		194	2	Bluejay	4	564	2023	1,092	6,052	4,842
400	Sumbawanga	Rukwa P/S	300MW in 2024	46	2	Bluejay	8	564	2024	1,092	12,105	9,684
132	Malagarasi P/S(Stage III)	Kigoma	44.7 MW	74	1	Hawk	1	242	2024	659	151	121
400	Chalinze	Bagamoyo		102	2	Bluejay	8	564	2025	1,092	12,105	9,684
400	Shinyanga	Mwanza		140	2	Bluejay	8	564	2025	1,092	12,105	9,684
220	Bagamoyo	North DSM		40	2	Bluejay	4	564	2025	1,092	3,329	2,663
220	Geothermal 1	Mbeya	(2 x 50 MW）×2	35	1	Bluejay	1	564	2025	1,092	416	333
220	Kinyerezi	South DSM		25	2	Bluejay	4	564	2025	1,092	3,329	2,663
220	Mkuranga	South-east DSM		50	2	Bluejay	4	564	2025	1,092	3,329	2,663
220	South DSM	South-east DSM		30	2	Bluejay	2	564	2025	1,092	1,664	1,332
132	Kyaka	Kibeta/Bukoba		54	1	Hawk	2	242	2025	659	301	241
66	Mbulu	Karatu		65	2	Wolf	2	150	2025	406	186	149

Note: *1 Source：SURAL catalogue
*2；Normal Rating＝Full Rating x 80%

Table 4-7: Transmission Additions from 2026 to 2030

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating*1 (Amps)	Full Rating (MVA)	Normal Rating*2 (MVA)
						Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				
220	Geothermal 1	Geothermal 2	2 x 50 MW	20	1	Bluejay	1	564	2026	1,092	416	333
220	Ibosa P/S (Hydro)	Iringa-L. Kihansi T branch	(36+52+120) MW	20	2	Bluejay	2	564	2026	1,092	1,664	1,332
220	Ibosa P/S (Hydro)	Nginayo P/S (Hydro)	52MW	10	1	Bluejay	1	564	2026	1,092	416	333
220	Zinga P/S	Bagamoyo	200 MW	15	1	Bluejay	2	564	2027	1,092	832	666
132	Kakono P/S (Hydro)	Kyaka	87 MW	39	1	Hawk	1	242	2027	659	151	121
400	Mnyera S/S (new)	Kisada	(668.2+358) MW	180	2	Bluejay	4	564	2028	1,092	6,052	4,842
220	Ruaha 2 P/S (Hydro)	Mnyera S/S (new)	(60.3+137.4+143.9) MW	33	1	Bluejay	2	564	2028	1,092	832	666
132	Songwe B S/S	Kyela	(79.5 + 88.1) MW	7	2	Hawk	1	242	2028	659	301	241
132	Songwe Manolo P/S (Hydro)	Songwe B S/S	88.1 MW	17	1	Hawk	1	242	2028	659	151	121
220	Kwanini P/S (Hydro)	Mnyera S/S-Ruaha2 T/L	T-branch	10	1	Bluejay	2	564	2029	1,092	832	666
220	Mnyera 2 P/S (Hydro)	Mnyera S/S-Ruaha2 T/L	T-branch	10	1	Bluejay	2	564	2029	1,092	832	666
400	Shinyanga	Tabora		200	2	Bluejay	8	564	2030	1,092	12,105	9,684
400	Somanga Fungu S/S	Future CGT3-1	4x470 MW	20	2	Bluejay	4	564	2030	1,092	6,052	4,842
400	Tab-Mpa SwS	Mpanda		150	2	Bluejay	8	564	2030	1,092	12,105	9,684
400	Tabora	Tab-Mpa SwS		150	2	Bluejay	8	564	2030	1,092	12,105	9,684
220	Bagamoyo	Mlandizi		40	2	Bluejay	1	564	2030	1,092	832	666
220	Kinyerezi	West DSM		20	2	Bluejay	4	564	2030	1,092	3,329	2,663
220	Mnyera S/S (new)	Taveta 3 P/S (Hydro)	(119.8+83.9+122.9) MW	26	1	Bluejay	2	564	2030	1,092	832	666
220	Pumbwe P/S (Hydro)	Mnyera S/S-Taveta3 T/L	T-branch	10	1	Bluejay	2	564	2030	1,092	832	666
220	West DSM	North DSM		20	2	Bluejay	2	564	2030	1,092	1,664	1,332
132	Njiro (Arusha existing)	Kiyungi	T-branch to KIA	77	2	Hawk	4	242	2030	659	1,205	964

Note: *1 Source：SURAL catalogue
*2；Normal Rating＝Full Rating x 80%

Table 4-8: Transmission Additions from 2031 to 2035

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating*1 (Amps)	Full Rating (MVA)	Normal Rating*2 (MVA)
						Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				
400	Mkuranga	Mku-Som SwS1		61	2	Bluejay	8	564	2031	1,092	12,105	9,684
400	Mku-Som SwS1	Mku-Som SwS2		61	2	Bluejay	8	564	2031	1,092	12,105	9,684
400	Mku-Som SwS2	Somanga Fungu S/S		61	2	Bluejay	8	564	2031	1,092	12,105	9,684
220	Mufindi	Mpanga P/S (Hydro)	160 MW	65	1	Bluejay	2	564	2031	1,092	832	666
220	Taveta 3 P/S (Hydro)	Kisingo P/S (Hydro)	119.8MW	15	1	Bluejay	2	564	2031	1,092	832	666
220	Masigira P/S (Hydro)	Madaba	118 MW	73	1	Bluejay	2	564	2032	1,092	832	666
400	Somanga Fungu S/S	Future CGT3-2	6x470 MW	20	2	Bluejay	4	564	2033	1,092	6,052	4,842
220	Mbeya	Rumakali P/S (Hydro)	222MW	104	1	Bluejay	2	564	2033	1,092	832	666
220	Mnyera S/S (new)	Ruhudji P/S (Hydro)	358 MW	88	1	Bluejay	2	564	2033	1,092	832	666
220	Kihansi P/S (Hydro)	Upper Kihansi P/S (Hydro)	47MW	10	1	Bluejay	1	564	2034	1,092	416	333
220	Kikonge P/S (Hydro)	Madaba	300 MW	49	1	Bluejay	2	564	2034	1,092	832	666
132	Songwe A S/S	Songwe B S/S		40	1	Hawk	1	242	2034	659	151	121
132	Songwe Sofre P/S (Hydro)	Songwe A S/S	79.5 MW	16	1	Hawk	1	242	2034	659	151	121
400	Chalinze	Segera		175	1	Bluejay	4	564	2035	1,092	3,026	2,421
400	Segera	Arusha		366	2	Bluejay	4	564	2035	1,092	6,052	4,842
400	Somanga Fungu S/S	Chalinze		284	2	Bluejay	8	564	2035	1,092	12,105	9,684
400	Stiegler's Gorge	Chalinze	2 x 1,048 MW	195	2	Bluejay	8	564	2035	1,092	12,105	9,684
220	Bulyanhulu	Shinyanga		130	2	Bluejay	4	564	2035	1,092	3,329	2,663
220	Bunda	Musona		60	1	Bluejay	4	564	2035	1,092	1,664	1,332
220	Kyaka	Masaka(Uganda)	up to Uganda border	30	1	Bluejay	2	564	2035	1,092	832	666
220	Musona	Nyamongo		90	1	Bluejay	4	564	2035	1,092	1,664	1,332
220	Mwanza	Bunda		150	1	Bluejay	4	564	2035	1,092	1,664	1,332
220	Nyakanazi	Rusumo Falls P/S		97	1	Bluejay	4	564	2035	1,092	1,664	1,332
220	Rusumo Falls P/S	Kyaka		150	1	Bluejay	4	564	2035	1,092	1,664	1,332
220	Shinyanga	Buswagi		108	2	Bluejay	4	564	2035	1,092	3,329	2,663
132	Kyaka	Kibeta/Bukoba		54	1	Hawk	2	242	2035	659	301	241
66	Babati	Kondoa		85	2	Wolf	2	150	2035	406	186	149

Note: *1 Source：SURAL catalogue
*2；Normal Rating＝Full Rating x 80%

Table 4-9: Transmission Additions from 2036 to 2040

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating*1 (Amps)	Full Rating (MVA)	Normal Rating*2 (MVA)
						Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				
400	Mtwara	Future CGT1 P/S	330MW	50	2	Bluejay	2	564	2036	1,092	3,026	2,421
400	Somanga Fungu	Future CGT3-3	5x470 MW	20	2	Bluejay	4	564	2038	1,092	6,052	4,842
220	Kinyerezi	West DSM		20	1	Bluejay	4	564	2040	1,092	1,664	1,332
220	Shinyanga	Mwanza		140	2	Bluejay	1	564	2040	1,092	832	666
220	Singida	Babati		150	2	Bluejay	1	564	2040	1,092	832	666
220	Singida	Shinyanga		200	2	Bluejay	1	564	2040	1,092	832	666
132	Chalinze	Morogoro		82	2	Hawk	1	242	2040	659	301	241

Note: *1 Source：SURAL catalogue
*2；Normal Rating＝Full Rating x 80%

Recommendations: Higher voltage (ex. 700kV) would be recommended for the 400kV transmission lines from Mtwara to Dar es Salaam to reduce the number of lines.

Table 4-10: Transmission line assumed parameters

Voltage	Conductor	Name	Size (mm^2)	*Normal Rating (MVA)
400kV	ACSR	Bluejay	565	605
220kV	ACSR	Bluejay	565	333
		Bison	350	207
		Pheasant	644	362
		Rail	483	303
132kV	ACSR	Wolf	150	74
		Hawk	241	121
		Tiger	130	66
	XLPE	—	300/400	143
		—	95	52
66kV	ACSR	Wolf	150	37
		Rabbit	50	18

[Remarks] *: 80% of current rating

4.6.2 Reactive compensation

It was assumed that each 400kV line would be compensated by two line-connected reactors located at the two line ends. The magnitude of each reactor was taken as 35% of the full line charging value, which is equivalent to a total of 70% compensation. These line-connected reactors would be switched on and off based on the system operation requirements. However, for line switching (or energization), these reactors must be switched on to avoid high voltages at the open line ends (Ferranti Effect). These factors are to be the subject of a detailed dynamic study performed at design stage.

4.6.3 Substation Additions

Lists of substation additions from 2016 to 2040 are shown in Table 4-11 up to 4-15 below. Configuration of substation equipment, abbreviations in the tables are provided at the bottom of the tables.

Table 4-11: Substation Additions from 2016 to 2020

Substation	Voltage	Equipment	Year	Q'ty	Remarks
Arusha	400	1-1/2 CB: 2 cct	2019	2	
		1-1/2 CB: 1 cct		2	
		Tr (375)		2	
		SR-F (70)		2	for Singida
		SR-F (25)		2	for Ishinya
		1-1/2 CB: 1 cct	2020	2	
		SR-F (95)		1	for Segera
		STATCOM (50)		1	
	220	DB-F	2019	2	Connection to existing bus
		DB-Tr		2	New 220 kV bus
		Tr (250)		2	
		DB-BC		1	
		DB-Tr	2020	2	
		Tr (200)		2	
	132	SB-Tr	2020	2	Existing 132 kV bus
Bagamoyo	220	DB-F	2020	2	
		DB-Tr		2	
		Tr (90)		2	220/33 kV Transformers
		DB-BC		1	
Bunda	220	DB-F	2020	2	
		DB-Tr		1	
		Tr (100)		1	
		DB-BC		1	
Musoma	220	DB-F	2020	2	
		DB-Tr		1	
		Tr (100)		1	
		DB-BC		1	
Nyamongo	220	DB-F	2020	2	
		DB-Tr		1	
		Tr (100)		1	
		DB-BC		1	
Chalinze	400	1-1/2 CB: 2 cct	2020	3	
		1-1/2 CB: 1 cct		2	
		Tr (150)		2	
		SR-F (75)		1	for Dodoma
		SR-F (45)		2	for Segera
		SR-F (35)		3	for Kinyerezi
		STATCOM (50)		1	
	220	DB-Tr	2020	3	
		Tr (90)		1	
		DB-BC		1	
	132	SB-F	2020	2	Connection between existing bus
		DB-Tr		1	
		DB-BC		1	
Dodoma	400	DB-F	2016	5	
		SR-F (50)		4	for Singida & Iringa
		SR-F (75)		1	for Chalinze
		DB-Tr		3	
		Tr (250)		2	
		DB-BC		1	
		STATCOM (50)		1	
	220	DB-Tr	2016	2	
		DB-F	2019	1	Dodoma Solar
Geita	220	DB-F	2018	4	
		DB-BC		1	
Iringa	400	DB-F	2016	2	
		SR-F (50)		2	for Dodoma
		DB-Tr		2	
		Tr (250)		2	
		DB-BC		1	
		DB-F	2018	2	
		SR-F (50)		2	for Kisada
		DB-Tr		1	
		STATCOM (50)		1	
	220	DB-Tr	2016	2	
		DB-F	2019	1	Lower Kihansi (Hydro)
Kigoma	400	DB-F	2020	4	
		SR-F (100)		2	for Nyakanazi
		SR-F (90)		2	for Mpanda
		DB-Tr		2	
		Tr (125)		1	
		STATCOM (50)		1	
	220	DB-Tr	2020	2	
		DB-BC		1	
Kinyerezi	400	1-1/2 CB: 2 cct	2018	2	
		1-1/2 CB: 1 cct		5	
		Tr (500)		5	
		SR (50)		1	
		SR-F (15)		2	for Somanga Fungu
		1-1/2 CB: 1 cct	2020	5	
		SR-F (35)		2	for Chalinze
		STATCOM (50)		1	
Kinyerezi	220	DB-F	2017	1	for G-I Extension
		DB-F	2018	1	for G-II
		DB-F	2020	2	for Ubungo
		DB-Tr		2	
		Tr (200)		2	
Ubungo	220	DB-F	2020	2	
		DB-Tr		3	
		Tr (150)		3	
	132	DB-Tr	2020	3	
Kin-Som SwS-1	400	DB-F	2018	4	SwS between Kinyerezi - Somanga Fungu
		SR-F (15)		4	for Kinyerezi & Kin-Som SwS-2
		DB-BC		1	
		DB-Tr	2020	1	
		STATCOM (50)		1	
Kin-Som SwS-2	400	DB-F	2018	4	SwS between Kinyerezi - Somanga Fungu
		SR-F (15)		4	for Kin-Som SwS-1 & Kin-Som SwS-3
		DB-BC		1	
		DB-Tr	2020	1	
		STATCOM (50)		1	
Kin-Som SwS-3	400	DB-F	2018	4	SwS between Kinyerezi - Somanga Fungu
		SR-F (15)		4	for Kin-Som SwS-2 & Somanga Fungu
		DB-BC		1	
		DB-Tr	2020	1	
		STATCOM (50)		1	
Kisada	400	1-1/2 CB: 2 cct	2018	2	
		1-1/2 CB: 1 cct		2	
		SR-F (60)		2	for Mbeya
		SR-F (75)		2	for Madaba
		SR-F (50)		2	for Iringa
		1-1/2 CB: 1 cct	2020	1	
		STATCOM (50)		1	
Kyaka	220	DB-F	2018	1	
		DB-Tr		1	
		Tr (100)		1	
		DB-BC		1	
		DB-F	2020	1	for Uganda (Export)
	132	SB-Tr	2018	1	
Rusumo	220	DB-F	2018	2	for Kyaka & Nyakanazi
Kyela	220	DB-F	2020	1	for Mbeya
		DB-F		1	for Malawi (Export)
		DB-BC		1	
Lindi	400	DB-F	2019	4	
		SR-F (65)		2	for Somanga Fungu
		SR-F (20)		2	for Mtwara
		DB-Tr		1	
		Tr (125)		1	
		DB-BC		1	
		DB-Tr	2020	1	

Symbols	Explanatior
1-1/2 CB: 2 cct:	One and Half Bus system with 2 circuits
1-1/2 CB: 1 cct:	One and Half Bus system with 1 circuit
DB-F:	Double Bus system - Feeder bay
DB-Tr:	Double Bus system - Transformer bay
DB-BC:	Double Bus system - Bus Coupler bay
SB-F:	Single Bus system - Feeder bay
SB-Tr:	Single Bus system - Transformer bay
400 kV Tr (xxx):	400/220 kV Transformer (xxx MVA)
220 kV Tr (xxx):	220/132 kV Transformer (xxx MVA)
SR (xxx):	Shunt Reactor (xxx Mvar)
SR-F (xxx):	Shunt Reactor for Feeder (xxx Mvar)
STATCOM (xxx):	Static Var Compensator (xxx Mvar)
SwS:	Switching Station between Substations

Substation	Voltage	Equipment	Year	Q'ty	Remarks
Lindi	400	STATCOM (50)	2020	1	
	220	DB-Tr	2019	1	
		DB-BC		1	
Madaba	400	DB-F	2018	4	
		SR-F (75)		2	for Kisada
		DB-Tr		1	
		Tr (125)		1	
		DB-BC		1	
		DB-Tr	2020	1	
		STATCOM (50)		1	
	220	DB-F	2018	2	for Makambako & Songea
		DB-Tr		1	
		DB-BC		1	
Mbeya	400	DB-F	2018	2	
		SR-F (60)		2	for Kisada
		DB-Tr		1	
		Tr (500)		1	
		DB-BC		1	
		DB-F	2020	6	
		SR-F (35)		2	for Kiwira (Coal)
		SR-F (50)		2	for Sumbawanga via SwS
		SR-F (20)		2	for Zambia (Export)
	220	DB-Tr	2018	1	
		DB-BC		1	
		DB-F	2020	1	for kyela
Makambako	220	SB-F	2018	1	for Madaba
	132	SB-F	2019	1	Wind Project
Morogoro	220	DB-Tr	2020	2	
		Tr (150)		2	
	132	DB-F	2016	1	for Mtibwa
		DB-F	2020	1	Ditto
Mtibwa	132	DB-F	2016	1	for Morogoro
		DB-F	2020	1	Ditto
Mpanda	220	DB-Tr	2020	1	
		DB-BC		1	
Sumbawanga	400	DB-F	2020	4	
		SR-F (35)		2	for Mpanda via SwS
		SR-F (50)		2	for Mbeya via SwS
		DB-Tr		2	
		Tr (125)		1	
		STATCOM (50)		1	
		DB-BC		1	
	220	DB-Tr	2020	1	
		DB-BC		1	
Mpa-Sum SwS	400	DB-F	2020	4	SwS between Mpanda - Sumbawanga
		SR-F (35)		4	for Mpanda & Sumbawanga
		DB-BC		1	
		DB-Tr		1	
		STATCOM (50)		1	

Substation	Voltage	Equipment	Year	Q'ty	Remarks
Mbe-Sum SwS	400	DB-F	2020	4	SwS between Mbeya - Sumbawanga
		SR-F (35)		2	for Sumbawanga
		SR-F (50)		2	for Mbeya
		DB-BC		1	
		DB-Tr		1	
		STATCOM (50)		1	
Mtwara	400	DB-F	2019	2	
		SR-F (20)		2	for Lindi
		DB-Tr		2	Mtwara Gen. & 125 MVA Tr
		Tr (125)		1	
		DB-BC		1	
		DB-F	2020	2	
		SR-F (10)		2	for Mozambique (Export)
		DB-Tr		1	
		STATCOM (50)		1	
	220	DB-Tr	2019	2	
		DB-BC		1	
	132	SB-Tr	2019	1	
Mwanza	220	DB-F	2020	1	for Bunda
		DB-BC		1	
Nyakanazi	400	DB-F	2020	2	
		SR-F (100)		2	for Kigoma
		DB-Tr		4	
		Tr (250)		2	
		SR (100)		1	
		STATCOM (50)		1	
		DB-BC		1	
	220	DB-F	2018	3	for Geita (2) & Rusumo
		DB-BC		1	
		DB-Tr	2020	2	
Segera	400	1-1/2 CB: 2 cct	2020	2	
		1-1/2 CB: 1 cct		1	
		SR-F (45)		1	for Chalinze
		SR-F (95)		1	for Arusha
		Tr (150)		2	
		STATCOM (50)		1	
	220	DB-F	2020	2	for Tanga (2)
		DB-Tr		2	
		DB-BC		1	
Shinyanga	400	DB-F	2016	2	
		SR-F (50)		2	for Singida
		DB-Tr		2	
		Tr (315)		2	
		DB-BC		1	
		DB-Tr	2020	1	
		STATCOM (50)		1	
	220	DB-F	2018	2	for Geita
		DB-BC		1	
		DB-F	2020	3	for Lusu & Kishapu Solar
Singida	400	DB-F	2016	4	

Substation	Voltage	Equipment	Year	Q'ty	Remarks
Singida	400	SR-F (50)	2016	4	for Shinyanga & Dodoma
		DB-BC		1	
		DB-F	2019	2	
		SR-F (70)		2	for Arusha
		DB-Tr		3	
		Tr (250)		2	
		STATCOM (50)		1	
	220	DB-F	2017	2	Singida Wind
		DB-Tr	2020	4	
		Tr (100)		2	
	132	SB-Tr	2020	2	
Somanga Fungu	400	1-1/2 CB: 2 cct	2018	2	Somanga Fungu I (210 MW)
		SR-F (15)		2	for Kinyerezi
		1-1/2 CB: 2 cct	2019	1	Somanga Fungu I (Add-on 110 MW)
		1-1/2 CB: 1 cct		1	
		SR-F (65)		2	for Lindi
		Tr (125)		1	
		1-1/2 CB: 2 cct	2020	1	Somanga Fungu (PPP 300 MW)
		1-1/2 CB: 1 cct		1	
		STATCOM (50)		1	
	220	DB-Tr	2019	1	
		DB-BC		1	
Songea	220	DB-F	2018	1	for Madaba
		DB-BC		1	
Tabora	220	DB-F	2020	1	
		DB-Tr		1	
		Tr (100)		1	
		DB-BC		1	
Lusu	220	DB-F	2020	1	
		DB-Tr		1	
		Tr (100)		1	
		DB-BC		1	
Tanga	220	DB-F	2020	2	for Segera
		DB-Tr		2	
		Tr (90)		1	
		DB-BC		1	

Table 4-12: Substation Additions from 2021 to 2025

Substation	Voltage	Equipment	Year	Q'ty	Remarks
Arusha	220	DB-Tr	2023	1	
		Tr (200)		1	
	132	SB-Tr	2023	1	Existing 132 kV bus
Babati	220	DB-Tr	2025	1	
		Tr (150)		1	
Bagamoyo	400	DB-F	2025	2	
		SR-F (30)		2	for Chalinze
		DB-Tr		1	
		Tr (500)		1	
		DB-BC		1	
		DB-Tr		1	
		STATCOM (50)		1	
	220	DB-F	2025	2	
Chalinze	400	1-1/2 CB: 1 cct	2025	2	
		SR-F (30)		2	for Bagamoyo
	220	DB-Tr	2025	1	
		Tr (90)		1	
	132	DB-Tr	2025	1	
Kigoma	400	DB-Tr	2025	1	
		SR (50)		1	
	220	DB-Tr	2024	1	
		Tr (55)		1	for Malagalasi (Hydro)
	132	SB-F	2024	1	for Malagalasi (Hydro)
Kinyerezi	400	1-1/2 CB: 1 cct	2022	2	
		SR-F (20)		1	for Mkuranga
	220	DB-F	2025	1	for South DSM
Kyaka	132	SB-F	2025	1	for Kibeta/Bokoba
Lindi	400	DB-F	2023	2	for Masasi
		SR-F (35)		2	
Madaba	400	DB-F	2023	2	for Songea
		SR-F (40)		2	
Mbeya	400	DB-Tr	2025	2	
		SR (50)		1	
		STATCOM (50)		1	
	220	DB-F	2025	1	Geothermal A
Geothermal A	220	DB-F	2025	1	for Mbeya
		DB-Tr		1	
		DB-BC		1	
Mkuranga	400	DB-F	2022	2	
		SR-F (20)		2	for Kinyerezi
		DB-BC		1	
		DB-Tr	2025	3	
		Tr (500)		2	
		STATCOM (50)		1	
	220	DB-Tr	2025	2	
		DB-BC		1	
		DB-F		2	for Southeast DSM
Mwanza	400	DB-F	2025	2	
		SR-F (45)		2	for Shinyanga
		DB-Tr		1	
Mwanza	400	Tr (500)	2025	2	
		DB-BC		1	
		DB-Tr		2	
		STATCOM (50)		1	
	220	DB-F	2025	2	Connection between existing bus
		DB-Tr		4	
		Tr (200)		2	
	132	SB-Tr	2025	2	
Shinyanga	400	DB-Tr	2022	1	
		Tr (1,000)		1	
		DB-F	2025	2	
		SR-F (45)		2	for Mwanza
	220	DB-Tr	2022	1	
Songea	400	DB-F	2023	6	
		SR-F (10)		2	Ngaka (Coal)
		SR-F (40)		2	for Madaba
		SR-F (60)		2	for Tunduru
		DB-Tr		1	
		Tr (125)		1	
		DB-BC		1	
		DB-Tr	2025	1	
		STATCOM (50)		1	
	220	DB-Tr	2023	1	
Tunduru	400	DB-F	2023	4	
		SR-F (60)		2	for Songea
		SR-F (50)		2	for Masasi
		DB-Tr		1	
		Tr (125)		1	
		DB-BC		1	
		DB-Tr	2025	1	
		STATCOM (50)		1	
	220	DB-Tr	2023	1	
		Tr (125)		1	
		DB-BC		1	
Masasi	400	DB-F	2023	4	
		SR-F (50)		2	for Tunduru
		SR-F (35)		2	for Lindi
		DB-Tr		1	
		Tr (125)		1	
		DB-BC		1	
		DB-Tr	2025	1	
		STATCOM (50)		1	
	220	DB-Tr	2023	1	
		Tr (125)		1	
		DB-BC		1	
North DSM	220	DB-F	2025	2	for Bagamoyo
		DB-Tr		1	
		Tr (400)		1	
		DB-BC		1	
	132	SB-Tr	2025	1	
South DSM	220	DB-F	2025	4	for Kinyerezi & Southeast DSM
		DB-Tr		1	
		Tr (400)		1	
		DB-BC		1	
	132	SB-Tr	2025	1	
Southeast DSM	220	DB-F	2025	4	for South DSM & Mkuranga
		DB-Tr		1	
		Tr (400)		1	
		DB-BC		1	
	132	SB-Tr	2025	1	

Table 4-13: Substation Additions from 2026 to 2030

Substation	Voltage	Equipment	Year	Q'ty	Remarks
Arusha	400	1-1/2 CB: 1 cct	2030	1	
		Tr (250)		1	
	220	DB-Tr	2029	1	
		Tr (200)		1	
		DB-Tr	2030	1	
		Tr (250)		1	New 220 kV bus
	132	SB-Tr	2029	1	Existing 132 kV bus
		SB-Tr	2030	1	Existing 132 kV bus
Bagamoyo	400	DB-Tr	2029	1	
		Tr (500)		1	
	220	DB-F	2027	1	
		DB-F	2030	2	
Bunda	220	DB-Tr	2030	1	
		Tr (100)		1	
Musoma	220	DB-Tr	2028	1	
		Tr (100)		1	
Nyamongo	220	DB-Tr	2026	1	
		Tr (100)		1	
Ibosa	220	DB-F	2026	3	for Iringa, Lower Kihansi & Nginayo
Kigoma	400	DB-Tr	2030	1	
		Tr (125)		1	
Kinyerezi	220	DB-F	2030	2	for West DSM
Kisada	400	1-1/2 CB: 1 cct	2028	2	
		SR-F (45)		1	for Mnyera (Hydro)
Kyaka	220	DB-Tr	2030	1	
		Tr (100)		1	
	132	SB-F	2027	1	for Kakono (Hydro)
		SB-Tr	2030	1	
Kyela	220	DB-Tr	2028	1	
		Tr (200)		1	
	132	SB-Tr	2028	1	
		SB-F		2	for Songwe B S/S
Songwe B S/S	132	SB-F	2028	3	Manalo (Hydro)
Lindi	400	DB-Tr	2030	1	
		Tr (125)		1	
	220	DB-Tr	2030	1	
Madaba	400	DB-Tr	2030	1	
		Tr (125)		1	
	220	DB-Tr	2030	1	
		DB-Tr	2028	1	
		Tr (500)		1	
Mbeya	400	DB-Tr	2028	1	
		Tr (500)		1	
	220	DB-Tr	2028	1	
Geothermal A	220	DB-F	2026	1	for Geothermal B
Mkuranga	400	DB-Tr	2030	1	
		Tr (500)		1	
	220	DB-Tr	2030	1	
Mlandizi	220	DB-F	2030	2	for Bagamoyo
Mlandizi	220	DB-Tr	2030	2	
		Tr (100)		2	
		DB-BC		1	
	132	SB-F	2030	1	
		SB-Tr		2	
		SB-Tr		1	
Mnyera	400	DB-F	2028	2	
		SR-F (45)		2	for Kisada
		DB-BC		1	
		DB-Tr		3	
		Tr (500)		2	
		STATCOM (50)		1	
	220	DB-F	2028	1	Ruaha 2 (Hydro)
		DB-Tr		2	
		DB-BC		1	
		DB-F	2030	1	Taveta 3 (Hydro)
Morogoro	220	DB-Tr	2030	1	
		Tr (150)		1	
Mpanda	400	DB-F	2030	2	
		SR-F (45)		2	for Tabora via SwS
Mpa-Tab SwS	400	DB-F	2030	4	SwS between Mpanda - Tabora
		SR-F (45)		4	for Mpanda & Tabora
		DB-BC		1	
		DB-Tr		1	
		STATCOM (50)		1	
Mtwara	400	DB-Tr	2030	1	
		Tr (125)		1	
	220	DB-Tr	2030	2	
	132	SB-Tr	2030	1	
Segera	400	1-1/2 CB: 1 cct	2029	1	
		Tr (250)		1	
	220	DB-Tr	2029	1	
Shinyanga	400	DB-F	2030	2	
		SR-F (65)		2	for Tabora via SwS
Somanga Fungu	400	1-1/2 CB: 2 cct	2030	1	Future CGT3-1
		1-1/2 CB: 1 cct		1	
		Tr (125)		1	
	220	DB-Tr	2030	1	
Tabora	400	DB-F	2030	4	
		SR-F (45)		2	for Mpanda via SwS
		SR-F (65)		2	for Shinyanga
		DB-Tr		3	
		Tr (500)		2	
		STATCOM (50)		1	
		DB-BC		1	
Lusu	220	DB-Tr	2026	1	
		Tr (100)		1	
North DSM	220	DB-F	2030	2	for West DSM
West DSM	220	DB-F	2030	4	for North DSM & Kinyerezi
		DB-Tr		1	
West DSM	220	Tr (400)	2030	1	
		DB-BC		1	
	132	SB-Tr	2030	1	
Southeast DSM	220	DB-Tr	2030	1	
		Tr (400)		1	
	132	SB-Tr	2030	1	

Table 4-14: Substation Additions from 2031 to 2035

Substation	Voltage	Equipment	Year	Q'ty	Remarks
Arusha	400	1-1/2 CB: 1 cct	2032	1	
		Tr (250)		1	
		1-1/2 CB: 1 cct	2035	2	
		SR-F (95)		2	for Segera
	220	DB-Tr	2032	1	
		Tr (250)		1	New 220 kV bus
		SB-Tr		1	
		Tr (200)		1	
		SB-Tr	2035	1	
		Tr (200)		1	
	132	SB-Tr	2032	1	Existing 132 kV bus
		SB-Tr	2035	1	Ditto
Babati		DB-Tr	2035	1	
		Tr (150)		1	
Bunda	220	DB-F	2035	2	
Musoma	220	DB-F	2035	2	
Nyamongo	220	DB-Tr	2033	1	
		Tr (100)		1	
		DB-F	2035	1	
Chalinze	400	1-1/2 CB: 1 cct	2035	4	
		SR-F (45)		1	for Segera
		SR-F (90)		2	for Somanga Fungu
		SR-F (60)		2	for Stiegler's Gorge
	220	DB-Tr	2034	1	
		Tr (90)		1	
	132	DB-Tr	2034	1	
Kihansi	220	SB-F	2034	1	for Upper Kihansi (Hydro)
Kigoma	400	DB-Tr	2035	1	
		STATCOM (145)		1	
Kinyerezi	400	1-1/2 CB: 1 cct	2035	1	
		Tr (500)		1	
Kyaka	220	DB-F	2035	2	for Uganda (Export) & Rusumo
		SB-F	2035	1	for Kibeta/Bokoba
Rusumo	220	DB-F	2035	1	for Kyaka
Songwe B S/S		SB-F	2034	1	for Songwe A S/S
Songwe A S/S	132	SB-F	2034	2	Sofre (Hydro)
Madaba	220	DB-F	2032	1	Masigira (Hydro)
		DB-F	2034	1	Kikonge (Hydro)
Mbeya	220	DB-F	2033	1	Rumalkali (Hydro)
Mufindi	220	SB-F	2032	1	Mpanga (Hydro)
Mkuranga	400	DB-F	2031	2	
		SR-F (20)		2	for Somanga Fungu
		DB-Tr	2035	1	
		Tr (500)		1	
	220	DB-Tr	2035	1	
Mnyera	400	DB-Tr	2033	1	
Mnyera	400	Tr (500)	2033	1	
	220	DB-F	2033	1	Ruhudji (Hydro)
		DB-Tr		1	
Mpanda	400	DB-Tr	2035	1	
		Tr (125)		1	
	220	DB-Tr	2035	1	
Sumbawanga	400	DB-Tr	2035	1	
		Tr (125)		1	
	220	DB-Tr	2035	1	
Mtwara	220	DB-Tr	2035	1	
	132	SB-Tr	2035	1	
Mwanza	220	DB-Tr	2033	1	
		Tr (200)		1	
		DB-F	2035	1	for Bunda
	132	SB-Tr	2033	1	
Nyakanazi	400	DB-Tr	2034	1	
		Tr (250)		1	
		DB-Tr	2035	1	
		STATCOM (150)		1	
		STATCOM (55)		1	
	220	DB-Tr	2034	1	
Segera	400	1-1/2 CB: 2 cct	2035	1	
		1-1/2 CB: 1 cct		3	
		SR-F (95)		2	for Arusha
		SR-F (45)		2	for chalinze
		Tr (250)		1	
	220	DB-Tr	2035	1	
Shinyanga	400	DB-Tr	2035	1	
		Tr (1,000)		1	
	220	DB-Tr	2034	2	
		DB-F	2035	4	for Bulyanhulu & Buzwagi
		DB-Tr		1	
Bulyanhulu	220	SB-F	2035	2	for Shinyanga
Buzwagi	220	SB-F	2035	2	for Shinyanga
Somanga Fungu	400	1-1/2 CB: 1 cct	2031	2	
		SR-F (20)		2	for Mkuranga via SwS
		1-1/2 CB: 1 cct	2033	2	Future CGT3-2
		1-1/2 CB: 1 cct	2035	2	
		SR-F (90)		2	for Chalinze
Mku-Som SwS-1	400	DB-F	2031	4	SwS between Mkuranga - Somanga Fungu
		SR-F (20)		4	for Somanga Fungu & Mku-Som SwS-2
		DB-BC		1	
Mku-Som SwS-2	400	DB-F	2031	4	SwS between Mkuranga - Somanga Fungu
		SR-F (20)		4	for Kin-Som SwS-2 & Mkuranga
		DB-BC		1	
Tabora	220	DB-Tr	2033	1	
Tabora	220	Tr (100)	2033	1	
Lusu	220	DB-Tr	2033	1	
		Tr (100)		1	
Tanga	220	DB-Tr	2031	1	
		Tr (100)		1	
Tunduru	400	DB-Tr	2033	1	
Tunduru	400	Tr (125)	2033	1	
	220	DB-Tr	2033	1	
		Tr (100)		1	
Masasi	400	DB-Tr	2033	1	
		Tr (125)		1	
	220	DB-Tr	2033	1	
		Tr (100)		1	
North DSM	220	DB-Tr	2035	1	
		Tr (400)		1	
	132	SB-Tr	2035	1	
West DSM	220	DB-Tr	2035	1	
		Tr (400)		1	
	132	SB-Tr	2035	1	
South DSM	220	DB-Tr	2035	1	
		Tr (400)		1	
	132	SB-Tr	2035	1	
Southeast DSM	220	DB-Tr	2035	1	
		Tr (400)		1	
	132	SB-Tr	2035	1	

Table 4-15: Substation Additions from 2036 to 2040

Substation	Voltage	Equipment	Year	Q'ty	Remarks
Arusha	400	1-1/2 CB: 1 cct	2037	1	
		Tr (250)		1	
		1-1/2 CB: 2 cct	2040	1	
		1-1/2 CB: 1 cct		1	
		STATCOM (150)		2	
		STATCOM (70)		1	
	220	SB-Tr	2038	1	
		Tr (200)		1	
	132	DB-Tr	2037	1	
		Tr (250)		1	New 220 kV bus
		SB-Tr	2038	1	
		Tr (200)		1	
Bagamoyo	400	DB-F	2040	1	
		STATCOM (60)		1	
Musoma	220	DB-Tr	2036	1	
		Tr (100)		1	
Nyamongo	220	DB-Tr	2037	1	
		Tr (100)		1	
Chalinze	400	1-1/2 CB: 1 cct	2039	1	
		Tr (150)		1	
		1-1/2 CB: 2 cct	2040	2	
		STATCOM (150)		3	
		STATCOM (80)		1	
	220	DB-Tr	2039	1	
		Tr (150)		1	
		DB-Tr	2040	1	
		Tr (90)		1	
	132	DB-Tr	2040	1	
		SB-F		2	
Dodoma	400	DB-F	2040	1	
		SR-F (75)		1	for Chalinze
		DB-Tr		4	
		STATCOM (150)		3	
		STATCOM (25)		1	
Iringa	400	DB-Tr	2040	2	
		STATCOM (100)		1	
		STATCOM (55)		1	
Kigoma	400	DB-Tr	2040	1	
		STATCOM (55)		1	
Kinyerezi	400	1-1/2 CB: 1 cct	2040	3	
		Tr (500)		1	
		STATCOM (150)		1	
		STATCOM (105)		1	
	220	DB-F	2040	1	for West DSM
Kin-Som SwS-1	400	DB-Tr	2040	3	SwS between Kinterezi - Somanga Fungu
		STATCOM (150)		2	
		STATCOM (145)		1	
Kin-Som SwS-2	400	DB-Tr	2040	1	SwS between Kinterezi - Somanga Fungu
		STATCOM (110)		1	
Kin-Som SwS-3	400	DB-Tr	2040	3	SwS between Kinterezi - Somanga Fungu
		STATCOM (150)		2	
		STATCOM (35)		1	
Kisada	400	1-1/2 CB: 2 cct	2040	1	
		STATCOM (150)		1	
		STATCOM (140)		1	
Kyaka	220	DB-Tr	2037	1	
		Tr (100)		1	
	132	SB-Tr	2037	1	
Rusumo	222	DB-F	2040	1	for Nyakanazi
Mbeya	400	DB-Tr	2037	1	
		Tr (500)		1	
		DB-Tr	2040	2	
		STATCOM (150)		1	
		STATCOM (140)		1	
	220	DB-Tr	2037	1	
Mkuranga	400	DB-Tr	2040	3	
		STATCOM (150)		2	
		STATCOM (140)		1	
Mlandizi	220	DB-Tr	2040	1	
		Tr (100)		1	
Mpanda	400	DB-Tr	2040	2	
		STATCOM (150)		2	
Mpa-Tab SwS	400	DB-Tr	2040	1	SwS between Mpanda & Tabora
		STATCOM (130)		1	
Sumbawanga	400	DB-Tr	2040	2	
		STATCOM (150)		1	
		STATCOM (60)		1	
Mpa-Sum SwS	400	DB-Tr	2040	3	SwS between Mpanda - Sumbawanga
		STATCOM (150)		2	
		STATCOM (50)		1	
Mbe-Sum SwS	400	DB-Tr	2040	1	SwS between Mbeya - Sumbawanga
		STATCOM (50)		1	
Mtwara	400	DB-Tr	2036	2	Future CGT 1 (CC)
		DB-Tr	2040	1	
		STATCOM (30)		1	
Mwanza	400	DB-Tr	2040	1	
		STATCOM (55)		1	
	220	DB-Tr	2037	1	
		Tr (200)		1	
		DB-F	2040	1	for Shinyanga
	132	SB-Tr	2037	1	
Nyakanazi	400	DB-Tr	2039	1	
		Tr (250)		1	
		DB-Tr	2040	1	
		STATCOM (150)		1	
	220	DB-Tr	2039	1	
		DB-F	2040	1	for Rusumo
Segera	400	1-1/2 CB: 1 cct	2040	2	
Segera	400	STATCOM (150)	2040	1	
		STATCOM (65)		1	
Shinyanga	400	DB-Tr	2040	3	
		STATCOM (150)		2	
		STATCOM (135)		1	
	220	DB-Tr	2038	1	
		DB-F	2040	4	for Singida & Mwanza
Singida	400	DB-Tr	2040	1	
		STATCOM (140)		1	
	220	DB-F	2040	4	for Shinyanga & Babati
Somanga Fungu	400	1-1/2 CB: 1 cct	2038	2	Future CGT3-3
		1-1/2 CB: 1 cct	2040	1	
		STATCOM (90)		1	
Mku-Som SwS-1	400	DB-Tr	2040	1	SwS between Mkuranga - Somanga Fungu
		STATCOM (140)		1	
Mku-Som SwS-2	400	DB-Tr	2040	3	SwS between Mkuranga - Somanga Fungu
		STATCOM (150)		2	
		STATCOM (80)		1	
Songea	400	DB-Tr	2036	1	
		Tr (125)		1	
	220	DB-Tr	2036	1	
Tabora	400	DB-Tr	2040	4	
		Tr (500)		1	
		STATCOM (150)		2	
		STATCOM (40)		1	
	220	DB-Tr	2037	1	
		Tr (100)		1	
		DB-F	2040	1	
Lusu	220	DB-Tr	2036	1	
		Tr (100)		1	
		DB-F	2040	1	
Tanga	220	DB-Tr	2036	1	
		Tr (100)		1	
North DSM	220	DB-Tr	2040	2	
		Tr (400)		2	
	132	SB-Tr	2040	2	
West DSM	220	DB-F	2040	1	for Kinyerezi
		DB-Tr		1	
		Tr (400)		1	
	132	SB-Tr	2040	1	
South DSM	220	DB-Tr	2040	2	
		Tr (400)		2	
	132	SB-Tr	2040	2	

4.7 Load flow analysis

The proposed Tanzania's transmission system is based on the load forecast and the new power plants as presented in the previous sections. Five study years were considered:

a) Y-2020 peak load case;
b) Y-2025 peak load case;
c) Y-2030 peak load case;
d) Y-2035 peak load case; and
e) Y-2040 peak load case.

Each case has been analyzed under both normal (N-0) and contingency (N-1) conditions. System reinforcements including transmission lines, transformers and reactive power compensations were defined as appropriate.

4.7.1 Year-2020 case

The results of analysis show that under normal conditions (N-0), all bus voltages are within the limits (0.95 -1.05 pu), as defined in the planning criteria. No voltage violation is recorded in the bulk system (220kV and above). Transmission line power flows are also below the line normal capacity (rating A).

Contingency analysis (N-1) for this case was performed and no voltage or overloading problems were encountered in the bulk system. Under contingency conditions the voltage check was based on the (0.9-1.1 pu) limits and the loading was based of the transmission line/transformer emergency capacity (rating B).

4.7.2 Year-2025 case

The major additions by year 2025 are divided into two categories. The first is the expansion of the 400kV network. It is composed of the Songea-Tunduru-Masasi-Lindi 400kV double-circuit lines, the Shinyanga-Mwanza 400kV double-circuit line, the Chalinze-Zinga 400kV double-circuit line and the Kinyerezi-Mkuranga 400kV double-circuit line. The second is the expansion of the network in Dar es Salaam area. It is composed of the Zinga-North Dar es Salaam 220kV double-circuit lines and the Kinyerezi-South Dar es Salaam-Southeast Dar es Salaam-Mkuranga 220kV double-circuit lines.

The results of analysis show that under normal conditions (N-0), all bus voltages are within the limits (0.95 -1.05 pu), as defined in the planning criteria. No voltage violations are recorded in the bulk system (220kV and above.). Transmission line power flows are also below the line normal capacity (rating A).

Contingency analysis (N-1) for this case was performed and no voltage or overloading problems were encountered in the bulk system. Under contingency conditions the voltage check was based on the (0.9-1.1 pu) limits and the loading was based of the transmission line/transformer emergency capacity (rating B).

4.7.3 Year-2030 case

The major additions by year 2030 are divided into two categories. The first is the expansion of the 400kV network. It is composed of the Shinyanga-Tabora-Mpanda 400kV double-circuit lines. The second is the expansion of the network in Dar es Salaam area. It is composed of the Zinga-Mlandizi 220kV double-circuit line and the North Dar es Salaam-West Dar es Salaam-Kinyerezi 220kV double-circuit lines.

Under normal conditions (N-0), all bus voltages are within the limits (0.95 -1.05 pu), as defined in the planning criteria. No voltage violation is recorded in the bulk system (220kV and above.). Transmission line power flows are also below the line normal capacity (rating A).

Contingency analysis (N-1) for this case was performed and no voltage or overloading problems were encountered in the bulk system. Under contingency conditions the voltage check was based on the (0.9-1.1 pu) limits and the loading was based of the transmission line/transformer emergency capacity (rating B).

4.7.4 Year-2035 case

The major additions by year 2035 divided into two categories. The first is the expansion of the 400kV network. It is composed of the Chalinze-Somanga Fungu 400kV double-circuit line, the Chalinze-Segera 400kV additional single-circuit line and the Segera-Arusha 400kV additional double-circuit line. The second is the enhancement of 220kV single-circuit lines to 220kV double-circuit lines. It is composed of the Nyakanazi-Rusumo-Kyaka-Masaka 220kV lines and the Mwanza-Bunda-Musoma-Nyamongo 220kV lines.

Under normal conditions (N-0), all bus voltages are within the limits (0.95 -1.05 pu), as defined in the planning criteria. No voltage violations are recorded in the bulk system (220kV and above.). Transmission line power flows are also below the line normal capacity (rating A).

Contingency analysis (N-1) for this case was performed and no voltage or overloading problems were encountered in the bulk system. Under contingency conditions the voltage check was based on the (0.9-1.1 pu) limits and the loading was based of the transmission line/transformer emergency capacity (rating B).

4.7.5 Year-2040 case

This case represents the ultimate load flow case for the Tanzania‘s power system. Generally, the importance of such a case is to plan the system in the early years (e.g. in Y-2020, Y-2025, Y2030 and Y-2035) with an eye on the foreseen ultimate configuration.

Both the 400kV and 220kV networks were expanded as many power plants were considered. Since the generation is mostly concentrated in the South and coastal areas and there are substantial load centers at North, reactive power compensation played an important role in reaching satisfactory operating conditions for the system developed.

Under normal conditions (N-0), all bus voltages are within the limits (0.95 -1.05 pu), as defined in the planning criteria. No voltage violation is recorded in the bulk system (220kV and above.). Transmission line power flows are also below the line normal capacity (rating A).

Contingency analysis (N-1) for this case was performed and no voltage or overloading problems were encountered in the bulk system. Under contingency conditions the voltage check was based on the (0.9-1.1 pu) limits and the loading was based of the transmission line/transformer emergency capacity (rating B).

4.8 Short circuit study

A Short circuit study was performed only on the bulk system (220kV and above) and results are given in Table 4-16.

A typical equivalent machine reactance of 15% for turbine generators and 20% for hydro generators was assumed for short circuit current calculations. Pre-fault conditions were set to the load flow solution.

All fault currents for 400kV and 220kV substations are well below the practical switchgear ratings for these levels. The minimum switchgear short circuit rating is in the range of 63 kA for 400kV level and 40kA for 220kV level. Therefore, the year 2040 case with the overall 400/220kV transmission system does not experience any switchgear short circuit rating problems.

Table 4-16: Year 2040 short circuit results

Bus			3-ph Short circuit Currents		
No.	Name	kV	kA	in MVA	X/R Ratio
220kV Buses					
10312	Ubungo	220	26.32	10,031	2.5
10402	Chalinze	220	11.32	4,313	5.9
10601	Mlandizi	220	11.48	4,374	3.9
11402	Bagamoyo	220	23.89	9,102	3.1
11501	Zinga	220	13.52	5,152	5.6
11601	Kibaha	220	7.09	2,700	5.2
11602	Kibaha	220	12.54	4,779	4.1
11701	Ubungo	220	20.65	7,869	3.4
11702	Ubungo	220	25.14	9,579	2.7
11802	Kinyerezi	220	34.54	13,161	2.1
12001	North Dar es Salaam	220	21.37	8,143	2.2
12101	Southeast Dar es Sallam	220	17.07	6,504	2.4
12201	South Dar es Sallam	220	21.55	8,212	2.1

Bus			3-ph Short circuit Currents		
No.	Name	kV	kA	in MVA	X/R Ratio
12301	West Dar es Salaam	220	26.53	10,109	2.2
20402	Mkuranga	220	21.45	8,173	4.1
20902	Songea	220	5.83	2,221	14.1
30112	Mtwara	220	8.84	3,367	0.7
30201	Bunda	220	4.14	1,577	1.2
30301	Musoma	220	3.39	1,294	1.2
30316	Nyamongo	220	2.66	1,013	1.4
30401	Geita	220	5.77	2,198	1.2
40112	Mufindi	220	5.03	1,918	4.1
40115	Makanbako	220	5.29	2,016	4.8
40212	Mbeya	220	15.57	5,933	4.9
40214	Uyole	220	12.97	4,943	4.9
40601	Madaba	220	13.57	5,169	18.3
40701	Masigira	220	4.69	1,787	20.5
40801	Kikonge	220	7.27	2,768	24.9
41001	Rumakali	220	4.74	1,807	17.6
41101	Geothermal	220	7.74	2,948	7.9
41201	Mpanda	220	3.78	1,439	7.9
41301	Ruhudji	220	6.30	2,401	33.5
41401	Ruaha2	220	7.44	2,835	21.8
41501	Kwanini	220	9.50	3,619	23.3
41602	Mnyera2	220	14.10	5,374	23.7
41701	Pumbwe	220	9.29	3,540	22.7
41801	Tavera3	220	8.33	3,176	22.2
41901	Kisingo	220	7.82	2,978	22.5
42801	Kyala	220	3.77	1,436	6.7
49101	Karonga	220	3.12	1,188	6.2
50112	Babati	220	4.17	1,590	2.5
51101	Tanga	220	5.47	2,083	3.3
51212	Njiro	220	8.97	3,418	1.7
51302	Segera	220	9.00	3,431	3.4
51402	Arusha	220	9.02	3,437	1.7
60112	Kidatu	220	7.16	2,728	5.3
60212	Kihansi	220	7.17	2,732	12.1
60312	Mtera	220	4.51	1,717	5.7
60412	Iringa	220	13.42	5,112	5.7
60501	Ibosa	220	4.19	1,596	13.2
70112	Bulyanhulu	220	5.96	2,270	1.3
70201	Lusu	220	5.55	2,113	1.5
70312	Shinyanga	220	11.51	4,385	0.6
70401	Tabora	220	8.74	3,329	1.1
71010	Buswagi	220	5.44	2,075	1.8
80112	Morogoro	220	7.46	2,843	3.1
80212	Dodoma	220	6.99	2,663	3.5
80312	Singida	220	8.35	3,183	1.9
90402	Kigoma	220	4.62	1,760	2.6
90602	Nyakanazi	220	6.42	2,445	1.5
90701	Rusmo	220	4.57	1,742	1.9
91001	Kyaka	220	3.15	1,199	2.0
91301	Masaka	220	2.80	1,069	2.1

Bus			3-ph Short circuit Currents		
No.	Name	kV	kA	in MVA	X/R Ratio
400kV Buses					
10401	Chalinze	400	22.19	15,376	3.6
10701	Somanga Fungu-Kinyerezi SwS1	400	20.93	14,503	4.1
10801	Somanga Fungu-Kinyerezi SwS2	400	20.68	14,330	5.4
10901	Somanga Fungu-Kinyerezi SwS3	400	24.13	16,719	6.3
11401	Bagamoyo	400	15.00	10,395	4.0
11801	Kinyerezi	400	25.36	17,570	2.8
20101	Mkuranga	400	20.93	14,500	3.7
20201	Somanga Fungu	400	36.52	25,303	6.4
20205	Future CGT3-1	400	26.53	18,383	9.2
20206	Future CGT3-2	400	32.11	22,245	10.0
20207	Future CGT3-3	400	26.70	18,498	9.2
20301	Lindi	400	13.17	9,126	10.9
20401	Mtwara	400	10.14	7,023	11.4
20403	Future CGT1	400	7.97	5,520	13.8
20501	Masasi	400	7.57	5,243	12.0
20601	Stiegler's Gorge	400	17.10	11,847	14.0
20701	Tunduru	400	6.71	4,646	13.7
20801	Ngaka	400	12.56	8,701	27.4
20901	Songea	400	12.51	8,670	20.0
21001	Mozambique	400	7.13	4,937	10.1
21101	Somanga Fungu-Mkuranga SwS1	400	19.85	13,755	5.1
21102	Somanga Fungu-Mkuranga SwS2	400	23.03	15,953	6.3
30101	Mwanza	400	5.78	4,005	0.8
40210	Mbeya	400	13.78	9,544	4.4
40215	Kiwira	400	11.69	8,102	7.5
40602	Madaba	400	16.28	11,277	15.3
41601	Mnyera	400	7.92	5,488	16.7
42001	Nakonde	400	6.73	4,663	5.9
42101	Kisada	400	14.63	10,135	6.1
51301	Segera	400	9.44	6,538	3.2
51401	Arusha	400	6.16	4,269	1.9
51501	Isinya	400	4.01	2,779	2.9
60401	Iringa	400	10.24	7,095	5.3
70301	Shinyanga	400	6.91	4,790	0.6
70402	Tabora	400	6.33	4,386	0.9
70501	Mpanda-Tabora SwS	400	6.24	4,325	1.2
80201	Dodoma	400	7.02	4,862	2.9
80301	Singida	400	7.33	5,075	1.5
90101	Sumbawanga	400	8.80	6,098	2.7
90102	Sumbawanga-Mbeya SwS	400	9.77	6,767	3.8
90301	Mpanda	400	6.70	4,645	1.4
90401	Kigoma	400	4.57	3,166	1.6
90601	Nyakanazi	400	3.73	2,586	1.6
90801	Sumbawanga-Mpanda SwS	400	7.25	5,026	2.0
91501	Rukwa	400	8.35	5,785	3.2

4.9 Transmission System Costs

The major 400kV and 220kV, transmission additions required for the above Least Cost Expansion Plan are illustrated in Figure 4-2, the costs of the transmission additions are listed in Table 4-17 up to 4-21 and those for substation additions are listed in Table 4-22 up to 4-26. The total transmission system costs in the Least Cost Expansion Plan from 2015 up to 2020 are US$ 4,925 million and from 2021 up to 2025 are US$1,279million while from 2026 up to 2040 are US$ 4,027 million. Accounting to the total amount from 2015 up to 2040 will be US$10,230million.

Table 4-17: Phased transmission lines cost estimates 2015-2020

No	Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)					
									2015	2016	2017	2018	2019	2020
1	400	Dodoma	Singida	Backbone Project	210	2	2016	79,800 *	39,900	39,900	0	0	0	0
2	400	Iringa	Dodoma	Backbone Project	237	2	2016	90,060 *	45,030	45,030	0	0	0	0
3	400	Singida	Shinyanga	Backbone Project	200	2	2016	76,000 *	38,000	38,000	0	0	0	0
4	220	Kinyerezi	Ubungo-Pai	Completed	8	1	2016		0	0	0	0	0	0
5	220	Ubungo-Pai	Kinyerezi	Completed	8	1	2016		0	0	0	0	0	0
6	132	Kinyerezi	FZ-II	Completed	5	1	2016		0	0	0	0	0	0
7	132	Morogoro	Mtibwa	MCC, F/S completed	88	1	2016	14,960	7,480	7,480	0	0	0	0
8	220	Wind Project	Singida		10	1	2017	2,300	0	1,150	1,150	0	0	0
9	400	Kin-Som SwS1	Kin-Som SwS2		53	2	2018	45,050	0	0	22,525	22,525	0	0
10	400	Kin-Som SwS2	Kin-Som SwS3		53	2	2018	45,050	0	0	22,525	22,525	0	0
11	400	Kin-Som SwS3	Somanga Fungu P/S	210 MW	53	2	2018	45,050	0	0	22,525	22,525	0	0
12	400	Kinyerezi	Kin-Som SwS1		53	2	2018	23,850	0	0	11,925	11,925	0	0
13	400	Kisada	Iringa		106	2	2018	90,100	0	0	45,050	45,050	0	0
14	400	Kisada	Madaba		243	2	2018	206,550	0	0	103,275	103,275	0	0
15	400	Muchuchuma P/S	Madaba	Total 1,800 MW	15	2	2018	8,400	0	0	4,200	4,200	0	0
16	220	Geita	Nyakanazi		130	2	2018	41,600	0	0	20,800	20,800	0	0
17	220	Madaba	Songea		171	1	2018	39,330	0	0	19,665	19,665	0	0
18	220	Makambako	Madaba		162	1	2018	37,260	0	0	18,630	18,630	0	0
19	220	Nyakanazi	Rusumo Falls P/S	30 MW	97	1	2018	32,980	0	0	16,490	16,490	0	0
20	220	Rusumo Falls P/S	Kyaka	30 MW	150	1	2018	51,000	0	0	25,500	25,500	0	0
21	220	Shinyanga	Geita		240	2	2018	108,000	0	0	54,000	54,000	0	0
22	400	Arusha	Singida		317	2	2019	120,460	0	0	0	60,230	60,230	0
23	400	Arusha	Isinya (Kenya)	up to Kenya border	114	2	2019	51,300 *	0	0	0	25,650	25,650	0
24	400	Lindi	Somanga Fungu		216	2	2019	97,200	0	0	0	48,600	48,600	0
25	400	Mtwara P/S	Lindi	400 MW	74	2	2019	33,300	0	0	0	16,650	16,650	0
26	220	Arusha	Njiro (Arusha existing)		5	2	2019	104,020	0	0	0	52,010	52,010	0
27	220	Iringa	Lower Kihansi P/S (Hydro)	(36+52+120) MW	120	1	2019	27,600	0	0	0	13,800	13,800	0
28	220	Solar I	Dodoma	50 MW	10	1	2019	167,680	0	0	0	83,840	83,840	0
29	132	Wind Project	Makambako	100 MW	10	1	2019	6,650	0	0	0	3,325	3,325	0
30	400	Chalinze	Segera		175	1	2020	80,180 *	0	0	0	0	40,090	40,090
31	400	Chalinze	Dodoma		336	1	2020	100,800	0	0	0	0	50,400	50,400
32	400	Chalinze	Segera		175	1	2020	70,000	0	0	0	0	35,000	35,000
33	400	Kigoma	Mpanda		290	2	2020	246,500	0	0	0	0	123,250	123,250
34	400	Kinyerezi	Chalinze		138	2	2020	104,020 *	0	0	0	0	52,010	52,010
35	400	Kisada	Mbeya		186	2	2020	158,100	0	0	0	0	79,050	79,050
36	400	Kiwira P/S	Mbeya	400MW in 2020	110	2	2020	93,500	0	0	0	0	46,750	46,750
37	400	Mbea	Nakonde(Zambia)	up to Zambia border	93	2	2020	35,340	0	0	0	0	17,670	17,670
38	400	Mbe－Sum SwS	Sumbawanga		150	2	2020	127,500	0	0	0	0	63,750	63,750
39	400	Mbeya	Mbe－Sum SwS		150	2	2020	127,500	0	0	0	0	63,750	63,750
40	400	Mpanda	Mpa-Sum SwS		119	2	2020	101,150	0	0	0	0	50,575	50,575
41	400	Mpa-Sum SwS	Sumbawanga		119	2	2020	101,150	0	0	0	0	50,575	50,575
42	400	Mtwara	Namialo(Mozambique)	up to Mozambique border	51	2	2020	19,257	0	0	0	0	9,628	9,628
43	400	Nyakanazi	Kigoma		317	2	2020	269,450	0	0	0	0	134,725	134,725
44	400	Segera	Arusha		366	1	2020	167,680 *	0	0	0	0	83,840	83,840
45	400	Somanga Fungu P/S	Somanga P/S(PPP)	300MW	20	2	2020	7,600	0	0	0	0	3,800	3,800
46	220	Bagamoyo (Zinga)	Kibaha-Pai		45	1	2020	6,650 *	0	0	0	0	3,325	3,325
47	220	Bunda	Musona		60	1	2020	20,400	0	0	0	0	10,200	10,200
48	220	Kibaha-Pai	Bagamoyo (Zinga)		45	1	2020	6,650 *	0	0	0	0	3,325	3,325
49	220	Kinyerezi	Ubungo		12	2	2020	2,640	0	0	0	0	1,320	1,320
50	220	Kishapu Solar	Shinyanga	150 MW	10	1	2020	1,900	0	0	0	0	950	950
51	220	Kyaka	Masaka(Uganda)	up to Uganda border	30	1	2020	6,900	0	0	0	0	3,450	3,450
52	220	Kyela	Karonga(Malawi)	up to Malawi border	20	1	2020	4,600	0	0	0	0	2,300	2,300
53	220	Lusu	Tabora		139	1	2020	31,970	0	0	0	0	15,985	15,985
54	220	Mbeya	Kyela		106	1	2020	24,380	0	0	0	0	12,190	12,190
55	220	Musona	Nyamongo		90	1	2020	30,600	0	0	0	0	15,300	15,300
56	220	Mwanza	Bunda		150	1	2020	51,000	0	0	0	0	25,500	25,500
57	220	Segera	Tanga		76	2	2020	33,470 *	0	0	0	0	16,735	16,735
58	220	Shinyanga	Lusu		64	1	2020	12,160	0	0	0	0	6,080	6,080
59	132	Kinyerezi	FZ-II		5	2	2020	1,150	0	0	0	0	575	575
60	132	Morogoro	Mtibwa		88	1	2020	14,960	0	0	0	0	7,480	7,480
61	66	Babati	Mbulu		85	2	2020	12,750	0	0	0	0	6,375	6,375
								(Thousand USD)	3,717,457					

Note: * Should be replaced with the contract amount

Table 4-18: Phased transmission lines cost estimates 2021-2025

No	Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)				
									2021	2022	2023	2024	2025
62	400	Kinyerezi	Mkuranga P/S	300 MW	70	2	2022	59,500	29,750	29,750	0	0	0
63	400	Madaba	Songea		171	2	2023	64,980	0	32,490	32,490	0	0
64	400	Masasi	Lindi		141	2	2023	78,960	0	39,480	39,480	0	0
65	400	Ngaka P/S	Songea	600MW in 2023	37	2	2023	20,720	0	10,360	10,360	0	0
66	400	Songea	Tunduru		230	2	2023	128,800	0	64,400	64,400	0	0
67	400	Tunduru	Masasi		194	2	2023	108,640	0	54,320	54,320	0	0
68	400	Sumbawanga	Rukwa P/S	300MW in 2024	46	2	2024	39,100	0	0	19,550	19,550	0
69	132	Malagarasi P/S(Stage III)	Kigoma	44.7 MW	74	1	2024	12,580	0	0	6,290	6,290	0
70	400	Chalinze	Bagamoyo		102	2	2025	86,700	0	0	0	43,350	43,350
71	400	Shinyanga	Mwanza		140	2	2025	119,000	0	0	0	59,500	59,500
72	220	Bagamoyo	North DSM		40	2	2025	18,000	0	0	0	9,000	9,000
73	220	Geothermal 1	Mbeya	(2 x 50 MW)×2	35	1	2025	6,650	0	0	0	3,325	3,325
74	220	Kinyerezi	South DSM		25	2	2025	11,250	0	0	0	5,625	5,625
75	220	Mkuranga	South-east DSM		50	2	2025	22,500	0	0	0	11,250	11,250
76	220	South DSM	South-east DSM		30	2	2025	9,600	0	0	0	4,800	4,800
77	132	Kyaka	Kibeta/Bukoba		54	1	2025	10,800	0	0	0	5,400	5,400
78	66	Mbulu	Karatu		65	2	2025	9,750	0	0	0	4,875	4,875
79	220	Geothermal 1	Geothermal 2	2 x 50 MW	20	1	2026	3,800	0	0	0	0	1,900
80	220	Ibosa P/S (Hydro)	Iringa-L. Kihansi T branch	(36+52+120) MW	20	2	2026	6,400	0	0	0	0	3,200
81	220	Ibosa P/S (Hydro)	Nginayo P/S (Hydro)	52MW	10	1	2026	1,900	0	0	0	0	950
								(Thousand USD)	**813,580**				

Table 4-19: Phased transmission lines cost estimates 2026-2030

No	Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)				
									2026	2027	2028	2029	2030
79	220	Geothermal 1	Geothermal 2	2 x 50 MW	20	1	2026	3,800	1,900	0	0	0	0
80	220	Ibosa P/S (Hydro)	Iringa-L. Kihansi T branch	(36+52+120) MW	20	2	2026	6,400	3,200	0	0	0	0
81	220	Ibosa P/S (Hydro)	Nginayo P/S (Hydro)	52MW	10	1	2026	1,900	950	0	0	0	0
82	220	Zinga P/S	Bagamoyo	200 MW	15	1	2027	3,450	1,725	1,725	0	0	0
83	132	Kakono P/S (Hydro)	Kyaka	87 MW	39	1	2027	6,596	3,298	3,298	0	0	0
84	400	Mnyera S/S (new)	Kisada	(668.2+358) MW	180	2	2028	100,800	0	50,400	50,400	0	0
85	220	Ruaha 2 P/S (Hydro)	Mnyera S/S (new)	(60.3+137.4+143.9) MW	33	1	2028	7,590	0	3,795	3,795	0	0
86	132	Songwe B S/S	Kyela	(79.5 + 88.1) MW	7	2	2028	1,400	0	700	700	0	0
87	132	Songwe Manolo P/S (Hydro)	Songwe B S/S	88.1 MW	17	1	2028	2,890	0	1,445	1,445	0	0
88	220	Kwanini P/S (Hydro)	Mnyera S/S-Ruaha2 T/L	T-branch	10	1	2029	2,300	0	0	1,150	1,150	0
89	220	Mnyera 2 P/S (Hydro)	Mnyera S/S-Ruaha2 T/L	T-branch	10	1	2029	2,300	0	0	1,150	1,150	0
90	400	Shinyanga	Tabora		200	2	2030	170,000	0	0	0	85,000	85,000
91	400	Somanga Fungu S/S	Future CGT3-1	4x470 MW	20	2	2030	11,200	0	0	0	5,600	5,600
92	400	Tab-Mpa SwS	Mpanda		150	2	2030	127,500	0	0	0	63,750	63,750
93	400	Tabora	Tab-Mpa SwS		150	2	2030	127,500	0	0	0	63,750	63,750
94	220	Bagamoyo	Mlandizi		40	2	2030	8,800	0	0	0	4,400	4,400
95	220	Kinyerezi	West DSM		20	2	2030	9,000	0	0	0	4,500	4,500
96	220	Mnyera S/S (new)	Taveta 3 P/S (Hydro)	(119.8+83.9+122.9) MW	26	1	2030	5,980	0	0	0	2,990	2,990
97	220	Pumbwe P/S (Hydro)	Mnyera S/S-Taveta3 T/L	T-branch	10	1	2030	2,300	0	0	0	1,150	1,150
98	220	West DSM	North DSM		20	2	2030	6,400	0	0	0	3,200	3,200
99	132	Njiro (Arusha existing)	Kiyungi	T-branch to KIA	77	2	2030	24,640	0	0	0	12,320	12,320
100	400	Mkuranga	Mku-Som SwS1		61	2	2031	51,850	0	0	0	0	25,925
101	400	Mku-Som SwS1	Mku-Som SwS2		61	2	2031	51,850	0	0	0	0	25,925
102	400	Mku-Som SwS2	Somanga Fungu S/S		61	2	2031	51,850	0	0	0	0	25,925
103	220	Mufindi	Mpanga P/S (Hydro)	160 MW	65	1	2031	14,950	0	0	0	0	7,475
104	220	Taveta 3 P/S (Hydro)	Kisingo P/S (Hydro)	119.8MW	15	1	2031	3,450	0	0	0	0	1,725
								(Thousand USD)	**713,671**				

Table 4-20: Phased transmission lines cost estimates 2031-2035

No	Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)				
									2031	2032	2033	2034	2035
100	400	Mkuranga	Mku-Som SwS1		61	2	2031	51,850	25,925	0	0	0	0
101	400	Mku-Som SwS1	Mku-Som SwS2		61	2	2031	51,850	25,925	0	0	0	0
102	400	Mku-Som SwS2	Somanga Fungu S/S		61	2	2031	51,850	25,925	0	0	0	0
103	220	Mufindi	Mpanga P/S (Hydro)	160 MW	65	1	2031	14,950	7,475	0	0	0	0
104	220	Taveta 3 P/S (Hydro)	Kisingo P/S (Hydro)	119.8MW	15	1	2031	3,450	1,725	0	0	0	0
105	220	Masigira P/S (Hydro)	Madaba	118 MW	73	1	2032	16,790	8,395	8,395	0	0	0
106	400	Somanga Fungu S/S	Future CGT3-2	6x470 MW	20	2	2033	11,200	0	5,600	5,600	0	0
107	220	Mbeya	Rumakali P/S (Hydro)	222MW	104	1	2033	23,920	0	11,960	11,960	0	0
108	220	Mnyera S/S (new)	Ruhudji P/S (Hydro)	358 MW	88	1	2033	20,240	0	10,120	10,120	0	0
109	220	Kihansi P/S (Hydro)	Upper Kihansi P/S (Hydro)	47MW	10	1	2034	1,900	0	0	950	950	0
110	220	Kikonge P/S (Hydro)	Madaba	300 MW	49	1	2034	11,270	0	0	5,635	5,635	0
111	132	Songwe A S/S	Songwe B S/S		40	1	2034	6,800	0	0	3,400	3,400	0
112	132	Songwe Sofre P/S (Hydro)	Songwe A S/S	79.5 MW	16	1	2034	2,720	0	0	1,360	1,360	0
113	400	Chalinze	Segera		175	1	2035	70,000	0	0	0	35,000	35,000
114	400	Segera	Arusha		366	2	2035	204,960	0	0	0	102,480	102,480
115	400	Somanga Fungu S/S	Chalinze		284	2	2035	241,400	0	0	0	120,700	120,700
116	400	Stiegler's Gorge	Chalinze	2 x 1,048 MW	195	2	2035	165,750	0	0	0	82,875	82,875
117	220	Bulyanhulu	Shinyanga		130	2	2035	58,500	0	0	0	29,250	29,250
118	220	Bunda	Musona		60	1	2035	20,400	0	0	0	10,200	10,200
119	220	Kyaka	Masaka(Uganda)	up to Uganda border	30	1	2035	6,900	0	0	0	3,450	3,450
120	220	Musona	Nyamongo		90	1	2035	30,600	0	0	0	15,300	15,300
121	220	Mwanza	Bunda		150	1	2035	51,000	0	0	0	25,500	25,500
122	220	Nyakanazi	Rusumo Falls P/S		97	1	2035	32,980	0	0	0	16,490	16,490
123	220	Rusumo Falls P/S	Kyaka		150	1	2035	51,000	0	0	0	25,500	25,500
124	220	Shinyanga	Buswagi		108	2	2035	48,600	0	0	0	24,300	24,300
125	132	Kyaka	Kibeta/Bukoba		54	1	2035	10,800	0	0	0	5,400	5,400
126	66	Babati	Kondoa		85	2	2035	12,750	0	0	0	6,375	6,375
127	400	Mtwara	Future CGT1 P/S	330MW	50	2	2036	19,000	0	0	0	0	9,500
								(Thousand USD)	1,196,955				

Table 4-21: Phased transmission lines cost estimates 2036-2040

No	Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)				
									2036	2037	2038	2039	2040
127	400	Mtwara	Future CGT1 P/S	330MW	50	2	2036	19,000	9,500	0	0	0	0
128	400	Somanga Fungu	Future CGT3-3	5x470 MW	20	2	2038	11,200	0	5,600	5,600	0	0
129	220	Kinyerezi	West DSM		20	1	2040	6,800	0	0	0	3,400	3,400
130	220	Shinyanga	Mwanza		140	2	2040	30,800	0	0	0	15,400	15,400
131	220	Singida	Babati		150	2	2040	33,000	0	0	0	16,500	16,500
132	220	Singida	Shinyanga		200	2	2040	44,000	0	0	0	22,000	22,000
133	132	Chalinze	Morogoro		82	2	2040	16,400	0	0	0	8,200	8,200
								(Thousand USD)	151,700				

Table 4-22: Phased substation cost estimates 2015-2020

No	Substation	New or Expansion	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)					
					2015	2016	2017	2018	2019	2020
1	Dodoma	E	2016	52,250 *	26,125	26,125	0	0	0	0
2	Iringa	N	2016	39,170 *	19,585	19,585	0	0	0	0
3	Morogoro	E	2016	700 *	350	350	0	0	0	0
4	Mtibwa	E	2016	700 *	350	350	0	0	0	0
5	Shinyanga	E	2016	34,540 *	17,270	17,270	0	0	0	0
6	Singida	E	2016	20,510 *	10,255	10,255	0	0	0	0
7	Kinyerezi	N	2017	935	0	468	468	0	0	0
8	Singida	E	2017	935	0	468	468	0	0	0
9	Geita	N	2018	8,400	0	0	4,200	4,200	0	0
10	Iringa	E	2018	14,500	0	0	7,250	7,250	0	0
11	Kin-Som SwS1	N	2018	24,810	0	0	12,405	12,405	0	0
12	Kin-Som SwS2	N	2018	24,810	0	0	12,405	12,405	0	0
13	Kin-Som SwS3	N	2018	24,810	0	0	12,405	12,405	0	0
14	Kinyerezi	E	2018	92,945	0	0	46,473	46,473	0	0
15	Kisada	N	2018	27,510	0	0	13,755	13,755	0	0
16	Kyaka	E	2018	9,930	0	0	4,965	4,965	0	0
17	Madaba	N	2018	25,330	0	0	12,665	12,665	0	0
18	Makambako	E	2018	935	0	0	468	468	0	0
19	Mbeya	E	2018	30,095	0	0	15,048	15,048	0	0
20	Nyakanazi	N	2018	7,630	0	0	3,815	3,815	0	0
21	Rusumo	E	2018	2,570	0	0	1,285	1,285	0	0
22	Shinyanga	E	2018	935	0	0	468	468	0	0
23	Somanga Fungu	N	2018	13,210	0	0	6,605	6,605	0	0
24	Songea	N	2018	5,390	0	0	2,695	2,695	0	0
25	Arusha (Njiro)	N	2019	46,590 *	0	0	0	23,295	23,295	0
26	Dodoma	E	2019	935	0	0	0	468	468	0
27	Iringa	E	2019	935	0	0	0	468	468	0
28	Lindi	N	2019	25,990	0	0	0	12,995	12,995	0
29	Makambako	E	2019	700	0	0	0	350	350	0
30	Mtwara	E	2019	23,330	0	0	0	11,665	11,665	0
31	Singida	E	2019	15,540	0	0	0	7,770	7,770	0
32	Somanga Fungu	E	2019	16,295	0	0	0	8,148	8,148	0
33	Arusha (Njiro)	E	2020	27,295	0	0	0	0	13,648	13,648
34	Babati	E	2020	700	0	0	0	0	350	350
35	Bagamoyo	N	2020	13,040	0	0	0	0	6,520	6,520
36	Bunda	N	2020	10,700	0	0	0	0	5,350	5,350
37	Chalinze	N	2020	47,930 *	0	0	0	0	23,965	23,965
38	Kigoma	N	2020	38,190	0	0	0	0	19,095	19,095
39	Kin-Som SwS1	E	2020	7,760	0	0	0	0	3,880	3,880
40	Kin-Som SwS2	N	2020	7,440	0	0	0	0	3,720	3,720
41	Kin-Som SwS3	N	2020	7,440	0	0	0	0	3,720	3,720
42	Kinyerezi	E	2020	36,320 *	0	0	0	0	18,160	18,160
43	Kisada	E	2020	7,900	0	0	0	0	3,950	3,950
44	Kyaka	E	2020	935	0	0	0	0	468	468
45	Kyela	N	2020	6,860	0	0	0	0	3,430	3,430
46	Lindi	E	2020	7,440	0	0	0	0	3,720	3,720
47	Lusu	E	2020	10,700	0	0	0	0	5,350	5,350
48	Madaba	E	2020	7,440	0	0	0	0	3,720	3,720
49	Mbe-Sum SwS	E	2020	27,120	0	0	0	0	13,560	13,560
50	Mbeya	E	2020	20,825	0	0	0	0	10,413	10,413
51	Morogoro	E	2020	12,190	0	0	0	0	6,095	6,095
52	Mpanda	N	2020	35,515	0	0	0	0	17,758	17,758
53	Mpa-Sum SwS	N	2020	26,490	0	0	0	0	13,245	13,245
54	Mtibwa	E	2020	700	0	0	0	0	350	350
55	Mtwara	E	2020	12,420	0	0	0	0	6,210	6,210
56	Musoma	E	2020	10,700	0	0	0	0	5,350	5,350
57	Mwanza	E	2020	5,390	0	0	0	0	2,695	2,695
58	Nyakanazi	E	2020	45,890	0	0	0	0	22,945	22,945
59	Nyamongo	E	2020	9,930	0	0	0	0	4,965	4,965
60	Segera	N	2020	34,230 *	0	0	0	0	17,115	17,115
61	Shinyanga	E	2020	10,245	0	0	0	0	5,123	5,123
62	Singida	E	2020	33,540	0	0	0	0	16,770	16,770
63	Somanga Fungu	E	2020	11,200	0	0	0	0	5,600	5,600
64	Sumbawanga	N	2020	33,560	0	0	0	0	16,780	16,780
65	Tabora	E	2020	12,530	0	0	0	0	6,265	6,265
66	Tanga	E	2020	14,020	0	0	0	0	7,010	7,010
67	Ubungo	E	2020	18,610	0	0	0	0	9,305	9,305
				(Thousand USD)	1,207,060					

Note: *: Should be replaced with the contract amount

Table 4-23: Phased substation cost estimates 2021-2025

No	Substation	New or Expansion	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)				
					2021	2022	2023	2024	2025
68	Kinyerezi	E	2022	6,820	3,410	3,410	0	0	0
69	Mkuranga	N	2022	13,930	6,965	6,965	0	0	0
70	Shinyanga	E	2022	28,975	14,488	14,488	0	0	0
71	Arusha (Njiro)	E	2023	7,045	0	3,523	3,523	0	0
72	Lindi	E	2023	6,630	0	3,315	3,315	0	0
73	Madaba	E	2023	6,840	0	3,420	3,420	0	0
74	Masasi	N	2023	25,990	0	12,995	12,995	0	0
75	Songea	E	2023	31,195	0	15,598	15,598	0	0
76	Tunduru	N	2023	27,370	0	13,685	13,685	0	0
77	Kigoma	E	2024	3,485	0	0	1,743	1,743	0
78	Sumbawanga	E	2024	5,790	0	0	2,895	2,895	0
79	Babati	E	2025	5,745	0	0	0	2,873	2,873
80	Bagamoyo	E	2025	36,680	0	0	0	18,340	18,340
81	Chalinze	E	2025	11,425	0	0	0	5,713	5,713
82	Geothermal A S/S	N	2025	6,305	0	0	0	3,153	3,153
83	Kigoma	E	2025	3,310	0	0	0	1,655	1,655
84	Kinyerezi	E	2025	1,870	0	0	0	935	935
85	Kyaka	E	2025	700	0	0	0	350	350
86	Masasi	E	2025	7,440	0	0	0	3,720	3,720
87	Mbeya	E	2025	11,685	0	0	0	5,843	5,843
88	Mkuranga	E	2025	42,580	0	0	0	21,290	21,290
89	Mpanda	N	2025	1,120	0	0	0	560	560
90	Mtwara	E	2025	10,820	0	0	0	5,410	5,410
91	Mwanza	E	2025	66,890	0	0	0	33,445	33,445
92	North DSM	N	2025	19,180	0	0	0	9,590	9,590
93	Nyakanazi	E	2025	1,430	0	0	0	715	715
94	Shinyanga	E	2025	7,050	0	0	0	3,525	3,525
95	Songea	E	2025	7,440	0	0	0	3,720	3,720
96	South DSM	N	2025	20,720	0	0	0	10,360	10,360
97	Southeast DSM	N	2025	20,720	0	0	0	10,360	10,360
98	Tunduru	E	2025	7,240	0	0	0	3,620	3,620
99	Geothermal A S/S	E	2026	935	0	0	0	0	468
100	Ibosa	N	2026	3,375	0	0	0	0	1,688
101	Iringa	E	2026	935	0	0	0	0	468
102	Lusu	E	2026	4,445	0	0	0	0	2,223
103	Nyamongo	E	2026	4,445	0	0	0	0	2,223
104	Tabora	E	2026	7,045	0	0	0	0	3,523
				(Thousand USD)	465,010				

Table 4-24: Phased substation cost estimates 2026-2030

No	Substation	New or Expansion	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)				
					2026	2027	2028	2029	2030
99	Geothermal A S/S	E	2026	935	468	0	0	0	0
100	Ibosa	N	2026	3,375	1,688	0	0	0	0
101	Iringa	E	2026	935	468	0	0	0	0
102	Lusu	E	2026	4,445	2,223	0	0	0	0
103	Nyamongo	E	2026	4,445	2,223	0	0	0	0
104	Tabora	E	2026	7,045	3,523	0	0	0	0
105	Bagamoyo	E	2027	935	468	468	0	0	0
106	Kyaka	E	2027	700	350	350	0	0	0
107	Kisada	E	2028	7,870	0	3,935	3,935	0	0
108	Kyela	N	2028	8,445	0	4,223	4,223	0	0
109	Mbeya	E	2028	15,975	0	7,988	7,988	0	0
110	Mnyera	N	2028	52,400	0	26,200	26,200	0	0
111	Musoma	E	2028	4,445	0	2,223	2,223	0	0
112	Songwe Hydro_B S/S	N	2028	4,560	0	2,280	2,280	0	0
113	Arusha (Njiro)	E	2029	7,045	0	0	3,523	3,523	0
114	Bagamoyo	E	2029	16,665	0	0	8,333	8,333	0
115	Segera	E	2029	9,935	0	0	4,968	4,968	0
116	Arusha (Njiro)	E	2030	10,375	0	0	0	5,188	5,188
117	Bagamoyo	E	2030	2,090	0	0	0	1,045	1,045
118	Bunda	E	2030	4,445	0	0	0	2,223	2,223
119	Kigoma	E	2030	6,225	0	0	0	3,113	3,113
120	Kinyerezi	E	2030	1,870	0	0	0	935	935
121	Kyaka	E	2030	4,445	0	0	0	2,223	2,223
122	Lindi	E	2030	6,225	0	0	0	3,113	3,113
123	Madaba	E	2030	6,225	0	0	0	3,113	3,113
124	Mkuranga	E	2030	2,975	0	0	0	1,488	1,488
125	Mlandizi	E	2030	12,790	0	0	0	6,395	6,395
126	Mnyera	E	2030	935	0	0	0	468	468
127	Morogoro	E	2030	5,745	0	0	0	2,873	2,873
128	Mpanda	E	2030	7,050	0	0	0	3,525	3,525
129	Mpa-Tab SwS	E	2030	27,330	0	0	0	13,665	13,665
130	Mtwara	E	2030	10,670	0	0	0	5,335	5,335
131	North DSM	E	2030	1,870	0	0	0	935	935
132	Shinyanga	E	2030	7,890	0	0	0	3,945	3,945
133	Somanga Fungu	E	2030	14,065	0	0	0	7,033	7,033
134	Southeast DSM	E	2030	12,245	0	0	0	6,123	6,123
135	Tab-Mpa SwS	N	2030	27,330	0	0	0	13,665	13,665
136	Tabora	E	2030	57,250	0	0	0	28,625	28,625
137	West DSM	N	2030	20,720	0	0	0	10,360	10,360
138	Mkuranga	E	2031	6,420	0	0	0	0	3,210
139	Mku-Som SwS-1	N	2031	17,990	0	0	0	0	8,995
140	Mku-Som SwS-2	N	2031	17,990	0	0	0	0	8,995
141	Somanga Fungu	E	2031	6,820	0	0	0	0	3,410
142	Tanga	E	2031	4,445	0	0	0	0	2,223
				(Thousand USD)	417,163				

Table 4-25: Phased substation cost estimates 2031-2035

No	Substation	New or Expansion	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)				
					2031	2032	2033	2034	2035
138	Mkuranga	E	2031	6,420	3,210	0	0	0	0
139	Mku-Som SwS-1	N	2031	17,990	8,995	0	0	0	0
140	Mku-Som SwS-2	N	2031	17,990	8,995	0	0	0	0
141	Somanga Fungu	E	2031	6,820	3,410	0	0	0	0
142	Tanga	E	2031	4,445	2,223	0	0	0	0
143	Arusha (Njiro)	E	2032	16,841	8,421	8,421	0	0	0
144	Ibosa	E	2032	935	468	468	0	0	0
145	Lusu	E	2032	4,445	2,223	2,223	0	0	0
146	Madaba	E	2032	935	468	468	0	0	0
147	Mufindi	E	2032	935	468	468	0	0	0
148	Masasi	E	2033	6,225	0	3,113	3,113	0	0
149	Mbeya	E	2033	935	0	468	468	0	0
150	Mnyera	E	2033	16,945	0	8,473	8,473	0	0
151	Mwanza	E	2033	7,045	0	3,523	3,523	0	0
152	Nyamongo	E	2033	4,445	0	2,223	2,223	0	0
153	Somanga Fungu	E	2033	4,400	0	2,200	2,200	0	0
154	Tabora	E	2033	7,045	0	3,523	3,523	0	0
155	Tunduru	E	2033	6,225	0	3,113	3,113	0	0
156	Chalinze	E	2034	4,020	0	0	2,010	2,010	0
157	Kihansi	E	2034	935	0	0	468	468	0
158	Madaba	E	2034	935	0	0	468	468	0
159	Nyakanazi	E	2034	9,475	0	0	4,738	4,738	0
160	Shinyanga	E	2034	14,090	0	0	7,045	7,045	0
161	Songwe Hydro_A S/S	N	2034	4,080	0	0	2,040	2,040	0
162	Songwe Hydro_B S/S	E	2034	1,400	0	0	700	700	0
163	Arusha (Njiro)	E	2035	17,015	0	0	0	8,508	8,508
164	Babati	E	2035	5,745	0	0	0	2,873	2,873
165	Bulyanhulu	E	2035	1,870	0	0	0	935	935
166	Bunda	E	2035	1,870	0	0	0	935	935
167	Buzwagi	E	2035	1,870	0	0	0	935	935
168	Chalinze	E	2035	20,195	0	0	0	10,098	10,098
169	Kigoma	E	2035	18,820	0	0	0	9,410	9,410
170	Kinyerezi	E	2035	16,435	0	0	0	8,218	8,218
171	Kyaka	E	2035	3,270	0	0	0	1,635	1,635
172	Mkuranga	E	2035	2,975	0	0	0	1,488	1,488
173	Mpanda	E	2035	6,225	0	0	0	3,113	3,113
174	Mtibwa	E	2035	3,690	0	0	0	1,845	1,845
175	Mtwara	E	2035	4,445	0	0	0	2,223	2,223
176	Musoma	E	2035	1,870	0	0	0	935	935
177	Mwanza	E	2035	5,525	0	0	0	2,763	2,763
178	North DSM	E	2035	12,245	0	0	0	6,123	6,123
179	Nyakanazi	E	2035	26,850	0	0	0	13,425	13,425
180	Nyamongo	E	2035	935	0	0	0	468	468
181	Rusumo	E	2035	935	0	0	0	468	468
182	Segera	E	2035	26,155	0	0	0	13,078	13,078
183	Shinyanga	E	2035	32,715	0	0	0	16,358	16,358
184	Somanga Fungu	E	2035	9,760	0	0	0	4,880	4,880
185	South DSM	E	2035	12,245	0	0	0	6,123	6,123
186	Southeast DSM	E	2035	12,245	0	0	0	6,123	6,123
187	Sumbawanga	E	2035	6,225	0	0	0	3,113	3,113
188	West DSM	E	2035	12,245	0	0	0	6,123	6,123
189	Chalinze	E	2036	8,500	0	0	0	0	4,250
190	Lusu	E	2036	4,445	0	0	0	0	2,223
191	Mtwara	E	2036	9,280	0	0	0	0	4,640
192	Musoma	E	2036	4,445	0	0	0	0	2,223
193	Songea	E	2036	6,225	0	0	0	0	3,113
194	Tanga	E	2036	4,445	0	0	0	0	2,223
				(Thousand USD)	422,169				

Table 4-26: Phased substation cost estimates 2036-2040

No	Substation	New or Expansion	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)				
					2036	2037	2038	2039	2040
189	Chalinze	E	2036	8,500	4,250	0	0	0	0
190	Lusu	E	2036	4,445	2,223	0	0	0	0
191	Mtwara	E	2036	9,280	4,640	0	0	0	0
192	Musoma	E	2036	4,445	2,223	0	0	0	0
193	Songea	E	2036	6,225	3,113	0	0	0	0
194	Tanga	E	2036	4,445	2,223	0	0	0	0
195	Arusha (Njiro)	E	2037	10,375	5,188	5,188	0	0	0
196	Kyaka	E	2037	4,445	2,223	2,223	0	0	0
197	Mbeya	E	2037	15,975	7,988	7,988	0	0	0
198	Mwanza	E	2037	7,045	3,523	3,523	0	0	0
199	Nyamongo	E	2037	4,445	2,223	2,223	0	0	0
200	Tabora	E	2037	7,045	3,523	3,523	0	0	0
201	Arusha (Njiro)	E	2038	7,045	0	3,523	3,523	0	0
202	Shinyanga	E	2038	7,045	0	3,523	3,523	0	0
203	Somanga Fungu	E	2038	4,400	0	2,200	2,200	0	0
204	Chalinze	E	2039	10,805	0	0	5,403	5,403	0
205	Nyakanazi	E	2039	9,475	0	0	4,738	4,738	0
206	Arusha (Njiro)	E	2040	47,280	0	0	0	23,640	23,640
207	Bagamoyo	E	2040	8,580	0	0	0	4,290	4,290
208	Chalinze	E	2040	72,205	0	0	0	36,103	36,103
209	Dodoma	E	2040	64,465	0	0	0	32,233	32,233
210	Iringa	E	2040	21,150	0	0	0	10,575	10,575
211	Kigoma	E	2040	8,060	0	0	0	4,030	4,030
212	Kin-Som SwS1	E	2040	56,910	0	0	0	28,455	28,455
213	Kin-Som SwS2	E	2040	14,280	0	0	0	7,140	7,140
214	Kin-Som SwS3	E	2040	44,370	0	0	0	22,185	22,185
215	Kinyerezi	E	2040	50,320	0	0	0	25,160	25,160
216	Kisada	E	2040	36,360	0	0	0	18,180	18,180
217	Lusu	E	2040	935	0	0	0	468	468
218	Mbe-Sum SwS	E	2040	7,760	0	0	0	3,880	3,880
219	Mbeya	E	2040	36,540	0	0	0	18,270	18,270
220	Mkuranga	E	2040	55,380	0	0	0	27,690	27,690
221	Mku-Som SwS-1	E	2040	17,700	0	0	0	8,850	8,850
222	Mku-Som SwS-2	E	2040	48,540	0	0	0	24,270	24,270
223	Mlandizi	E	2040	4,445	0	0	0	2,223	2,223
224	Mpanda	E	2040	37,680	0	0	0	18,840	18,840
225	Mpa-Sum SwS	E	2040	46,080	0	0	0	23,040	23,040
226	Mpa-Tab SwS	E	2040	17,080	0	0	0	8,540	8,540
227	Mtwara	E	2040	5,160	0	0	0	2,580	2,580
228	Mwanza	E	2040	8,945	0	0	0	4,473	4,473
229	North DSM	E	2040	24,490	0	0	0	12,245	12,245
230	Nyakanazi	E	2040	19,775	0	0	0	9,888	9,888
231	Rusumo	E	2040	935	0	0	0	468	468
232	Segera	E	2040	27,810	0	0	0	13,905	13,905
233	Shinyanga	E	2040	58,550	0	0	0	29,275	29,275
234	Singida	E	2040	21,490	0	0	0	10,745	10,745
235	Somanga Fungu	E	2040	12,460	0	0	0	6,230	6,230
236	South DSM	E	2040	24,490	0	0	0	12,245	12,245
237	Sumbawanga	E	2040	27,420	0	0	0	13,710	13,710
238	Tab-Mpa SwS	E	2040	17,080	0	0	0	8,540	8,540
239	Tabora	E	2040	60,890	0	0	0	30,445	30,445
240	West DSM	E	2040	13,180	0	0	0	6,590	6,590
				(Thousand USD)	1,125,565				

4.9.1 Summary of cost estimate

The overall phased costs for the transmission lines, transformers, substation and reactive power compensation over the planning horizon (2016-2040) are summarized in Table 4-27 below;

Table 4-27: Cost Estimate Summary

Cost of	Option, MUSD					Total
	2015-2020	2021-2025	2025-2030	2031-2035	2036-2040	
Transmission Lines	3,717	814	714	1,197	152	6,593
Substation	1,207	465	417	422	1,126	3,637
Total	4,925	1,279	1,131	1,619	1,277	10,230
% of Each Period	48%	12%	11%	16%	12%	100%

4.9.2 Connection of Isolated Network to the National Grid

The current independent network system is expected to connect to the national grid in accordance with the transmission project. The connection plans are summarized in Table 4-28 below;

Table 4-28: Plan for Connection of Isolated Network to the National Grid

Region	Isolated area	Source of Power/Fuel	Installed Capacity (MW)	Earliest Connection to the Nation Grid (Year)	Transmission Project Name
Kagera	Biharamulo	Diesel/HFO	0.85	2018	Geita - Nyakanazi
	Ngara	Diesel/HFO	0.75	2018	Masaka-Ngara-Rusumo
	Bukoba	Diesel/HFO	2.56	2018	Masaka-Ngara-Rusumo
Kigoma	Kibondo	Diesel/HFO	2.50	2020	North West Grid
	Kasulu	Diesel/HFO	2.50	2020	North West Grid
	Kigoma town	Diesel/HFO	12.48	2020	North West Grid
Pwani	Mafia	Diesel/HFO	2.13	2018	Somangafungu - Kinyerezi
Lindi	Somanga	Gas	7.50	2018	Somangafungu - Kinyerezi
	Liwale	Diesel/HFO	0.85	2023	Mtwara -Songea
Ruvuma	Songea	Diesel/HFO	8.10	2018	Makambako - Songea
	Mbinga	Diesel/HFO	2.00	2018	Makambako - Songea
	Namtumbo	Diesel/HFO	0.34	2018	Makambako - Songea
	Tunduru	Diesel/HFO	1.98	2023	Mtwara - Songea
Mtwara	Mtwara GPP	Gas	18.00	2019	Dar - Somanga - Mtwara/Mtwara - Songea
Katavi	Mpanda	Diesel/HFO	3.60	2020	North West Grid
Rukwa	Sumbawanga	Diesel/HFO	5.00	2020	North West Grid
Njombe	Ludewa	Diesel/HFO	1.27	2018	Makambako - Songea
Arusha	Loliondo	Diesel/HFO	5.00	2018	REA extension (33kV Karatu -Mto wa Loliondo)
		Total	77.41		

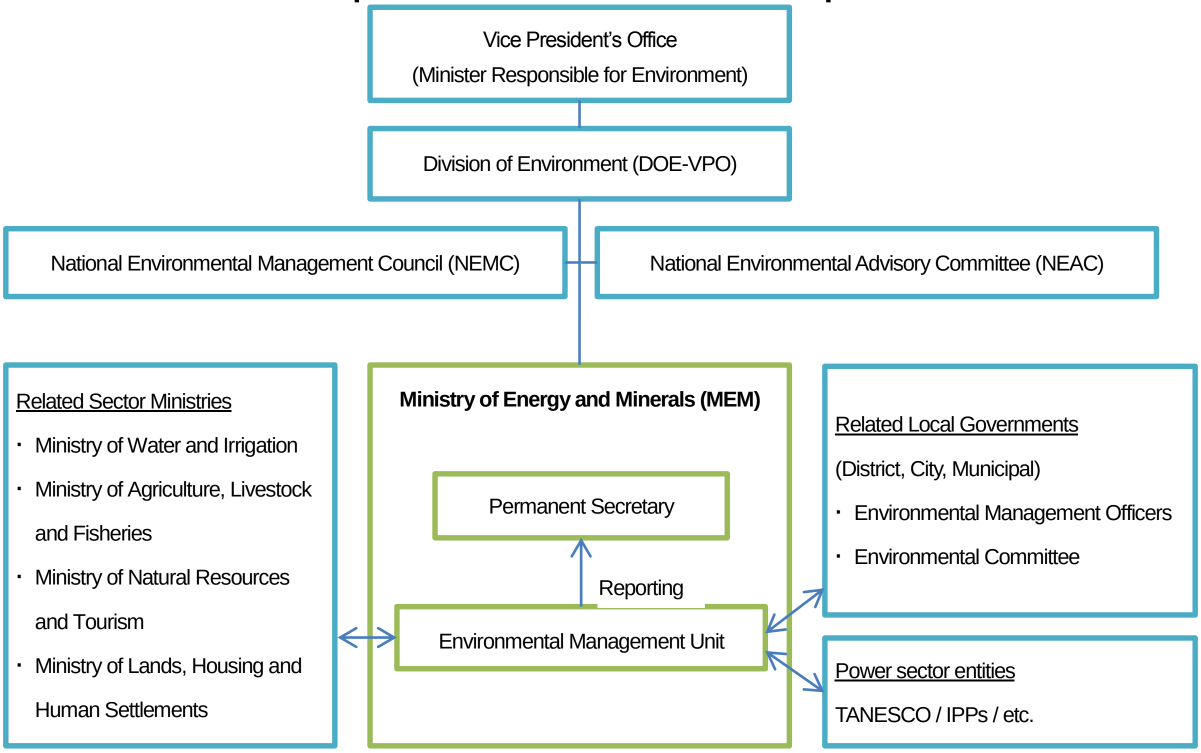
CHAPTER FIVE

5 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

5.1 Environmental Institutional Arrangement

The Environmental Management Act, 2004 sets up the institutional framework for environmental management in the country. The overall coordination and policy articulation of environmental management and provision of the central support functions are conferred to the Vice President's Office. The direct operational role on management of specific natural resources or environmental services such as water, agriculture, fisheries, forestry, wildlife, energy, mining, and waste management is conferred to sector ministries and local government authorities (LGAs). Figure below shows the institutional arrangement in relation to the implementation of the PSMP2016 Update.

Figure 5-1: Environmental Institutional Arrangement in relation to the implementation of the PSMP2016 Update



5.2 Legal Framework

Environmental management in Tanzania is guided by the National Environmental Policy, 1997, Environmental Management Act, 2004, National Environmental Action Plan (NEAP), 2013, and related sectorial polices and legal instruments. The followings are the major policies and legal framework related to implementing the PSMP2016 Update.

5.2.1 Policies

(a) **National Environmental Policy, 1997:** This policy provides the framework for making fundamental changes that are needed to mainstream environmental considerations into decision making in Tanzania. The policy provides guidelines for determining priority actions, and provides monitoring and regular review of polices, plans and programmes.

Relation to the PSMP: This policy is related to mainstreaming environmental considerations into decision making on PSMP implementation as well as the adoption of Environmental Impact Assessment (EIA) as a tool for screening development proposed projects in PMSP.

(b) **National Energy Policy, 2015:** It aims at improving the security of supply through effective use of energy resources; promotion of energy efficiency and conservation; facilitating the adoption of renewable energies technologies to increase its contribution to electricity generation mix; improving energy sector planning through integrated plans, ensuring that prudent environmental, social, health and safety considerations are factored in energy sector developments.

Relation to the PSMP: As a cross-cutting issue, promotion of environmental protection, health and safety management in the energy sector is stated in 4.2. Promotion of disaster prevention and response plans is part of this statement.

(c) **National Water Policy, 2002**: The main objective is to develop a comprehensive framework for sustainable development and management of the nation's water resources and putting in place an effective legal and institutional framework for its implementation. It emphasizes that water related activities are to be planned to enhance or to cause least detrimental effects on the environment.

Relation to the PSMP: Hydropower is still important power source and thermal power plants also use water for cooling. Sustainable water resource management is a key issue for the implementation of planned projects under PSMP2016 Update.

(d) **Wildlife Policy, 2007:** The Policy focuses on wildlife protection and conservation in order to ensure sustainability of wildlife ecosystems. Some of the objectives include establishment, maintenance and development of Protected Areas network in order to enhance biological diversity; conservation of wildlife and its habitats outside the core areas by establishing Wildlife Management Areas (WMAs); and conservation of Wetlands.

Relation to the PSMP: The planned projects under PSMP are located all over in Tanzania and it is necessary to consider wildlife habitat in locating the identified projects under PSMP2016 Update.

(e) **National Land Policy, 1997**: The overall aim of this policy is to address the various ever-changing land use needs and to promote or ensure a secure land tenure system; to encourage the optimal use of land resources and; to facilitate broad-based social and economic development without endangering the ecological balance of the environment.

Relation to the PSMP: PSMP involves land use change and it is necessary to consider optimal land use in implementing the projects under PSMP2016 Update.

(f) **National Health Policy, 2007**: The overall objective of this policy is to improve the health and well-being of all Tanzanians. In line with environmental health, the Policy seeks to protect community health, emphasizing on community adherence to environmental health standards; improvement of waste management system.

Relation to the PSMP: All the projects proposed under PSMP2016 Update have considered mitigation measures for air emission and waste generation which would affect human health.

(g) **National Human Settlements Development Policy, 2000:** This policy stresses on the need for ensuring that human settlements are kept clean and pollution effects of solid and liquid wastes do not endanger the health of residents.

Relation to the PSMP: All the projects proposed under PSMP2016 Update have considered mitigation measures for the impact on human settlement or urban environment.

5.2.2 Legislation

(a) **The Environmental Management Act, 2004:** The act is a framework environmental law which provides for legal and institutional framework for sustainable management of the environmental and natural resources in the country. It includes provisions for institutional roles and responsibilities with regard to environmental management; Environmental Impact Assessments (EIA); Strategic Environmental Assessments (SEA); pollution prevention and control; waste management; environmental standards. Between 2005 and 2013, a total of 21 regulations have been developed to facilitate implementation of the Act. Some of them are as follows.

Table 5-1: List of Environmental Management Regulation

Category	Environmental Management Regulation
Environmental management framework	· Environmental Impact Assessment and Audit Regulations (2005) · Strategic Environmental Assessment Regulations (2009) · Environmental Inspectors Regulations (2011) · Registration of Environmental Experts Regulations (2005)
Air quality and Noise	· Air Quality Standards Regulations (2007) · Noise and Vibrations Standards Regulations (2009)
Water quality	· Water Quality Standards Regulations (2007)
Soil quality	· The Soil Quality Standards Regulations (2007)
Waste management	· Hazardous Waste Management Regulations (2009) · Solid Waste Management Regulations (2009)

Relation to the PSMP: In implementing the identified projects under PSMP2016 Update, all necessary Acts and related regulations have to be taken into consideration.

(b) **Standards Act, 2009:** It provides for the promotion of the standardization of specifications of commodities and services, to re-establish the Tanzania Bureau of Standards (TBS) and to provide better provisions for the functions, management and control of the Bureau. Some of the TBS related standards are: TZS 825:2012 (Air quality-Specification), TZS 860:2006 (Municipal and industrial wastewaters – General tolerance limits for municipal and industrial wastewaters), TZS 932:2007 (Acoustics – General tolerance limits for environmental noise), TZS 972:2007 (Soil quality – Limits for soil contaminants in habitat and agriculture).

Relation to the PSMP: All the projects identified under PSMP2016 Update have been taken into consideration the necessary environmental standards to ensure the implementation of PSMP is in compliance with such standards.

(c) **Land Act, 1999:** It provides for the basic law in relation to land other than the village land, the management of land, settlement of disputes and related matters. The Land Act,1999 relates to land-use planning processes and land-use management and guidance to land ownership in Tanzania. Acquisition of way leave is governed by this Act.

Relation to the PSMP: The projects identified under PSMP2016 Update is expected to involve the land acquisition and it needs to be in line with this Act.

(d) **Village Land Act, 1999:** The Village Land Act was enacted specifically for the administration and management of land in villages. Under the provisions of this Act, the village council is responsible for the management of the village land.

Relation to the PSMP: PSMP implementation is expected to involve the rural land acquisition and it needs to be in compliance with this Act.

(e) **Land Acquisition Act, 1967**: Any land acquisition that shall be done during the implementation of PSMP shall be guided by this law. Under the Land Acquisition Act, 1967, the President may, subject to the provisions of this Act, acquire any land for any estate or term where such land is required for any public purpose.

Relation to the PSMP: The implementation of PSMP involves the rural and urban land acquisition and it needs to be in compliance with this Act.

(f) **Land Use Planning Act, 2007:** It provides for the procedures for the preparation, administration and enforcement of land use plans. Among the objectives of the Act as given in Section 4 are to facilitate the orderly management of land use and to promote sustainable land use practices.

Relation to the PSMP: PSMP is expected to affect land use and livelihood therefore shall comply with the provisions of this Act. If there is any conflict with existing land use plans, shall need consultation with land use planning authorities.

(g) **Water Resources Management Act, 2009**: It provides the legal framework for the management of water resources within the integrated water resource management (IWRM) framework including environmental flow of rivers. It provides for pollution control and issues discharge permits of effluents to water bodies. **Dam Safety Regulation, 2013** under this Act is also related to hydropower.

Relation to the PSMP: Hydropower projects planned under this PSMP2016 Update consists of 20% of the generation mix by the year 2040 and all of them are to be implemented under this Act.

(h) **Forest Act, 2002**: It provides for the management of forests, to repeal certain laws relating to forests and for related matters. Forest reserves and Mangrove forest reserves are established based on this act.

Relation to the PSMP: Gas-fired thermal power plants are expected to be located along the coastal area where mangrove reserves are also located. Forest reserves are also considered in siting the PSMP components including transmission lines.

(i) **Wildlife Conservation Act, 2013**: It provides for the conservation of wildlife and ensures protection, management and sustainable utilization of wildlife resources, habitats, ecosystems and the non-living environment supporting such resources, habitats or ecosystems. Game Reserves, Game controlled areas, corridor areas, buffer zones are established based on this Act.

Relation to the PSMP: The planned projects under PSMP are located all over in Tanzania and it is necessary to consider wildlife habitat in locating the identified projects under PSMP2016 Update.

(j) **National Parks Act, 2002**: The Act provided for the establishment, control and management of national parks in the country. Tanzania National Parks Authority (TANAPA) is governed by this Act. This Act avoids or prohibits developments of projects within the national parks.

Relation to the PSMP: If any projects planned under PSMP2016 Update are expected to have impact on National Parks, it is subjected to this Act.

(k) **Marine Parks and Reserves Act, 1994**: It provides for management of marine and coastal areas so as to promote sustainability of existing resource use, and the recovery of areas and resources. Marine parks and reserves are established based on this Act.

Relation to the PSMP: Gas-fired thermal power plants are expected to be located along the coastal area and if PSMP components are expected to have impact on Marine Parks and reserves, it is subjected to this Act.

(l) **Energy and Water Utilities Regulatory Authority Act, 2001:** EWURA is an autonomous multi-sectoral regulatory authority and is responsible for technical and economic regulation of the electricity, petroleum, natural gas and water sectors in Tanzania.

Relation to the PSMP: EWURA as a regulatory authority for electricity needs to take into account the need to protect and preserve the environment based on this Act.

(m) **Electricity Act, 2008**: It provides for the facilitation and regulation of generation, transmission, transformation, distribution, supply and use of electric energy to provide for cross-border trade in electricity and the planning and regulation of rural electrification and related matters.

Relation to the PSMP: The Act stipulates obligations of the licensee and it is required to take into account a need to preserve natural beauty, flora and fauna, buildings and sites of geological, archaeological or cultural significance. It also stipulates the access to land for installations, acquisition of wayleaves and land and related compensation.

(n) **Petroleum Act, 2015**: It covers both oil and natural gas and has health & safety regulation in PART VI, and environmental principles in PART VII. It provides a comprehensive framework to regulate oil and gas development in petroleum value chain (up-stream, mid-stream and down-stream activities).

Relation to the PSMP: According to the generation mix target of the PSMP, 40% is expected to be sourced from gas-fired power plants. This Act is related to regulate natural gas supply to power plants.

5.3 Major potential impacts

In revising the PSMP, the following six different generation mix scenarios were considered as indicated in Table 5-2. Considering various aspects such as the investment and operational cost, energy security perspective, and the potential environmental and social impacts, then PSMP2016 Update adopted scenario 2 which is consisted of 40% of energy from gas-fired thermal power, 35% from coal-fired thermal power, 20% from hydropower, and 5% from others including renewables.

Table 5-2: Generation Mix Scenarios in 2040 for the PSMP

Scenario	Generation Mix			
	Gas	Coal	Hydro	Renewables and others*
Scenario 1	50%	25%	20%	5%
Scenario 2	40%	35%	20%	5%
Scenario 3	35%	40%	20%	5%
Scenario 4	25%	50%	20%	5%
Scenario 5	50%	35%	10%	5%
Scenario 6	40%	30%	20%	10%

*: Renewables and others include solar, wind, biomass, geothermal and power import.

The potential impacts in implementing the PSMP, based on the selected power generation mix, are as follows:

5.3.1 Air emission and pollution

Under the power generation mix target, coal plays an essential role in the national energy mix. The primary emissions to air from the combustion of fossil fuels including coal are sulfur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM), carbon monoxide (CO), and greenhouse gases (GHG) such as carbon dioxide (CO_2).

The estimated emissions of GHG, SO_2 and NOx in implementing the PSMP are shown in Figure 5-2 and Figure 5-3. The amount of emissions was estimated based on the projected annual fuel consumption and related guidelines, namely, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," and "EMEP/EEA air pollutant emission inventory guidebook 2013."

During the study period of 25 years up to 2040, emissions of GHG increases from 3.4 million tonnes to 46.0 million tonnes (by 13.5 times) and NOx from 6.3 thousand tonnes to 78.6 thousand tonnes (by 12.5 times). SOx releases increase from 37.8 thousand tonnes in 2020 to 256.9 thousand tonnes in 2040 (by 6.8 times) if abatement is not considered. Air pollution contributes to the incidence of respiratory diseases. The impact radius is usually within about 10 km to 20 km from the thermal power plant. The impact radius varies depending on the geography, the wind and the height of the gas emission source. The level of impacts on human health, the ecology and others also varies depending on the proportion of polluted airs in the air and the density of the pollution sources.

Pollutants like Sulphur Oxide (SOx) and Nitrogen Oxide (NOx) contribute to the incidence of acid rain or acidification. It could cause impacts on freshwater aquatic ecosystems, vegitation and drinking water. The acidification of soils can also have an adverse impact on agricultural productivity.

Figure 5-2a: Estimated GHG emission in implementing PSMP (comparison of senarios)

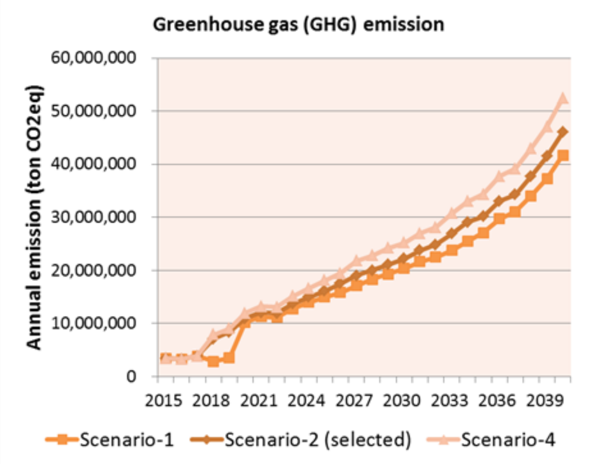


Figure 5-2b: Estimated GHG emission in implementing PSMP (scenario-2 by source)

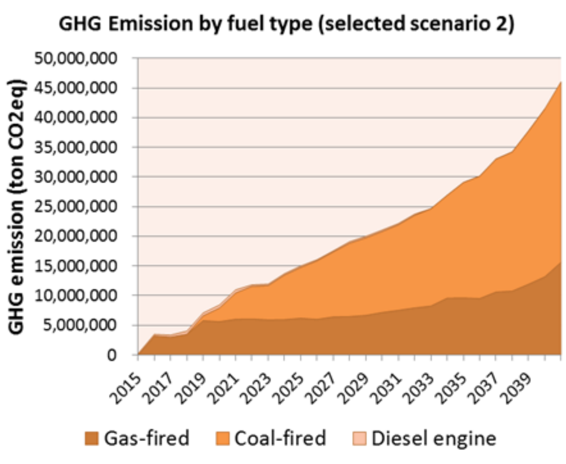


Figure 5-3a: Estimated SOx emissions in impelmenting PSMP(comparison of scenarios)

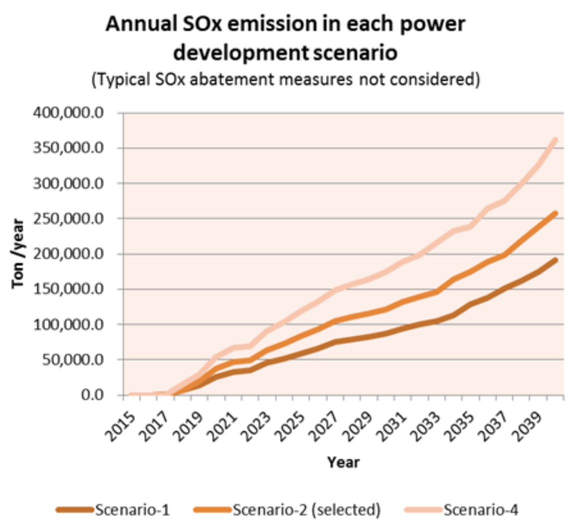


Figure 5-3b: Estimated SOx emission in implementing PSMP (scenario-2 by source)

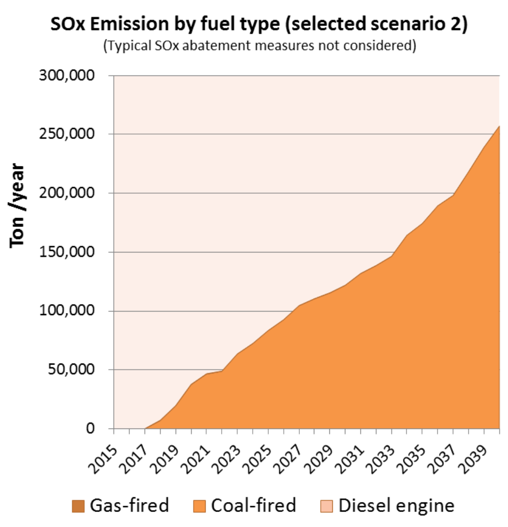


Figure 5-4a: Estimated NOx emissions in impelmenting PSMP

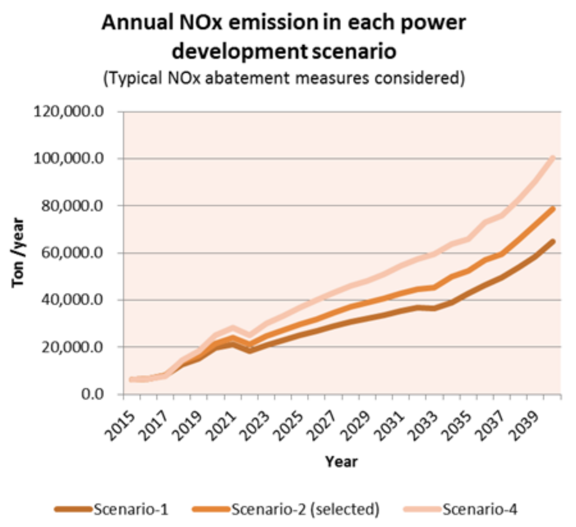
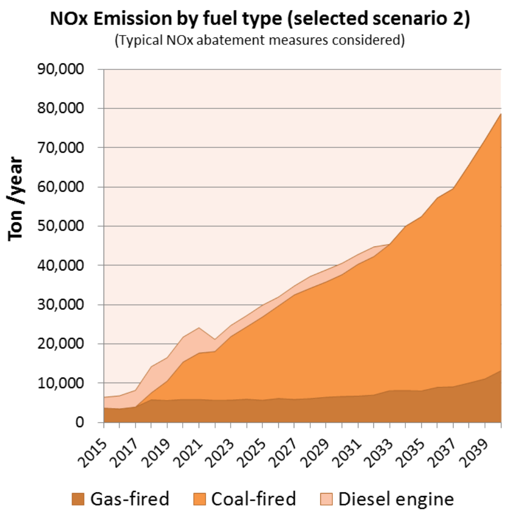


Figure 5-4b: Estimated NOx emission in implementing PSMP (scenario-2 by source)



5.3.2 Water use

Since many of the proposed hydropower plants are located in Rufiji Basin, which is the largest basin in Tanzania covering 20.1% of mainland Tanzania, it is recommended to coordinate and harmonize the water use in the Basin with other water user such as domestic and irrigation use. It is projected that the human water demand in agricultural and domestic use would increase in the most of the sub-basins of Rufiji Basin. This human water use demand could affect the hydropower generation downstream.

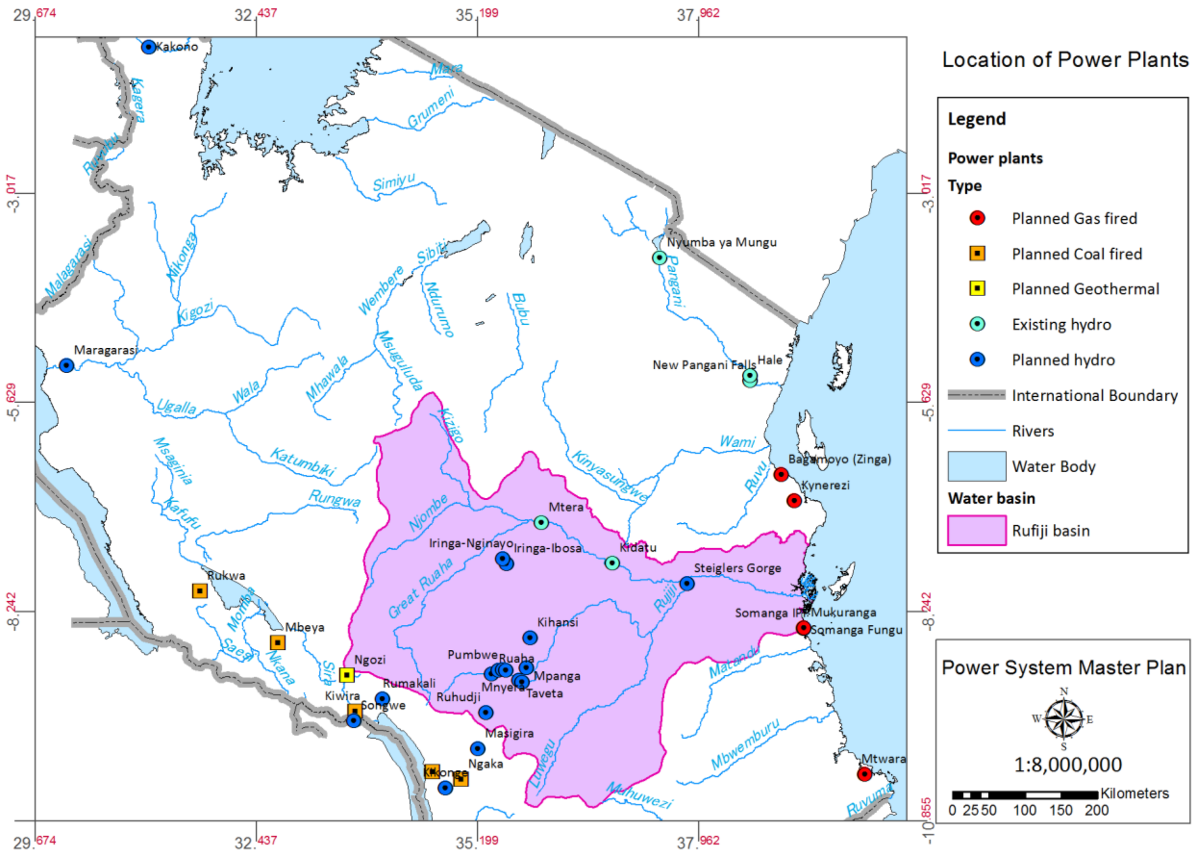
Furthermore, catchment degradation resulting from indiscriminate tree cutting for fuel and poor agricultural practices among others have caused land degradation at many places in Tanzania resulting into increased sedimentation and reduced dry season flows.

According to Tanzania Hydropower Sustainability Assessment: Hydropower Vulnerability Report (MEM, World Bank, 2014), improved operation of both irrigation and hydropower schemes are essential in Tanzania. It has shown that the development of hydropower, as well as the expansion of irrigation, can both be achieved if well-planned and operated.

5.3.3 Water quality

(a) **Hydropower:** The damming of rivers can cause water quality deterioration due to the reduced oxygenation and dilution of pollutants, flooding of biomass and resulting underwater decay, and/or reservoir stratification (where deeper lake waters lack oxygen). Where poor water quality would result from the decay of flooded biomass, selective forest clearing within the impoundment area should be completed before reservoir filling.

Figure 5-5: Location of planned power plants of the PSMP

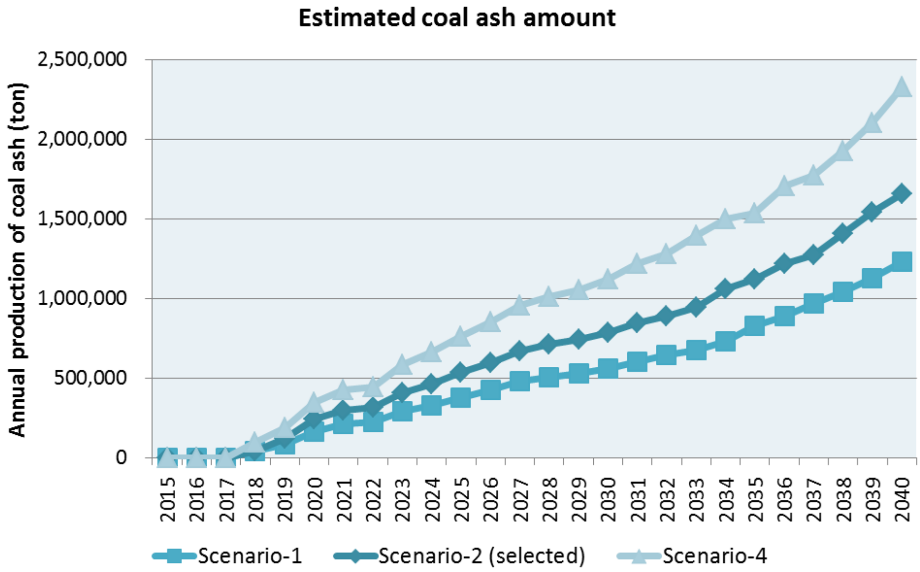


(b) **Thermal power:** Thermal power stations require large quantities of cooling water for their thermal powers, with temperature increases of about 3 to 8 degrees when released. Main impact of cooling water discharge is the temperature increases that may affect aquatic organisms, including phytoplankton, zooplankton, fish, crustaceans, shellfish, and many other forms of aquatic life. Wastewater discharges from thermal power plants carry variable amounts of pollutants depending on the types of thermal plant. If not properly treated, wastewater discharges from thermal power plants tend to cause pollution to surface water.

5.3.4 Waste generation

Coal ash produced from the coal combustion process in thermal power plants accounts for the largest proportion of solid waste. As the number and capacity of the coal thermal power plants increases, the amount of coal ash produced from the power plants also increases. In PSMP2016 Update, the amount of solid waste (coal ash) from thermal power production is estimated about 0.24 million tonnes in 2020 and 1.36 million tonnes in 2040. It increases by 6.8 times from 2020 to 2040. The land area required for managing solid waste will increase accordingly; therefore appropriate management of coal ash is required for implementing planned projects. If coal ash is not managed properly, it can cause serious impacts on water resources and air pollution in waste dump areas because coal ash contains a few lethal substances such as heavy metals.

Figure 5-6: Estimated coal ash amount in implementing the PSMP



5.3.5 Natural Environment

(a) **Thermal power plants:** Gas-fired power plants are planned along the coastal area of Tanzania, while coal power plants are planned in the southwestern part of Tanzania nearby coal mining sites. Mangrove forests and coral reefs are located along the coastal area and the areas for fishing are also identified in these area. Water withdrawal and discharge would have potential impacts on these habitat and fishery activity.

(b) **Hydropower:** Hydropower projects often have major effects on fish and other aquatic life and reservoirs permanently flood natural habitats. The presence of a hydro dam can cause changes to river ecology downstream due to changes in water flow (in both volume flow rate and time), water chemical properties, physical structure of the river bed and river basin, and the hydrological connectivity between upstream and downstream water. Chemical and physical changes to the river often lead to ecological changes, notably the loss of high economic value fauna and flora that local residents use as food, construction materials, and effects on other entertainment, tourism and cultural purposes.

(c) **Transmission lines:** Construction of transmission lines may result in alteration and disruption to terrestrial habitat, including impacts to avian species depending on the characteristics of existing vegetation, topographic features, and installed height of the transmission lines. It includes fragmentation of forested habitat; loss of wildlife habitat, therefore it is necessary to identify which transmission line passes through areas of biodiversity interest and forest area. Large birds are sometimes killed in collisions with power lines, or by electrocution. Multiple transmission lines closer to important bird areas like Kilombero valley, south coast corridor from Mtwara to Dar es Salaam and southern highland areas could interfere free flying zone particularly for migratory birds.

5.3.6 Social impacts

(a) PSMP contains plans for the significant improvement and extension of the transmission grid across the country. These investments are essential for the continued development and improvement of power supply system; however, their construction and the associated land clearance would have socio-economic impacts including the displacement of affected people and crop clearance. According to the way-leave requirements, 50 meter clearance for 400kV lines, 35 meter clearance for 220kV lines, and 27 meter clearance for 132kV lines are required. Issues associated with transmission line include significant land take to allow establishment of way leave for transmission line.

(b) Since there is diversity of sources with varying generation capacity, there will be varying magnitude of impacts on land acquisition for specific power plant. Hydropower development could affect the current livelihood of the local people due to dam inundation and water flow change.

5.4 Mitigation measures to potential impacts

5.4.1 Thermal power:

(a) Particular care needs to be taken when planning and selecting the site of thermal power plants to (i) ensure that the quantities of water used will not disrupt local hydrological conditions and (ii) avoid locations where cooling waters will be released close to or affecting areas of high ecological and biodiversity value or sensitivity: especially areas such as mangroves and coral reefs that are extremely sensitive to water temperature changes. The coastal location of many thermal power plants means that this is a particularly sensitive issue and it is to be assessed in project EIAs.

(b) Measures to prevent, minimize, and control environmental impacts associated with water withdrawal should be established based on the results of a project EIA and EMP, considering the availability and use of water resources locally and the ecological characteristics of the project affected area.

(c) All waste water from thermal power plants should be collected, and thoroughly recycled or treated before discharging into receiving water bodies. Wastewater with high temperature should be cooled, recycled or treated before discharged into receiving bodies.

(d) It is necessary to assess the cumulative effects of cooling water of several power stations located near each other in project EIAs.

(e) Fly ash and other wastes should be disposed in an appropriate area such as designated landfills or as backfill on abandoned mines, while some amounts are recycled into useful products, such as briquettes, cement and building materials.

(f) Abatement technologies for air emissions are to be considered such as flue gas desulfurization (FGD) for SO_2, low NOx burners, a selective catalytic reduction (SCR) system, a selective noncatalytic reduction (SNCR) system, fabric filters and electrostatic precipitators (ESPs) for particulate matter, where necessary to meet the emission limits.

5.4.2 Hydropower:

(a) When affected people need to be relocated, resettlement plan needs to be appropriately implemented and monitored in order to ensure that the means for displaced people are to be established in a new location and they can gain access to adequate services and reconstruct their livelihoods. This cost should be considered as a part of project cost for hydropower sustainable development and social responsibility.

(b) In optimizing water releases from the turbines, it is necessary to consider adequate downstream water supply for riparian ecosystems, reservoir and downstream fish survival, reservoir and downstream water quality, aquatic weed and disease vector control, irrigation and other human uses of water, and downstream flood protection in addition to power generation.

(c) Environmental management plans for hydropower projects should specify environmental water releases.

5.4.3 Transmission lines:

(a) Under the legal requirement, acquisition of way leave is governed by the Land Act of 1999 and its Regulations of 2001, whereby full, fair and prompt compensation is required before land acquisition.

(b) Where possible, the use of higher voltage and multiple conductors per phase is recommended to reduce the number of lines. It is also recommended to use transmission lines that require less space for the safety corridor to save land and reduce risk of impacts.

(c) During project EIAs, attention should be paid on minimizing potential impacts when mapping transmission line routes including evaluation of the scale and level of ecosystem fragmentation.

(d) In areas with concentrations of vulnerable bird species, the top (grounding) wire should be made more visible by using plastic objects.

(e) Electrocution (mainly of large birds of prey) should be avoided through bird-friendly tower design and proper spacing of conducting wires.

5.4.4 Cross-cutting issue

5.4.4.1 Inter-ministerial cooperation for water resource management

Different institutions as shown in Table 5-3 are responsible for water use and its management at basin level. Therefore, these institutions should work closely for the benefit of efficient water resource management.

Table 5-3: Key institutions for sustainable water use for power generation

Roles	Responsible Institution
PSMP implementation including hydropower	Ministry of Energy and Minerals and TANESCO
Management of water bodies	Ministry of Water and Basin Water Offices
Allocation of water	Basin Water Offices
Catchment forest management	Ministry of Natural Resources and Tourism

Payment for Ecosystem Services (PES) for water management and erosion control is a potential measure to ensure sustainable water supply for power generation.

5.4.4.2 Land use change

The implementation of the planned projects under PSMP2016 Update involves the change of land use. During the implementation of project EIAs, the implications need to be understood in each locality and strategies developed in consultation with local communities to manage extra pressure on remaining resources such as agriculture, grazing and fishing rights.

5.5 Environmental Management and Monitoring

Objective: To ensure that the mitigation measures are implemented appropriately and to collect information on the changes of the environmental quality on a regular basis to identify any impacts on the environment caused by sub-component projects.

Institutional arrangement: In order to monitor and manage the environmental and social consideration in implementing the PSMP, the Environmental Management Unit of MEM should work collaboratively with TANESCO, other sub-project owners, and related institutions.

Monitoring: The project owners should take charge of the monitoring of each project in accordance with project EIA and Environmental Management Plan (EMP). The Environmental Management Unit of MEM should conduct monitoring in cooperation with NEMC through reports submission.

Table 5-4: Potential key items for monitoring the projects under PSMP2016 Update

Category	Potential key monitoring item	Related component: Hydro power	Thermal power	Renew ables	Transmission line
Physical Environment					
Air quality	· Emission of SOx, NOx, PM · Emission of GHG (ton-CO2eq/year) · Ambient air quality		✓	✓ e.g. Geothermal Biomass	
Water quality	· Temperature of discharged cooling water from thermal power plants · Temperature of ambient water (river, lake, coastal area) · Discharged wastewater quality · Waste water recycling	✓	✓	✓ e.g. Geothermal	
Waste	· Amount of coal ash waste generated (ton/year)		✓		
Natural Environment					
Natural habitat	· Interference with habitats · Impacts on ecosystems and sensitive areas including national parks, nature reserves, wetlands, wildlife habitat, forest area, etc.	✓	✓	✓	✓
Vegetation	· Vegetation clearance (ha)	✓	✓	✓	✓
Social Environment					
Land acquisition	· Implementation of resettlement plan, compensation of affected persons	✓	✓	✓	✓
Water use	· Acquisition of water use permit · Water withdrawal (m^3/s) of thermal power plants · Number of conflicts on water reported · Number of water users within the project area	✓	✓	✓	
Access to electricity	· % of access to electricity · Electricity consumption (kWh/capita)	✓	✓	✓	✓

Reporting: The Environmental Management Unit of MEM reports to the Permanent Secretary of Energy and Minerals on the status of environmental and social consideration in implementing the projects outlined under PSMP2016 Update including implementation progress of mitigation measures and changes in environmental quality referring to the relevant regulations and environmental standards in Tanzania.

CHAPTER SIX

6 ECONOMIC AND FINANCIAL ANALYSIS

This chapter presents economic and financial analysis of the proposed power investment plan. It identifies planning criteria used in the analysis that covers three major themes, namely:

a) A financial analysis of the proposed generation and transmission expansion plans

b) An estimate of the long-run marginal cost of generation, transmission, distribution and debt balance; and

c) An assessment of whether and when the isolated load centers should be connected to the main grid

Furthermore, the chapter shows the project costs and returns involved in the implementation of the proposed plan so that the players can identify the projects to implement either independently or in partnership. The modality of implementing these projects can either be purely Government or purely private sector or in partnership (PPP). The Government‘s role in this respect will be two folds: to mobilize financial resources to implement some of the earmarked projects and to create conducive environment of attracting investors in the power sector. In additional, this chapter also analyzes economics of interconnecting the isolated load centers as well as estimating long run marginal cost.

6.1 Main Assumptions

6.1.1 Discount rate

The discount rate may be considered as the time value of money, and is used to calculate the present value of a series of future costs. The selection of an appropriate discount rate value should reflect the opportunity cost of capital, and therefore it tends to be higher in regions where capital is relatively scarcer. The choice of discount rate is discretionary. Use of a higher discount rate will tend to favor thermal plants in cost comparisons with hydro due to their lower initial costs, but higher yearly operating costs, while lower interest rates would favor hydroelectric plants, where most of the expenditures are at the beginning of the project cycle. A real discount rate of 10 percent (i.e. excluding inflation) was used in converting capital costs into equivalent annual costs over the life of an asset and for comparisons of unit generation costs for initial screening of options.

6.1.2 Debt Equity Ratio

The debt equity ratio of 70:30 is a standard ratio preferred by most financiers/banks, and has been adopted in this study. Although somehow it may be difficult for the project developers (in this case, the Government and/or private sector) to raise such equity, it reflects their commitment towards implementation of the projects and its operations to be able to service the debt.

6.1.3 Interest Rate

Different source of finance have different cost of the loan to be offered. Loan interest rate is varied from 1.0% to 7.1% in the long-term borrowing of TANESCO. For the purpose of this document, an interest rate of 7 percent has been assumed which is considered to represent required return by the international investors for the Tanzanian government in the current international bond market.

6.1.4 Loan Condition

Different source of finance have different cost of the loan to be offered. For the purpose of this assignment, loan tenor for financing project is set at 14years with 4 years grace period.

6.1.5 Interest During Construction (IDC)

This is interest incurred directly as the result of investment cost obtain as loan. This has impact on the overall project cost as it is added on the project cost by capitalizing them. A 7% per annum equivalent to the interest rate has been assumed in calculating IDC of projects by WASP model based on the investment plan.

6.1.6 Inflation Rate on Capital Cost

The analyses and comparisons made in this PSMP process are based on constant prices of the year 2015. This constant price method avoids the assumption of the price escalation, as forecasting inflation rate in long term is not reliable. Also, price escalation of benefit and cost will be balance out if the escalation rate is the same for the both of them in this investment plan. Therefore, price escalation is not priced in this investment plan.

6.1.7 Discount Rate for Debt Stock

This is an interest rate to discount debt stock to GDP. Discount rate of 5% per annum is used for this assignment as this discount rate is used in "TANZANIA NATIONAL DEBT SUSTAINABILITY ANALYSIS, 2013", Ministry of Finance, Tanzania.

6.1.8 Method to calculate Internal Rate of Return (IRR)

Cash flow basis is used for calculating IRR as a standard methodology. Internal Rate of Return (IRR) is used to evaluate financial and economic viability of a project. IRR means a discount rate when NPV (Net Present Value) of a project becomes 0 (zero). NPV is the sum of annual cost and benefit of a project discounted to the base year (present time) using a discount rate.

$$\mathrm{NPV} = \sum_{i=1}^{n} (Bi - Ci)/(1+r)^{i}$$

Where:

n: Project life

Bi: Benefit of the project in year "*i*"

Ci: Cost of the project in year "*i*"

r: Discount rate

6.1.9 Foreign Exchange Rate

Tsh. 2200 against 1 US Dollar is used for this document. This value is calculated by analyzing the trend of the past period from June 2015 to November 2016.

6.1.10 Residual Value

Residual value of plants and facilities that still have operational value at year 2040 is counted in benefits for calculating IRR with residual value.

6.1.11 Income Tax

Tanzanian corporate tax rate of 30% is applied. Benefit exceeding cost is subject to be deducted by 30% tax in this investment plan.

6.2 Financial Analysis

This section presents the approach and results of the financial analysis. It follows from the economic analysis and long run marginal costs. The financial analysis looks at the overall Tanzanian PSMP from the financial point of view and takes into consideration the financing for the plan, the total amount of required debt and equity. During the financial forecast period the annual interest costs, repayment of debt, and project IRR and income taxes are presented.

6.2.1 Summary of Financial Analysis

The financing requirement to implement the PSMP (2016 – 2040) is about US$ 46.2 billion for capital cost, the breakdown of which is indicated in Table 6-1 below and details are presented in Appendix-1, 2 and 3. The financing of capital expenditures is given below and is based on the 70% debt and 30% equity financings for capital expenditures with IDC.

Table 6-1: Breakdown of Capital Costs including IDC and financing requirement (2016-2040, US Dollar million)

Capital Cost including IDC					Debt: Equity Ratio	
					0.7	0.3
Year	Generation	Transmission	Distribution	Annual Capital Cost	Financed by Debt	Financed by Equity
2016	142	215	9	366	256	110
2017	888	569	35	1,493	1,045	448
2018	1,674	952	63	2,688	1,882	807
2019	2,078	1,785	92	3,955	2,768	1,186
2020	1,771	1,400	76	3,247	2,273	974
2021	328	57	9	394	276	118
2022	1,017	321	32	1,370	959	411
2023	968	296	30	1,294	906	388
2024	896	337	29	1,262	883	379
2025	1,332	322	39	1,692	1,185	508
2026	1,030	23	25	1,078	755	323
2027	1,816	114	45	1,974	1,382	592
2028	2,043	128	51	2,221	1,555	666
2029	1,831	408	52	2,291	1,604	687
2030	2,437	497	67	3,002	2,101	901
2031	2,031	131	49	2,211	1,547	663
2032	2,051	78	47	2,175	1,523	653
2033	2,366	87	56	2,508	1,756	753
2034	1,411	692	49	2,151	1,506	645
2035	2,064	691	65	2,821	1,974	846
2036	1,696	55	41	1,793	1,255	538
2037	1,610	41	39	1,690	1,183	507
2038	1,698	26	41	1,765	1,235	529
2039	1,589	585	52	2,225	1,558	668
2040	1,117	574	40	1,732	1,212	520
Sub Total	37,883	10,383	1,131			
Total Capital Cost for PSMP			49,397			
Total Capital Cost Financed by Debt			34,578			
Total Capital Cost Financed by Equity			14,819			

Source: Task Force Team for PSMP 2016 Update

The IDC is added to the debt principal and results in increase in total debt. The increase in debt is marginal since this is the IDC over the study period. At the same time as the IDC is accumulating, the overall debt portion decreases during the study period since the principal including previous accumulated IDC is also being repaid.

6.2.2 Project IRR with different tariff scenarios

Project IRR is calculated based on the different tariff scenarios that are indicated in Table 6-2, 6-3 and 6-4. Independent Power Producer (IPP) ratio is set at 50% for the purpose of this simulation. Details of the project cash flows for calculating IRR are presented in Appendix-4.

Table 6-2: Project IRR with Tariff Scenario –Base Case

	Year			IRR		
Tariff Rate	2016~2020	2021~2030	2031~2040	Overall	TANESCO	IPP
Tsh, kWh	300	330	350	10.1%	8.8%	12.8%
US$, kWh	0.136	0.150	0.159			

Table 6-3: Project IRR with Tariff Scenario – Higher Tariff Case

	Year			IRR		
Tariff Rate	2016~2020	2021~2030	2031~2040	Overall	TANESCO	IPP
Tsh, kWH	310	350	380	11.4%	9.8%	14.5%
US$, kWH	0.141	0.159	0.173			

Table 6-4: Project IRR with Tariff Scenario – Lower Tariff Case

	Year			IRR		
Tariff Rate	2016~2020	2021~2030	2031~2040	Overall	TANESCO	IPP
Tsh, kWH	300	300	300	8.2%	7.2%	10.1%
US$, kWH	0.136	0.136	0.136			

Source: Task Force Team for PSMP 2016 Update

6.2.3 Public Debt balance and stock to GDP with different IPP ratio

(The following debt balance scenarios are calculated with base tariff case).

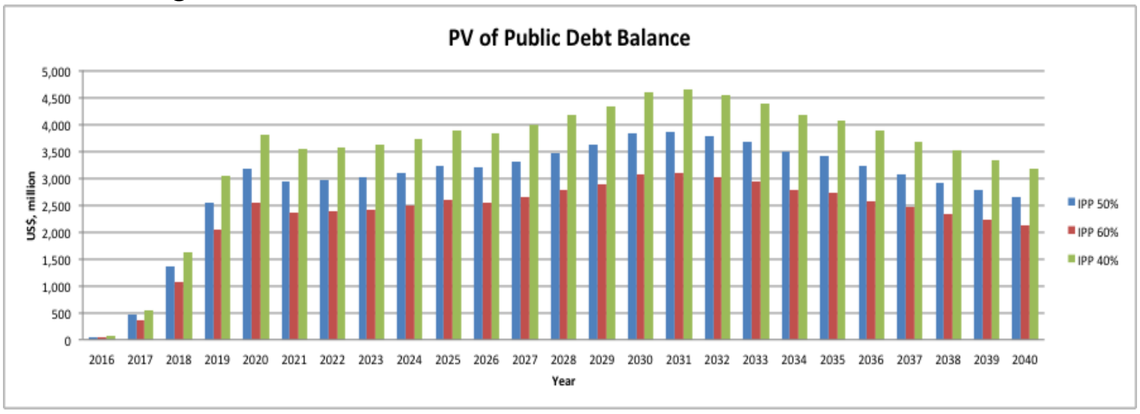
a) With IPP ratio 50%, Present Value (PV) of public debt balance will be peaked around US$ 3.9 billion at year 2031 and Debt stock to GDP is peaked at 5.0% at year 2020.

b) With IPP ratio 60%, Present Value (PV) of public debt balance will be peaked around US$ 3.1 billion at year 2031 and Debt stock to GDP is peaked at 4.0% at year 2020.

c) With IPP ratio 40%, Present Value (PV) of public debt balance will be peaked around US$ 4.6 billion at year 2031 and Debt stock to GDP is peaked at 6.0% at year 2020.

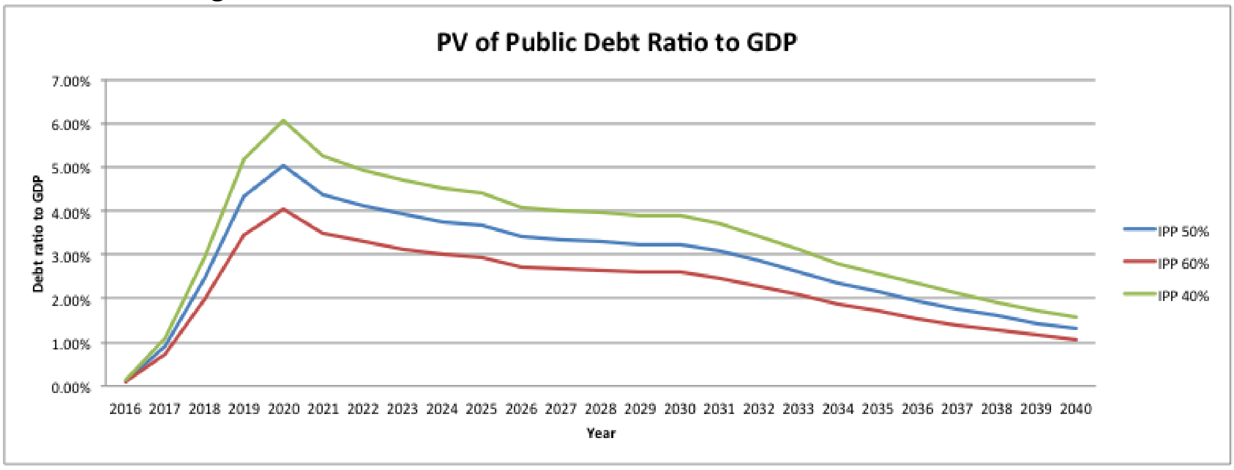
Debt balance is presented in the Figure 6-1 and Debt ratio to GDP is presented in the Figure 6-2. Details of the cash flows for financing the project are presented in Appendix-5.

Figure 6-1: Public Debt balance with IPP 40%, 50% and 60%



Source: Task Force Team for PSMP 2016 Update

Figure 6-2: Public Debt balance with IPP 40%, 50% and 60%



Source: Task Force Team for PSMP 2016 Update

6.2.4 Public Debt balance and stock to GDP with different Interest Rate on Debt

(The following debt balance scenarios are calculated with base tariff case).

Public debt balance and debt stock to GDP is calculated with different interest rate cost. IPP ratio is set at 50% and the base tariff scenario is used for the purpose of this simulation.

Table 6-5: PV of Public Debt Balance and PV of Debt Stock to GDP

(Loan tenor 14 years with 4 years grace period)

Loan Interest Rate	PV of Debt Balance		PV of Debt Stock/GDP	
	Peak balance (US$, million)	Peak Year	Peak rate	Peak Year
5%	3,259	2030	4.87%	2020
7%	3,870	2031	5.05%	2020
9%	4,699	2032	5.23%	2020

Source: Task Force Team for PSMP 2016 Update

6.2.5 Sensitivity analysis with the different fuel and O&M cost

(The following IRR are calculated with base tariff case).

a) Sensitivity analysis of the project IRR is calculated with changes in cost of the fuel and O&M for generation. IPP ratio is set at 50% and the base tariff scenario is used for the purpose of this simulation.

Table 6-6: Sensitivity of the project IRR for the changes in Fuel and O&M cost

Changes in cost of Fuel and O&M for generation					
Variation of Fuel and O&M cost	-10%	0%	10%	20%	30%
Overall Project IRR	11.2%	10.1%	9.2%	8.2%	7.2%

Source: Task Force Team for PSMP 2016 Update

b) Sensitivity analysis for IRR of TANESCO is calculated with changes in IPP ratio for generation. IRR for the overall project and IPP is unchanged.

Table 6-7: Sensitivity of the TANESCO IRR for the changes in IPP ratio

Changes in IPP Ratio for generation			
IPP share	IPP 40%	IPP 50%	IPP 60%
TANESCO IRR	9.2%	8.8%	8.3%

Source: Task Force Team for PSMP 2016 Update

6.3 Estimate of Long Run Marginal Costs

From an economic perspective, the long run marginal cost is the cost of supplying an incremental unit of electricity (kWh) to the system at a future date.

The rationale for using marginal costs as a basis for electricity pricing is to direct the customer, through the price charged for electricity, towards the most efficient use of resources available. Theoretically, if the price is equal to the marginal cost of supply, an optimal allocation of resources takes place and economic efficiency will result.

Marginal cost is one of many considerations used in the development of electricity tariffs. The long run marginal costs (LRMC) of electricity supply are computed to satisfy the criterion of economic efficiency. Marginal costs are usually adjusted to arrive at an appropriate tariff structure that meets various other goals and constraints, including, the financial viability of the electric power sector, social objectives, metering and billing constraints etc. This report focuses exclusively on the estimate of long-run marginal costs and does not address the financial viability or tariff structure issues.

6.3.1 Approach Used to Estimate Marginal Costs

Two broad categories of cost are considered: demand or capacity-related costs and energy-related costs. Marginal capacity costs (also referred to as marginal demand costs) are taken as the costs of investment in generation, transmission and distribution to supply additional kilowatts plus the fixed costs of operation and maintenance. To establish these demand costs the projected capital investment is required for the generation and transmission aspects. Marginal energy costs are the costs of fuel, energy purchases and the variable operating and maintenance costs needed to provide additional kilowatt-hours.

One issue that needs particular attention is the estimate of the capital costs for the expansion of the distribution system to meet the system needs at the end of this plan (2040). The mandate for the master plan considered only the expansion of the generation and transmission system. An estimate of the distribution investments is required, even though it was not part of the mandate for the study. Based on studies elsewhere, it is assumed that the distribution costs for the Tanzania's system will amount to about twice the investment costs in transmission. For instance, SNC-Lavalin calculated the marginal costs for a specific system in India where Generation = 64% of the total, transmission = 11 to 13% and distribution = 23 to 25%.

6.3.2 Summary of Results

The long run marginal cost of power in Tanzania was calculated on a year-by-year basis by examining the incremental cost over the base year. This approach is closer to the strict definition of long run marginal cost.

From the analyses, the unit cost of generation, transmission and distribution are calculated for each year. These are presented below.

Table 6-8: Marginal cost ($ per kWh) for the period 2016-2040

Marginal Cost Production	Marginal Cost Transmission	Marginal Cost Distribution	Marginal Cost for Supply
0.103	0.009	0.025	0.137

Appendix-1: Capital Cost for Generation (US Dollar, million)

ANNUAL EXPENDITURE OF CONSTRUCTION COST							Annual Expenditure of Construction Cost (US$ million, Not Discounted)																										
Plant name	Type	Capacity (MW)	Unit Cost ($/kW)	Const. period (yr)	IDC(%)	Total Const. Cost ($million)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Kinyerezi I Extension	GT	185	900	1	2.90%	171.3				171.3																							
Kinyerezi II	C/C	240	1200	2	6.08%	305.5			94.7	210.8																							
Somanga Fungu-1	GT	210	1200	2	6.08%	267.3				82.9	184.5																						
Somanga Fungu-2	ST add-on	110	1200	2	6.08%	140.0					43.4	96.6																					
Kinyerezi III(Ph1) 1-3	GT	300	900	1	2.90%	277.8					277.8																						
Kinyerezi III(Ph2) 1-2	C/C	300	900	2	6.08%	286.4				88.8	197.6																						
Kinyerezi IV 1-2	C/C	330	900	2	6.08%	315.1						97.7	217.4																				
Mtwara	C/C	400	900	2	6.08%	381.9					118.4	263.5																					
Mkuranga (PPP) 1-2	C/C	300	900	2	6.08%	286.4								88.8	197.6																		
Somanga (PPP)	C/C	300	900	2	6.08%	286.4						88.8	197.6																				
Bagamoyo(Zinga)	C/C	200	900	2	6.08%	190.9													59.2	131.8													
Future CGT1(1&3)	CGT1	110	1200	2	6.08%	140.0																						43.4	96.6		43.4	96.6	
Future CGT1(2)	CGT1	110	1200	2	6.08%	140.0															43.4	96.6							43.4	96.6			
Future CGT3(1-2)	CGT3	470	900	2	6.08%	448.7																278.2	619.2										
Future CGT3(3-4)	CGT3	470	900	2	6.08%	448.7																	278.2	619.2									
Future CGT3(5-6)	CGT3	470	900	2	6.08%	448.7																			278.2	619.2							
Future CGT3(7-8)	CGT3	470	900	2	6.08%	448.7																					278.2	619.2					
Future CGT3(9)	CGT3	470	900	2	6.08%	448.7																						139.1	309.6				
Future CGT3(10)	CGT3	470	900	2	6.08%	448.7																							139.1	309.6			
Future CGT3(11)	CGT3	470	900	2	6.08%	448.7																								139.1	309.6		
Future CGT3(12)	CGT3	470	900	2	6.08%	448.7																									139.1	309.6	
Future CGT3(13-15)	CGT3	470	900	2	6.08%	448.7																										417.3	928.8
Mchuchuma-1(1)	SBCL	150	2000	3	9.29%	327.9			32.8	190.2	104.9																						
Mchuchuma-1(2-3)	SBCL	150	2000	3	9.29%	327.9				65.6	380.3	209.8																					
Mchuchuma-1(4)	SBCL	150	2000	3	9.29%	327.9					32.8	190.2	104.9																				
Ngaka 1-3	SBCL	200	2000	3	9.29%	437.2								131.1	760.7	419.7																	
Ngaka (Exp)1-2	ASUB	300	2000	3	9.29%	655.7																			131.1	760.7	419.7						
Ngaka (Exp)2-3	ASUB	300	2000	3	9.29%	655.7																								131.1	760.7	419.7	
Ngaka (Exp)5	ASUB	300	2000	3	9.29%	655.7																									65.6	380.3	209.8
Kiwira 1-2	SBCL	200	2000	3	9.29%	437.2					87.4	507.1	279.8																				
Kiwira (Exp)1-2	ASUB	300	2000	3	9.29%	655.7													131.1	760.7	419.7												
Mchuchuma(Exp)1	ASUB	300	2000	3	9.29%	655.7											65.6	380.3	209.8														
Mchuchuma(Exp)2	ASUB	300	2000	3	9.29%	655.7													65.6	380.3	209.8												
Mchuchuma(Exp)3	ASUB	300	2000	3	9.29%	655.7																					65.6	380.3	209.8				
Mchuchuma(Exp)4	ASUB	300	2000	3	9.29%	655.7																						65.6	380.3	209.8			
Rukwa 1	ASUB	300	2000	3	9.29%	655.7									65.6	380.3	209.8																
Rukwa Exp-1	ASUB	300	2000	3	9.29%	655.7														65.6	380.3	209.8											
Rukwa Exp-2	ASUB	300	2000	3	9.29%	655.7														65.6	380.3	209.8							131.1	760.7	419.7		
Singida Wind (50MW)		50	2,720	1	2.90%	139.9					139.9																						
Singida Wind (75MW)		75	2,213	1	2.90%	170.8						170.8																					
Makambako Wind (100MW)		100	2,213	1	2.90%	227.7						227.7																					
Dodoma solar (50MW)		50	4,183	1	2.90%	215.2						215.2																					
Singida Wind (75MW) Extension		75	2,213	1	2.90%	170.8							170.8																				
Singida Wind (100MW)		100	2,213	1	2.90%	227.7							227.7																				
Kishapu-Shinyanga Solar		150	3,873	1	2.90%	597.8							597.8																				
Singida Wind (75MW) Extension		50	2,213	1	2.90%	113.9								113.9																			
GEO-1	Geothermal	50	6500	3	9.29%	355.2										35.5	206.0	113.7															
GEO-2	Geothermal	50	6500	3	9.29%	355.2										35.5	206.0	113.7															
GEO-3	Geothermal	50	6500	3	9.29%	355.2											35.5	206.0	113.7														
GEO-4	Geothermal	50	6500	3	9.29%	355.2											35.5	206.0	113.7														
Rusmo	Hydro-Dam	30.0	1,670.2	3	9.29%	54.8			5.5	31.8	17.5																						
Malagarasi Stage III	Hydro-Dam	44.7	3,695.7	3	9.29%	180.5									18.1	104.7	57.8																
Rumakali	Hydro-Dam	222.0	2,521.9	6	19.64%	669.8															20.1	46.9	140.7	247.8	167.5	46.9							
Mpanga	Hydro-Dam	160.0	2,626.4	5	16.06%	487.7														19.5	73.2	165.8	175.6	53.6									
Iringa-Nginayo	Hydro-Dam	52.0	2,412.7	3	9.29%	137.1											13.7	79.5	43.9														
Iringa-Ibosa	Hydro-Dam	36.0	3,418.3	3	9.29%	134.5											13.4	78.0	43.0														
Mnyera Ruaha	Hydro-Dam	60.3	4,230.2	3	9.29%	278.8													27.9	161.7	89.2												
Mnyera-Pumbwe	Hydro-Dam	122.9	1,783.2	3	9.29%	239.5															24.0	138.9	76.6										
Mnyera-Kwanini	Hydro-Dam	143.9	1,140.5	3	9.29%	179.4														17.9	104.0	57.4											
Mnyera-Kisingo	Hydro-Dam	119.8	2,617.1	3	9.29%	342.7																34.3	198.7	109.6									
Mnyera-Taveta	Hydro-Dam	83.9	2,452.3	3	9.29%	224.9															22.5	130.4	72.0										
Mnyera-Mnyera	Hydro-Dam	137.4	1,994.7	3	9.29%	299.5														30.0	173.7	95.9											
Songwe Manolo	Hydro-Dam	88.1	2,662.8	5	16.06%	272.3											10.9	40.8	92.6	98.0	29.9												
Lower Kihansi	Hydro-Dam	120.0	1,839.6	4	12.62%	248.6			12.4	64.6	121.8	49.7																					
Kakono	Hydro-Dam	87.0	4,412.4	5	16.06%	445.5										17.8	66.8	151.5	160.4	49.0													
Songwe Sofre	Hydro-Dam	79.5	2,947.0	5	16.06%	271.9																	10.9	40.8	92.5	97.9	29.9						
Masigira	Hydro-Dam	118.0	2,213.6	5	16.06%	303.2															12.1	45.5	103.1	109.1	33.3								
Ruhudji	Hydro-Dam	358.0	1,860.4	6	19.64%	796.8														23.9	55.8	167.3	294.8	199.2	55.8								
Kikonge	Hydro-Dam	300.0	2,235.6	6	19.64%	802.4																24.1	56.2	168.5	296.9	200.6	56.2						
Stieglers Gorge Ph-1	Hydro-Dam	1,048.0	2,343.5	9	31.16%	3,221.3														64.4	64.4	193.3	483.2	483.2	902.0	515.4	418.8	96.6					
Stieglers Gorge Ph-2	Hydro-Dam	1,048.0	1,161.3	3	9.29%	1,330.1																					133.0	771.5	425.6				
Upper Kihansi	Hydro-Dam	47.0	11,061.4	5	16.06%	603.4																	24.1	90.5	205.1	217.2	66.4						
Total Annual Expenditure (US$ million)							**0.0**	**0.0**	**145.4**	**905.9**	**1,706.5**	**2,117.1**	**1,796.0**	**333.8**	**1,041.9**	**993.6**	**921.1**	**1,369.5**	**1,060.8**	**1,868.3**	**2,102.5**	**1,894.2**	**2,533.3**	**2,121.7**	**2,162.4**	**2,457.9**	**1,467.7**	**2,115.7**	**1,735.7**	**1,647.0**	**1,738.0**	**1,623.5**	**1,138.7**

Appendix-2: Capital Cost for Transmission Line (US Dollar, thousand)

Annual Expenditure of Transmission Line Construction Cost

GOT Base

Future (2016-2040)

No	Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Unit Cost (T. USD/km)	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)																									
							Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				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
1	400	Dodoma	Singida	Backbone Project	210	2	Bluejay	2	564	2016	380	79,800 *3	39,900	39,900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	400	Iringa	Dodoma	Backbone Project	237	2	Bluejay	2	564	2016	380	90,060 *3	45,030	45,030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	400	Singida	Shinyanga	Backbone Project	200	2	Bluejay	2	564	2016	380	76,000 *3	38,000	38,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	220	Kinyerezi	Ubungo-Pai	Completed	8	1	Bluejay	2	564	2016	-		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	220	Ubungo-Pai	Kinyerezi	Completed	8	1	Bluejay	2	564	2016	-		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	132	Kinyerezi	FZ-II	Completed	5	1	Wolf	1	150	2016	-		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	132	Morogoro	Mtibwa	MCC, F/S completed	88	1	Hawk	1	242	2016	170	14,960	7,480	7,480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	220	Wind Project	Singida		10	1	Bluejay	2	564	2017	230	2,300	0	1,150	1,150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	400	Kin-Som SwS1	Kin-Som SwS2		53	2	Bluejay	8	564	2018	850	45,050	0	0	22,525	22,525	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	400	Kin-Som SwS2	Kin-Som SwS3		53	2	Bluejay	8	564	2018	850	45,050	0	0	22,525	22,525	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	400	Kin-Som SwS3	Somanga Fungu P/S	210 MW	53	2	Bluejay	8	564	2018	850	45,050	0	0	22,525	22,525	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	400	Kinyerezi	Kin-Som SwS1		53	2	Bluejay	8	564	2018	450	23,850	0	0	11,925	11,925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	400	Kisada	Iringa		106	2	Bluejay	8	564	2018	850	90,100	0	0	45,050	45,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	400	Kisada	Madaba		243	2	Bluejay	8	564	2018	850	206,550	0	0	103,275	103,275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	400	Muchuchuma P/S	Madaba	Total 1,800 MW	15	2	Bluejay	4	564	2018	560	8,400	0	0	4,200	4,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	220	Geita	Nyakanazi		130	2	Bluejay	2	564	2018	320	41,600	0	0	20,800	20,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	220	Madaba	Songea		171	1	Bluejay	2	564	2018	230	39,330	0	0	19,665	19,665	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	220	Makambako	Madaba		162	1	Bluejay	2	564	2018	230	37,260	0	0	18,630	18,630	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	220	Nyakanazi	Rusumo Falls P/S	30 MW	97	1	Bluejay	4	564	2018	340	32,980	0	0	16,490	16,490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	220	Rusumo Falls P/S	Kyaka	30 MW	150	1	Bluejay	4	564	2018	340	51,000	0	0	25,500	25,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	220	Shinyanga	Geita		240	2	Bluejay	4	564	2018	450	108,000	0	0	54,000	54,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	400	Arusha	Singida		317	2	Bluejay	2	564	2019	380	120,460	0	0	0	60,230	60,230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	400	Arusha	Isinya (Kenya)	up to Kenya border	114	2	Flint	3	375	2019	450	51,300 *3	0	0	0	25,650	25,650	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	400	Lindi	Somanga Fungu		216	2	Bluejay	8	564	2019	450	97,200	0	0	0	48,600	48,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	400	Mtwara P/S	Lindi	400 MW	74	2	Bluejay	4	564	2019	450	33,300	0	0	0	16,650	16,650	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	220	Arusha	Njiro (Arusha existing)		5	2	Bluejay	4	564	2019	450	104,020	0	0	0	52,010	52,010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	220	Iringa	Lower Kihansi P/S (Hydro)	(36+52+120) MW	120	1	Bluejay	2	564	2019	230	27,600	0	0	0	13,800	13,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	220	Solar I	Dodoma	50 MW	10	1	Bluejay	1	242	2019	190	167,680	0	0	0	83,840	83,840	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	132	Wind Project	Makambako	100 MW	10	1	Hawk	1	242	2019	170	6,650	0	0	0	3,325	3,325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	400	Chalinze	Segera		175	1	Bluejay	4	564	2020	-	80,180 *4	0	0	0	0	40,090	40,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	400	Chalinze	Dodoma		336	1	Bluejay	2	564	2020	300	100,800	0	0	0	0	50,400	50,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	400	Chalinze	Segera		175	1	Bluejay	4	564	2020	400	70,000	0	0	0	0	35,000	35,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	400	Kigoma	Mpanda		290	2	Bluejay	8	564	2020	850	246,500	0	0	0	0	123,250	123,250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	400	Kinyerezi	Chalinze		138	2	Bluejay	4	564	2020	-	104,020 *4	0	0	0	0	52,010	52,010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	400	Kisada	Mbeya		186	2	Bluejay	8	564	2020	850	158,100	0	0	0	0	79,050	79,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	400	Kiwira P/S	Mbeya	400MW in 2020	110	2	Bluejay	8	564	2020	850	93,500	0	0	0	0	46,750	46,750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	400	Mbea	Nakonde(Zambia)	up to Zambia border	93	2	Bluejay	2	564	2020	380	35,340	0	0	0	0	17,670	17,670	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	400	Mbe－Sum SwS	Sumbawanga		150	2	Bluejay	8	564	2020	850	127,500	0	0	0	0	63,750	63,750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	400	Mbeya	Mbe－Sum SwS		150	2	Bluejay	8	564	2020	850	127,500	0	0	0	0	63,750	63,750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	400	Mpanda	Mpa-Sum SwS		119	2	Bluejay	8	564	2020	850	101,150	0	0	0	0	50,575	50,575	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	400	Mpa-Sum SwS	Sumbawanga		119	2	Bluejay	8	564	2020	850	101,150	0	0	0	0	50,575	50,575	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	400	Mtwara	Namialo(Mozambique)	up to Mozambique border	51	2	Bluejay	2	564	2020	380	19,257	0	0	0	0	9,628	9,628	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	400	Nyakanazi	Kigoma		317	2	Bluejay	8	564	2020	850	269,450	0	0	0	0	134,725	134,725	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	400	Segera	Arusha		366	1	Bluejay	4	564	2020	-	167,680 *4	0	0	0	0	83,840	83,840	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	400	Somanga Fungu P/S	Somanga P/S(PPP)	300MW	20	2	Bluejay	2	564	2020	380	7,600	0	0	0	0	3,800	3,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	220	Bagamoyo (Zinga)	Kibaha-Pai		45	1	Bluejay	1	564	2020	-	6,650 *4	0	0	0	0	3,325	3,325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	220	Bunda	Musona		60	1	Bluejay	4	564	2020	340	20,400	0	0	0	0	10,200	10,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	220	Kibaha-Pai	Bagamoyo (Zinga)		45	1	Bluejay	1	564	2020	-	6,650 *4	0	0	0	0	3,325	3,325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	220	Kinyerezi	Ubungo		12	2	Bluejay	1	564	2020	220	2,640	0	0	0	0	1,320	1,320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	220	Kishapu Solar	Shinyanga	150 MW	10	1	Bluejay	1	382	2020	190	1,900	0	0	0	0	950	950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	220	Kyaka	Masaka(Uganda)	up to Uganda border	30	1	Bluejay	2	564	2020	230	6,900	0	0	0	0	3,450	3,450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	220	Kyela	Karonga(Malawi)	up to Malawi border	20	1	Bluejay	2	564	2020	230	4,600	0	0	0	0	2,300	2,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	220	Lusu	Tabora		139	1	Bluejay	2	564	2020	230	31,970	0	0	0	0	15,985	15,985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	220	Mbeya	Kyela		106	1	Bluejay	2	564	2020	230	24,380	0	0	0	0	12,190	12,190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	220	Musona	Nyamongo		90	1	Bluejay	4	564	2020	340	30,600	0	0	0	0	15,300	15,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	220	Mwanza	Bunda		150	1	Bluejay	4	564	2020	340	51,000	0	0	0	0	25,500	25,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	220	Segera	Tanga		76	2	Bluejay	2	564	2020	-	33,470 *4	0	0	0	0	16,735	16,735	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	220	Shinyanga	Lusu		64	1	Bluejay	1	564	2020	190	12,160	0	0	0	0	6,080	6,080	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	132	Kinyerezi	FZ-II		5	2	Hawk	2	242	2020	230	1,150	0	0	0	0	575	575	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	132	Morogoro	Mtibwa		88	1	Hawk	1	242	2020	170	14,960	0	0	0	0	7,480	7,480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	66	Babati	Mbulu		85	2	Wolf	2	150	2020	150	12,750	0	0	0	0	6,375	6,375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	400	Kinyerezi	Mkuranga P/S	300 MW	70	2	Bluejay	8	564	2022	850	59,500	0	0	0	0	0	0	29,750	29,750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	400	Madaba	Songea		171	2	Bluejay	2	564	2023	380	64,980	0	0	0	0	0	0	0	32,490	32,490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	400	Masasi	Lindi		141	2	Bluejay	4	564	2023	560	78,960	0	0	0	0	0	0	0	39,480	39,480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	400	Ngaka P/S	Songea	600MW in 2023	37	2	Bluejay	4	564	2023	560	20,720	0	0	0	0	0	0	0	10,360	10,360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	400	Songea	Tunduru		230	2	Bluejay	4	564	2023	560	128,800	0	0	0	0	0	0	0	64,400	64,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

No	Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Unit Cost (T. USD/km)	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)																									
							Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				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
67	400	Tunduru	Masasi		194	2	Bluejay	4	564	2023	560	108,640	0	0	0	0	0	0	0	54,320	54,320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	400	Sumbawanga	Rukwa P/S	300MW in 2024	46	2	Bluejay	8	564	2024	850	39,100	0	0	0	0	0	0	0	0	19,550	19,550	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	132	Malagarasi P/S(Stage III)	Kigoma	44.7 MW	74	1	Hawk	1	242	2024	170	12,580	0	0	0	0	0	0	0	0	6,290	6,290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	400	Chalinze	Bagamoyo		102	2	Bluejay	8	564	2025	850	86,700	0	0	0	0	0	0	0	0	0	43,350	43,350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	400	Shinyanga	Mwanza		140	2	Bluejay	8	564	2025	850	119,000	0	0	0	0	0	0	0	0	0	59,500	59,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72	220	Bagamoyo	North DSM		40	2	Bluejay	4	564	2025	450	18,000	0	0	0	0	0	0	0	0	0	9,000	9,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	220	Geothermal 1	Mbeya	(2 x 50 MW)×2	35	1	Bluejay	1	564	2025	190	6,650	0	0	0	0	0	0	0	0	0	3,325	3,325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	220	Kinyerezi	South DSM		25	2	Bluejay	4	564	2025	450	11,250	0	0	0	0	0	0	0	0	0	5,625	5,625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75	220	Mkuranga	South-east DSM		50	2	Bluejay	4	564	2025	450	22,500	0	0	0	0	0	0	0	0	0	11,250	11,250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	220	South DSM	South-east DSM		30	2	Bluejay	2	564	2025	320	9,600	0	0	0	0	0	0	0	0	0	4,800	4,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	132	Kyaka	Kibeta/Bukoba		54	1	Hawk	2	242	2025	200	10,800	0	0	0	0	0	0	0	0	0	5,400	5,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	66	Mbulu	Karatu		65	2	Wolf	2	150	2025	150	9,750	0	0	0	0	0	0	0	0	0	4,875	4,875	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	220	Geothermal 1	Geothermal 2	2 x 50 MW	20	1	Bluejay	1	564	2026	190	3,800	0	0	0	0	0	0	0	0	0	0	1,900	1,900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	220	Ibosa P/S (Hydro)	Iringa-L. Kihansi T branch	(36+52+120) MW	20	2	Bluejay	2	564	2026	320	6,400	0	0	0	0	0	0	0	0	0	0	3,200	3,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81	220	Ibosa P/S (Hydro)	Nginayo P/S (Hydro)	52MW	10	1	Bluejay	1	564	2026	190	1,900	0	0	0	0	0	0	0	0	0	0	950	950	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	220	Zinga P/S	Bagamoyo	200 MW	15	1	Bluejay	2	564	2027	230	3,450	0	0	0	0	0	0	0	0	0	0	0	1,725	1,725	0	0	0	0	0	0	0	0	0	0	0	0	0
83	132	Kakono P/S (Hydro)	Kyaka	87 MW	39	1	Hawk	1	242	2027	170	6,596	0	0	0	0	0	0	0	0	0	0	0	3,298	3,298	0	0	0	0	0	0	0	0	0	0	0	0	0
84	400	Mnyera S/S (new)	Kisada	(668.2+358) MW	180	2	Bluejay	4	564	2028	560	100,800	0	0	0	0	0	0	0	0	0	0	0	0	50,400	50,400	0	0	0	0	0	0	0	0	0	0	0	0
85	220	Ruaha 2 P/S (Hydro)	Mnyera S/S (new)	(60.3+137.4+143.9) MW	33	1	Bluejay	2	564	2028	230	7,590	0	0	0	0	0	0	0	0	0	0	0	0	3,795	3,795	0	0	0	0	0	0	0	0	0	0	0	0
86	132	Songwe B S/S	Kyela	(79.5 + 88.1) MW	7	2	Hawk	1	242	2028	200	1,400	0	0	0	0	0	0	0	0	0	0	0	0	700	700	0	0	0	0	0	0	0	0	0	0	0	0
87	132	Songwe Manolo P/S (Hydro)	Songwe B S/S	88.1 MW	17	1	Hawk	1	242	2028	170	2,890	0	0	0	0	0	0	0	0	0	0	0	0	1,445	1,445	0	0	0	0	0	0	0	0	0	0	0	0
88	220	Kwanini P/S (Hydro)	Mnyera S/S-Ruaha2 T/L	T-branch	10	1	Bluejay	2	564	2029	230	2,300	0	0	0	0	0	0	0	0	0	0	0	0	0	1,150	1,150	0	0	0	0	0	0	0	0	0	0	0
89	220	Mnyera 2 P/S (Hydro)	Mnyera S/S-Ruaha2 T/L	T-branch	10	1	Bluejay	2	564	2029	230	2,300	0	0	0	0	0	0	0	0	0	0	0	0	0	1,150	1,150	0	0	0	0	0	0	0	0	0	0	0
90	400	Shinyanga	Tabora		200	2	Bluejay	8	564	2030	850	170,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85,000	85,000	0	0	0	0	0	0	0	0	0	0
91	400	Somanga Fungu S/S	Future CGT3-1	4x470 MW	20	2	Bluejay	4	564	2030	560	11,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,600	5,600	0	0	0	0	0	0	0	0	0	0
92	400	Tab-Mpa SwS	Mpanda		150	2	Bluejay	8	564	2030	850	127,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63,750	63,750	0	0	0	0	0	0	0	0	0	0
93	400	Tabora	Tab-Mpa SwS		150	2	Bluejay	8	564	2030	850	127,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63,750	63,750	0	0	0	0	0	0	0	0	0	0
94	220	Bagamoyo	Mlandizi		40	2	Bluejay	1	564	2030	220	8,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,400	4,400	0	0	0	0	0	0	0	0	0	0
95	220	Kinyerezi	West DSM		20	2	Bluejay	4	564	2030	450	9,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,500	4,500	0	0	0	0	0	0	0	0	0	0
96	220	Mnyera S/S (new)	Taveta 3 P/S (Hydro)	(119.8+83.9+122.9) MW	26	1	Bluejay	2	564	2030	230	5,980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,990	2,990	0	0	0	0	0	0	0	0	0	0
97	220	Pumbwe P/S (Hydro)	Mnyera S/S-Taveta3 T/L	T-branch	10	1	Bluejay	2	564	2030	230	2,300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,150	1,150	0	0	0	0	0	0	0	0	0	0
98	220	West DSM	North DSM		20	2	Bluejay	2	564	2030	320	6,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,200	3,200	0	0	0	0	0	0	0	0	0	0
99	132	Njiro (Arusha existing)	Kiyungi	T-branch to KIA	77	2	Hawk	4	242	2030	320	24,640	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,320	12,320	0	0	0	0	0	0	0	0	0	0
100	400	Mkuranga	Mku-Som SwS1		61	2	Bluejay	8	564	2031	850	51,850	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,925	25,925	0	0	0	0	0	0	0	0	0
101	400	Mku-Som SwS1	Mku-Som SwS2		61	2	Bluejay	8	564	2031	850	51,850	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,925	25,925	0	0	0	0	0	0	0	0	0
102	400	Mku-Som SwS2	Somanga Fungu S/S		61	2	Bluejay	8	564	2031	850	51,850	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,925	25,925	0	0	0	0	0	0	0	0	0
103	220	Mufindi	Mpanga P/S (Hydro)	160 MW	65	1	Bluejay	2	564	2031	230	14,950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,475	7,475	0	0	0	0	0	0	0	0	0
104	220	Taveta 3 P/S (Hydro)	Kisingo P/S (Hydro)	119.8MW	15	1	Bluejay	2	564	2031	230	3,450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,725	1,725	0	0	0	0	0	0	0	0	0
105	220	Masigira P/S (Hydro)	Madaba	118 MW	73	1	Bluejay	2	564	2032	230	16,790	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,395	8,395	0	0	0	0	0	0	0	0
106	400	Somanga Fungu S/S	Future CGT3-2	6x470 MW	20	2	Bluejay	4	564	2033	560	11,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,600	5,600	0	0	0	0	0	0	0
107	220	Mbeya	Rumakali P/S (Hydro)	222MW	104	1	Bluejay	2	564	2033	230	23,920	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11,960	11,960	0	0	0	0	0	0	0
108	220	Mnyera S/S (new)	Ruhudji P/S (Hydro)	358 MW	88	1	Bluejay	2	564	2033	230	20,240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,120	10,120	0	0	0	0	0	0	0
109	220	Kihansi P/S (Hydro)	Upper Kihansi P/S (Hydro)	47MW	10	1	Bluejay	1	564	2034	190	1,900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	950	950	0	0	0	0	0	0
110	220	Kikonge P/S (Hydro)	Madaba	300 MW	49	1	Bluejay	2	564	2034	230	11,270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,635	5,635	0	0	0	0	0	0
111	132	Songwe A S/S	Songwe B S/S		40	1	Hawk	1	242	2034	170	6,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,400	3,400	0	0	0	0	0	0
112	132	Songwe Sofre P/S (Hydro)	Songwe A S/S	79.5 MW	16	1	Hawk	1	242	2034	170	2,720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,360	1,360	0	0	0	0	0	0
113	400	Chalinze	Segera		175	1	Bluejay	4	564	2035	400	70,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35,000	35,000	0	0	0	0	0
114	400	Segera	Arusha		366	2	Bluejay	4	564	2035	560	204,960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102,480	102,480	0	0	0	0	0
115	400	Somanga Fungu S/S	Chalinze		284	2	Bluejay	8	564	2035	850	241,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	120,700	120,700	0	0	0	0	0
116	400	Stiegler's Gorge	Chalinze	2 x 1,048 MW	195	2	Bluejay	8	564	2035	850	165,750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	82,875	82,875	0	0	0	0	0
117	220	Bulyanhulu	Shinyanga		130	2	Bluejay	4	564	2035	450	58,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29,250	29,250	0	0	0	0	0
118	220	Bunda	Musona		60	1	Bluejay	4	564	2035	340	20,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,200	10,200	0	0	0	0	0
119	220	Kyaka	Masaka(Uganda)	up to Uganda border	30	1	Bluejay	2	564	2035	230	6,900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,450	3,450	0	0	0	0	0
120	220	Musona	Nyamongo		90	1	Bluejay	4	564	2035	340	30,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15,300	15,300	0	0	0	0	0
121	220	Mwanza	Bunda		150	1	Bluejay	4	564	2035	340	51,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,500	25,500	0	0	0	0	0
122	220	Nyakanazi	Rusumo Falls P/S		97	1	Bluejay	4	564	2035	340	32,980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16,490	16,490	0	0	0	0	0
123	220	Rusumo Falls P/S	Kyaka		150	1	Bluejay	4	564	2035	340	51,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,500	25,500	0	0	0	0	0
124	220	Shinyanga	Buswagi		108	2	Bluejay	4	564	2035	450	48,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24,300	24,300	0	0	0	0	0
125	132	Kyaka	Kibeta/Bukoba		54	1	Hawk	2	242	2035	200	10,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,400	5,400	0	0	0	0	0
126	66	Babati	Kondoa		85	2	Wolf	2	150	2035	150	12,750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,375	6,375	0	0	0	0	0
127	400	Mtwara	Future CGT1 P/S	330MW	50	2	Bluejay	2	564	2036	380	19,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9,500	9,500	0	0	0	0
128	400	Somanga Fungu	Future CGT3-3	5x470 MW	20	2	Bluejay	4	564	2038	560	11,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,600	5,600	0	0
129	220	Kinyerezi	West DSM		20	1	Bluejay	4	564	2040	340	6,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,400	3,400
130	220	Shinyanga	Mwanza		140	2	Bluejay	1	564	2040	220	30,800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15,400	15,400
131	220	Singida	Babati		150	2	Bluejay	1	564	2040	220	33,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16,500	16,500
132	220	Singida	Shinyanga		200	2	Bluejay	1	564	2040	220	44,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,000	22,000
133	132	Chalinze	Morogoro		82	2	Hawk	1	242	2040	200	16,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,200	8,200
											Total Expenditure (Annual)	6,593,363	130,410	131,560	388,260	691,215	1,340,058	1,035,953	29,750	230,800	226,890	172,965	153,175	11,073	61,363	58,640	248,960	333,635	95,370	36,075	39,025	514,165	512,320	9,500	5,600	5,600	65,500	65,500
											(Thousand USD)					3,717,457					813,580					713,671					1,196,955					151,700		

Note: *1 Source: SURAL catalogue

*2: Normal Rating = Full Rating x 80%

*3: Should be replaced with the contract amount

*4: Assumed allocation from the contract amount obtained from TANESCO

Appendix-3: Capital Cost for Substation (US Dollar, thousand)

Annual Expenditure of Substation Construction & Expansion Cost

No	Substation	New or Expansion	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)																									
					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
1	Arusha (Njiro)	N	2019	46,590 *1	0	0	0	23,295	23,295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Arusha (Njiro)	E	2020	27,295	0	0	0	0	13,648	13,648	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Arusha (Njiro)	E	2023	7,045	0	0	0	0	0	0	0	3,523	3,523	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Arusha (Njiro)	E	2029	7,045	0	0	0	0	0	0	0	0	0	0	0	0	0	3,523	3,523	0	0	0	0	0	0	0	0	0	0	0
5	Arusha (Njiro)	E	2030	10,375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,188	5,188	0	0	0	0	0	0	0	0	0	0
6	Arusha (Njiro)	E	2032	16,841	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,421	8,421	0	0	0	0	0	0	0	0
7	Arusha (Njiro)	E	2035	17,015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,508	8,508	0	0	0	0	0
8	Arusha (Njiro)	E	2037	10,375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,188	5,188	0	0	0
9	Arusha (Njiro)	E	2038	7,045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,523	3,523	0	0
10	Arusha (Njiro)	E	2040	47,280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23,640	23,640
11	Babati	E	2020	700	0	0	0	0	350	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Babati	E	2025	5,745	0	0	0	0	0	0	0	0	0	2,873	2,873	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	Babati	E	2035	5,745	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,873	2,873	0	0	0	0	0
14	Bagamoyo	N	2020	13,040	0	0	0	0	6,520	6,520	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	Bagamoyo	E	2025	36,680	0	0	0	0	0	0	0	0	0	18,340	18,340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Bagamoyo	E	2027	935	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Bagamoyo	E	2029	16,665	0	0	0	0	0	0	0	0	0	0	0	0	0	8,333	8,333	0	0	0	0	0	0	0	0	0	0	0
18	Bagamoyo	E	2030	2,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,045	1,045	0	0	0	0	0	0	0	0	0	0
19	Bagamoyo	E	2040	8,580	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,290	4,290
20	Bulyanhulu	E	2035	1,870	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	935	935	0	0	0	0	0
21	Bunda	N	2020	10,700	0	0	0	0	5,350	5,350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Bunda	E	2030	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0	0	0	0	0	0	0
23	Bunda	E	2035	1,870	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	935	935	0	0	0	0	0
24	Buzwagi	E	2035	1,870	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	935	935	0	0	0	0	0
25	Chalinze	N	2020	47,930 *1	0	0	0	0	23,965	23,965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	Chalinze	E	2025	11,425	0	0	0	0	0	0	0	0	0	5,713	5,713	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	Chalinze	E	2034	4,020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,010	2,010	0	0	0	0	0	0
28	Chalinze	E	2035	20,195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,098	10,098	0	0	0	0	0
29	Chalinze	E	2036	8,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,250	4,250	0	0	0	0
30	Chalinze	E	2039	10,805	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,403	5,403	0
31	Chalinze	E	2040	72,205	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36,103	36,103
32	Dodoma	E	2016	52,250 *1	26,125	26,125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	Dodoma	E	2019	935	0	0	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Dodoma	E	2040	64,465	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32,233	32,233
35	Geita	N	2018	8,400	0	0	4,200	4,200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	Geothermal A S/S	N	2025	6,305	0	0	0	0	0	0	0	0	0	3,153	3,153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	Geothermal A S/S	E	2026	935	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	Geothermal B S/S	N	2026	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	Ibosa	N	2026	3,375	0	0	0	0	0	0	0	0	0	0	1,688	1,688	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	Ibosa	E	2032	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0	0	0
41	Iringa	N	2016	39,170 *1	19,585	19,585	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	Iringa	E	2018	14,500	0	0	7,250	7,250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	Iringa	E	2019	935	0	0	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	Iringa	E	2026	935	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	Iringa	E	2040	21,150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,575	10,575
46	KIA (Kilimanjaro Internati	E	2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	Kigoma	N	2020	38,190	0	0	0	0	19,095	19,095	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	Kigoma	E	2024	3,485	0	0	0	0	0	0	0	0	1,743	1,743	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	Kigoma	E	2025	3,310	0	0	0	0	0	0	0	0	0	1,655	1,655	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	Kigoma	E	2030	6,225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,113	3,113	0	0	0	0	0	0	0	0	0	0
51	Kigoma	E	2035	18,820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9,410	9,410	0	0	0	0	0
52	Kigoma	E	2040	8,060	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,030	4,030
53	Kihansi	E	2034	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0
54	Kin-Som SwS1	N	2018	24,810	0	0	12,405	12,405	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	Kin-Som SwS1	E	2020	7,760	0	0	0	0	3,880	3,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	Kin-Som SwS1	E	2040	56,910	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28,455	28,455
57	Kin-Som SwS2	N	2018	24,810	0	0	12,405	12,405	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	Kin-Som SwS2	N	2020	7,440	0	0	0	0	3,720	3,720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	Kin-Som SwS2	E	2040	14,280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,140	7,140
60	Kin-Som SwS3	N	2018	24,810	0	0	12,405	12,405	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	Kin-Som SwS3	N	2020	7,440	0	0	0	0	3,720	3,720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	Kin-Som SwS3	E	2040	44,370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22,185	22,185
63	Kinyerezi	N	2017	935	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	Kinyerezi	E	2018	92,945	0	0	46,473	46,473	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	Kinyerezi	E	2020	36,320 *1	0	0	0	0	18,160	18,160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	Kinyerezi	E	2022	6,820	0	0	0	0	0	0	3,410	3,410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	Kinyerezi	E	2025	1,870	0	0	0	0	0	0	0	0	0	935	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	Kinyerezi	E	2030	1,870	0	0	0	0	0	0	0	0	0	0	0	0	0	0	935	935	0	0	0	0	0	0	0	0	0	0
69	Kinyerezi	E	2035	16,435	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,218	8,218	0	0	0	0	0
70	Kinyerezi	E	2040	50,320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,160	25,160
71	Kisada	N	2018	27,510	0	0	13,755	13,755	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72	Kisada	E	2020	7,900	0	0	0	0	3,950	3,950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	Kisada	E	2028	7,870	0	0	0	0	0	0	0	0	0	0	0	0	3,935	3,935	0	0	0	0	0	0	0	0	0	0	0	0
74	Kisada	E	2040	36,360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18,180	18,180
75	Kiyungi	E	2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	Kyaka	E	2018	9,930	0	0	4,965	4,965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	Kyaka	E	2020	935	0	0	0	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	Kyaka	E	2025	700	0	0	0	0	0	0	0	0	0	350	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	Kyaka	E	2027	700	0	0	0	0	0	0	0	0	0	0	0	350	350	0	0	0	0	0	0	0	0	0	0	0	0	0

Annual Expenditure of Substation Construction & Expansion Cost

No	Substation	New or Expansion	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)																									
					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
80	Kyaka	E	2030	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0	0	0	0	0	0	0
81	Kyaka	E	2035	3,270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,635	1,635	0	0	0	0	0
82	Kyaka	E	2037	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0
83	Kyela	N	2020	6,860	0	0	0	0	3,430	3,430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	Kyela	N	2028	8,445	0	0	0	0	0	0	0	0	0	0	0	0	4,223	4,223	0	0	0	0	0	0	0	0	0	0	0	0
85	Lindi	N	2019	25,990	0	0	0	12,995	12,995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86	Lindi	E	2020	7,440	0	0	0	0	3,720	3,720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	Lindi	E	2023	6,630	0	0	0	0	0	0	0	3,315	3,315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	Lindi	E	2030	6,225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,113	3,113	0	0	0	0	0	0	0	0	0	0
89	Lusu	E	2020	10,700	0	0	0	0	5,350	5,350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	Lusu	E	2026	4,445	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	Lusu	E	2032	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0	0	0	0	0
92	Lusu	E	2036	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0
93	Lusu	E	2040	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468
94	Madaba	N	2018	25,330	0	0	12,665	12,665	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95	Madaba	E	2020	7,440	0	0	0	0	3,720	3,720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	Madaba	E	2023	6,840	0	0	0	0	0	0	0	3,420	3,420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
97	Madaba	E	2030	6,225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,113	3,113	0	0	0	0	0	0	0	0	0	0
98	Madaba	E	2032	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0	0	0
99	Madaba	E	2034	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0
100	Makambako	E	2018	935	0	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101	Makambako	E	2019	700	0	0	0	350	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	Masasi	N	2023	25,990	0	0	0	0	0	0	0	12,995	12,995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103	Masasi	E	2025	7,440	0	0	0	0	0	0	0	0	0	3,720	3,720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104	Masasi	E	2033	6,225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,113	3,113	0	0	0	0	0	0	0
105	Mbeya	E	2018	30,095	0	0	15,048	15,048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106	Mbeya	E	2020	20,825	0	0	0	0	10,413	10,413	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107	Mbeya	E	2025	11,685	0	0	0	0	0	0	0	0	0	5,843	5,843	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
108	Mbeya	E	2028	15,975	0	0	0	0	0	0	0	0	0	0	0	0	7,988	7,988	0	0	0	0	0	0	0	0	0	0	0	0
109	Mbeya	E	2033	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0	0
110	Mbeya	E	2037	15,975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,988	7,988	0	0	0
111	Mbeya	E	2040	36,540	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18,270	18,270
112	Mbe-Sum SwS	E	2020	27,120	0	0	0	0	13,560	13,560	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113	Mbe-Sum SwS	E	2040	7,760	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,880	3,880
114	Mkuranga	N	2022	13,930	0	0	0	0	0	0	6,965	6,965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115	Mkuranga	E	2025	42,580	0	0	0	0	0	0	0	0	0	21,290	21,290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
116	Mkuranga	E	2030	2,975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,488	1,488	0	0	0	0	0	0	0	0	0	0
117	Mkuranga	E	2031	6,420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,210	3,210	0	0	0	0	0	0	0	0	0
118	Mkuranga	E	2035	2,975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,488	1,488	0	0	0	0	0
119	Mkuranga	E	2040	55,380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27,690	27,690
120	Mku-Som SwS-1	N	2031	17,990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,995	8,995	0	0	0	0	0	0	0	0	0
121	Mku-Som SwS-1	E	2040	17,700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,850	8,850
122	Mku-Som SwS-2	N	2031	17,990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,995	8,995	0	0	0	0	0	0	0	0	0
123	Mku-Som SwS-2	E	2040	48,540	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24,270	24,270
124	Mlandizi	E	2030	12,790	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,395	6,395	0	0	0	0	0	0	0	0	0	0
125	Mlandizi	E	2040	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223
126	Mnyera	N	2028	52,400	0	0	0	0	0	0	0	0	0	0	0	0	26,200	26,200	0	0	0	0	0	0	0	0	0	0	0	0
127	Mnyera	E	2030	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0	0	0	0	0
128	Mnyera	E	2033	16,945	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,473	8,473	0	0	0	0	0	0	0
129	Morogoro	E	2016	700 *1	350	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	Morogoro	E	2020	12,190	0	0	0	0	6,095	6,095	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131	Morogoro	E	2030	5,745	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,873	2,873	0	0	0	0	0	0	0	0	0	0
132	Mpanda	N	2020	35,515	0	0	0	0	17,758	17,758	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133	Mpanda	N	2025	1,120	0	0	0	0	0	0	0	0	0	560	560	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134	Mpanda	E	2030	7,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,525	3,525	0	0	0	0	0	0	0	0	0	0
135	Mpanda	E	2035	6,225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,113	3,113	0	0	0	0	0
136	Mpanda	E	2040	37,680	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18,840	18,840
137	Mpa-Sum SwS	N	2020	26,490	0	0	0	0	13,245	13,245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
138	Mpa-Sum SwS	E	2040	46,080	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23,040	23,040
139	Mpa-Tab SwS	E	2030	27,330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13,665	13,665	0	0	0	0	0	0	0	0	0	0
140	Mpa-Tab SwS	E	2040	17,080	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,540	8,540
141	Mtibwa	E	2016	700 *1	350	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
142	Mtibwa	E	2020	700	0	0	0	0	350	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
143	Mtibwa	E	2035	3,690	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,845	1,845	0	0	0	0	0
144	Mtwara	E	2019	23,330	0	0	0	11,665	11,665	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145	Mtwara	E	2020	12,420	0	0	0	0	6,210	6,210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
146	Mtwara	E	2025	10,820	0	0	0	0	0	0	0	0	0	5,410	5,410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
147	Mtwara	E	2030	10,670	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,335	5,335	0	0	0	0	0	0	0	0	0	0
148	Mtwara	E	2035	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0	0
149	Mtwara	E	2036	9,280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,640	4,640	0	0	0	0
150	Mtwara	E	2040	5,160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,580	2,580
151	Mufindi	E	2032	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0	0	0	0
152	Musoma	E	2020	10,700	0	0	0	0	5,350	5,350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
153	Musoma	E	2028	4,445	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0	0	0	0	0	0	0	0	0
154	Musoma	E	2035	1,870	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	935	935	0	0	0	0	0
155	Musoma	E	2036	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0
156	Mwanza	E	2020	5,390	0	0	0	0	2,695	2,695	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157	Mwanza	E	2025	66,890	0	0	0	0	0	0	0	0	0	33,445	33,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
158	Mwanza	E	2033	7,045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,523	3,523	0	0	0	0	0	0	0
159	Mwanza	E	2035	5,525	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,763	2,763	0	0	0	0	0
160	Mwanza	E	2037	7,045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,523	3,523	0	0	0
161	Mwanza	E	2040	8,945	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,473	4,473
162	North DSM	N	2025	19,180	0	0	0	0	0	0	0	0	0	9,590	9,590	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
163	North DSM	E	2030	1,870	0	0	0	0	0	0	0	0	0	0	0	0	0	0	935	935	0	0	0	0	0	0	0	0	0	0

Annual Expenditure of Substation Construction & Expansion Cost

No	Substation	New or Expansion	Year to be Com-missioned	Construction Cost (T. USD)	Annual Expenditure (Thousand USD)																									
					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
164	North DSM	E	2035	12,245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,123	6,123	0	0	0	0	0
165	North DSM	E	2040	24,490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,245	12,245
166	Nyakanazi	N	2018	7,630	0	0	3,815	3,815	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
167	Nyakanazi	E	2020	45,890	0	0	0	0	22,945	22,945	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
168	Nyakanazi	E	2025	1,430	0	0	0	0	0	0	0	0	0	715	715	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
169	Nyakanazi	E	2034	9,475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,738	4,738	0	0	0	0	0	0
170	Nyakanazi	E	2035	26,850	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13,425	13,425	0	0	0	0	0
171	Nyakanazi	E	2039	9,475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,738	4,738	0
172	Nyakanazi	E	2040	19,775	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9,888	9,888
173	Nyamongo	E	2020	9,930	0	0	0	0	4,965	4,965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
174	Nyamongo	E	2026	4,445	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175	Nyamongo	E	2033	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0	0	0	0
176	Nyamongo	E	2035	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0
177	Nyamongo	E	2037	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0
178	Rusumo	E	2018	2,570	0	0	1,285	1,285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
179	Rusumo	E	2035	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468	0	0	0	0	0
180	Rusumo	E	2040	935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468	468
181	Segera	N	2020	34,230 *1	0	0	0	0	17,115	17,115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
182	Segera	E	2029	9,935	0	0	0	0	0	0	0	0	0	0	0	0	0	4,968	4,968	0	0	0	0	0	0	0	0	0	0	0
183	Segera	E	2035	26,155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13,078	13,078	0	0	0	0	0
184	Segera	E	2040	27,810	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13,905	13,905
185	Shinyanga	E	2016	34,540 *1	17,270	17,270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
186	Shinyanga	E	2018	935	0	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
187	Shinyanga	E	2020	10,245	0	0	0	0	5,123	5,123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
188	Shinyanga	E	2022	28,975	0	0	0	0	0	0	14,488	14,488	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
189	Shinyanga	E	2025	7,050	0	0	0	0	0	0	0	0	0	3,525	3,525	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190	Shinyanga	E	2030	7,890	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,945	3,945	0	0	0	0	0	0	0	0	0	0
191	Shinyanga	E	2034	14,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,045	7,045	0	0	0	0	0	0
192	Shinyanga	E	2035	32,715	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16,358	16,358	0	0	0	0	0
193	Shinyanga	E	2038	7,045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,523	3,523	0	0
194	Shinyanga	E	2040	58,550	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29,275	29,275
195	Singida	E	2016	20,510 *1	10,255	10,255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
196	Singida	E	2017	935	0	468	468	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
197	Singida	E	2019	15,540	0	0	0	7,770	7,770	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
198	Singida	E	2020	33,540	0	0	0	0	16,770	16,770	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
199	Singida	E	2040	21,490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,745	10,745
200	Somanga Fungu	N	2018	13,210	0	0	6,605	6,605	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
201	Somanga Fungu	E	2019	16,295	0	0	0	8,148	8,148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202	Somanga Fungu	E	2020	11,200	0	0	0	0	5,600	5,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
203	Somanga Fungu	E	2030	14,065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,033	7,033	0	0	0	0	0	0	0	0	0	0
204	Somanga Fungu	E	2031	6,820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,410	3,410	0	0	0	0	0	0	0	0	0
205	Somanga Fungu	E	2033	4,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,200	2,200	0	0	0	0	0	0	0
206	Somanga Fungu	E	2035	9,760	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,880	4,880	0	0	0	0	0
207	Somanga Fungu	E	2038	4,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,200	2,200	0	0
208	Somanga Fungu	E	2040	12,460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,230	6,230
209	Songea	N	2018	5,390	0	0	2,695	2,695	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210	Songea	E	2023	31,195	0	0	0	0	0	0	0	15,598	15,598	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
211	Songea	E	2025	7,440	0	0	0	0	0	0	0	0	0	3,720	3,720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
212	Songea	E	2036	6,225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,113	3,113	0	0	0	0
213	Songwe Hydro_A S/S	N	2034	4,080	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,040	2,040	0	0	0	0	0	0
214	Songwe Hydro_B S/S	N	2028	4,560	0	0	0	0	0	0	0	0	0	0	0	0	2,280	2,280	0	0	0	0	0	0	0	0	0	0	0	0
215	Songwe Hydro_B S/S	E	2034	1,400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	700	700	0	0	0	0	0	0
216	South DSM	N	2025	20,720	0	0	0	0	0	0	0	0	0	10,360	10,360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
217	South DSM	E	2035	12,245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,123	6,123	0	0	0	0	0
218	South DSM	E	2040	24,490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,245	12,245
219	Southeast DSM	N	2025	20,720	0	0	0	0	0	0	0	0	0	10,360	10,360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	Southeast DSM	E	2030	12,245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,123	6,123	0	0	0	0	0	0	0	0	0	0
221	Southeast DSM	E	2035	12,245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,123	6,123	0	0	0	0	0
222	Sumbawanga	N	2020	33,560	0	0	0	0	16,780	16,780	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
223	Sumbawanga	E	2024	5,790	0	0	0	0	0	0	0	0	2,895	2,895	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
224	Sumbawanga	E	2035	6,225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,113	3,113	0	0	0	0	0
225	Sumbawanga	E	2040	27,420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13,710	13,710
226	Tab-Mpa SwS	N	2030	27,330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13,665	13,665	0	0	0	0	0	0	0	0	0	0
227	Tab-Mpa SwS	E	2040	17,080	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,540	8,540
228	Tabora	E	2020	12,530	0	0	0	0	6,265	6,265	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
229	Tabora	E	2026	7,045	0	0	0	0	0	0	0	0	0	0	3,523	3,523	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230	Tabora	E	2030	57,250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28,625	28,625	0	0	0	0	0	0	0	0	0	0
231	Tabora	E	2033	7,045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,523	3,523	0	0	0	0	0	0	0
232	Tabora	E	2037	7,045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,523	3,523	0	0	0
233	Tabora	E	2040	60,890	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30,445	30,445
234	Tanga	E	2020	14,020	0	0	0	0	7,010	7,010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
235	Tanga	E	2031	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0	0	0	0	0	0
236	Tanga	E	2036	4,445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,223	2,223	0	0	0	0
237	Tunduru	N	2023	27,370	0	0	0	0	0	0	0	13,685	13,685	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
238	Tunduru	E	2025	7,240	0	0	0	0	0	0	0	0	0	3,620	3,620	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
239	Tunduru	E	2033	6,225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,113	3,113	0	0	0	0	0	0	0
240	Ubungo	E	2020	18,610	0	0	0	0	9,305	9,305	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
241	West DSM	N	2030	20,720	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,360	10,360	0	0	0	0	0	0	0	0	0	0
242	West DSM	E	2035	12,245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,123	6,123	0	0	0	0	0
243	West DSM	E	2040	13,180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,590	6,590
	Total Expenditure (Annual)			3,636,966	73,935	74,870	157,840	222,063	371,755	306,598	24,863	77,398	57,173	149,813	155,765	11,408	47,665	63,670	142,205	152,215	38,878	38,678	44,100	149,655	150,858	43,335	33,910	19,385	519,538	509,398
	Note: *1: Should be replaced with the cc			(Thousand USD)	1,207,060						465,010					417,163					422,169					1,125,565				

Appendix-4: Cash flows for the PSMP 2016-2040 (US Dollar, million)

Year	Domestic Power Sales, GOT Base Case (GWh)	Export (MW)	Export Sales (GWh)	Total Power Sales (GWh)	Cost - Generation - Capital Expenditure - Thermal. Wind & Solar	Geothermal	Hydro	Capital Cost for Generation	IDC at 70:30 Debt:Equity	Fuel, O&M Cost	Cost for Generation	Cost balance - TANESCO Cost for Generation	IPP Cost for Generation	Transmission - Capital Cost	IDC at 70:30 Debt:Equity	O&M Cost	Cost for Transmission	Distribution - Capital Expenditure	O&M Cost	Cost for Distribution
2016	6,761	0	0	6,761	119	0	16	135	7	561	704	352	352	206	9	46.1	261	9	92	101
2017	7,888	0	0	7,888	761	0	86	847	41	656	1,544	772	772	546	23	53.8	623	35	108	142
2018	9,196	0	0	9,196	1,473	0	124	1,597	77	1,174	2,848	1,424	1,424	913	39	62.7	1,015	63	125	188
2019	10,580	0	0	10,580	1,942	0	44	1,986	92	1,207	3,285	1,643	1,643	1,712	73	72.1	1,857	92	144	237
2020	17,343	600	3,679	21,022	1,711	0	0	1,711	59	1,400	3,171	1,585	1,585	1,343	57	118.2	1,518	76	236	313
2021	18,690	600	3,679	22,370	314	0	0	314	14	1,472	1,800	900	900	55	2	140.2	197	9	280	290
2022	20,166	600	3,679	23,845	942	0	17	959	58	1,550	2,567	1,284	1,284	308	13	151.2	473	32	302	334
2023	21,776	600	3,679	25,455	732	65	111	908	60	1,625	2,593	1,296	1,296	284	12	163.3	459	30	327	356
2024	23,580	600	3,679	27,259	252	442	145	839	58	1,715	2,612	1,306	1,306	323	14	176.8	513	29	354	383
2025	25,513	600	3,679	29,192	348	585	310	1,243	89	1,792	3,124	1,562	1,562	309	13	191.3	513	39	383	421
2026	27,526	600	3,679	31,205	428	208	323	959	71	1,832	2,862	1,431	1,431	22	1	206.4	230	25	413	437
2027	29,718	600	3,679	33,398	1,288	0	404	1,693	123	1,928	3,743	1,872	1,872	109	5	222.9	337	45	446	491
2028	32,082	600	3,679	35,761	1,313	0	590	1,903	140	2,101	4,144	2,072	2,072	122	5	240.6	368	51	481	532
2029	34,690	600	3,679	38,370	737	0	947	1,684	147	2,212	4,043	2,022	2,022	391	17	260.2	668	52	520	572
2030	37,556	600	3,679	41,235	846	0	1,367	2,213	224	2,312	4,749	2,375	2,375	477	20	281.7	779	67	563	631
2031	40,684	600	3,679	44,363	584	0	1,237	1,820	211	2,397	4,428	2,214	2,214	125	5	305.1	436	49	610	659
2032	44,107	600	3,679	47,786	382	0	1,408	1,790	261	2,478	4,529	2,264	2,264	75	3	350.8	429	47	702	748
2033	47,863	600	3,679	51,543	1,280	0	871	2,151	215	2,553	4,918	2,459	2,459	83	4	380.7	467	56	761	817
2034	51,964	600	3,679	55,643	706	0	571	1,277	133	2,737	4,147	2,074	2,074	664	28	413.4	1,105	49	827	875
2035	56,444	600	3,679	60,123	1,164	0	780	1,943	121	2,828	4,892	2,446	2,446	663	28	449.0	1,140	65	898	963
2036	61,002	600	3,679	64,681	1,215	0	389	1,604	92	3,074	4,770	2,385	2,385	53	2	485.2	540	41	970	1,012
2037	65,954	600	3,679	69,633	1,522	0	0	1,522	87	3,221	4,831	2,415	2,415	40	2	524.6	566	39	1,049	1,088
2038	71,340	600	3,679	75,019	1,604	0	0	1,604	94	3,522	5,220	2,610	2,610	25	1	567.5	594	41	1,135	1,176
2039	77,183	600	3,679	80,862	1,508	0	0	1,508	81	3,854	5,443	2,721	2,721	561	24	614.0	1,199	52	1,228	1,280
2040	83,524	600	3,679	87,203	1,068	0	0	1,068	50	4,240	5,358	2,679	2,679	551	23	664.4	1,238	40	1,329	1,369

Year	Total Cost with IDC	Tariff Rate (US$, kWH)	Tariff Rate for Export (US$, kWH)	Benefit - Domestic Revenue	Revenue from Export	Total Revenue	Revenue for TANESCO	Revenue for IPP	Income (Loss)	Income for TANESCO	Income for IPP	Tax	Tax for TANESCO	Tax for IPP	Net Benefit/ Cost	TANESCO Net benefit	IPP Net benefit	Net Benefit/Cost With residual Value	TANESCO Net benefit	IPP Net benefit
2016	1,066	0.136	0.116	922	0	922	530	392	(144)	(184)	40	0	0	12	(144)	(184)	28	(144)	(184)	28
2017	2,310	0.136	0.116	1,076	0	1,076	618	457	(1,234)	(919)	(315)	0	0	0	(1,234)	(919)	(315)	(1,234)	(919)	(315)
2018	4,051	0.136	0.116	1,254	0	1,254	721	533	(2,797)	(1,906)	(891)	0	0	0	(2,797)	(1,906)	(891)	(2,797)	(1,906)	(891)
2019	5,379	0.136	0.116	1,443	0	1,443	830	613	(3,936)	(2,906)	(1,029)	0	0	0	(3,936)	(2,906)	(1,029)	(3,936)	(2,906)	(1,029)
2020	5,002	0.136	0.116	2,365	426	2,791	1,786	1,005	(2,210)	(1,630)	(580)	0	0	0	(2,210)	(1,630)	(580)	(2,210)	(1,630)	(580)
2021	2,287	0.150	0.128	2,804	469	3,273	2,081	1,192	986	694	291	296	208	87	690	486	204	690	486	204
2022	3,374	0.150	0.128	3,025	469	3,494	2,208	1,286	120	118	2	36	35	1	84	83	1	84	83	1
2023	3,408	0.150	0.128	3,266	469	3,736	2,347	1,388	327	235	92	98	71	28	229	165	64	229	165	64
2024	3,508	0.150	0.128	3,537	469	4,006	2,503	1,503	498	301	197	150	90	59	349	211	138	349	211	138
2025	4,059	0.150	0.128	3,827	469	4,296	2,670	1,626	237	173	64	71	52	19	166	121	45	166	121	45
2026	3,529	0.150	0.128	4,129	469	4,598	2,843	1,755	1,069	745	324	321	223	97	748	521	227	748	521	227
2027	4,571	0.150	0.128	4,458	469	4,927	3,032	1,895	356	333	23	107	100	7	249	233	16	249	233	16
2028	5,044	0.150	0.128	4,812	469	5,281	3,236	2,045	238	264	(27)	71	79	0	166	185	(27)	166	185	(27)
2029	5,283	0.150	0.128	5,204	469	5,673	3,461	2,212	389	199	190	117	60	57	273	140	133	273	140	133
2030	6,159	0.150	0.128	5,633	469	6,102	3,708	2,394	(56)	(76)	19	0	0	6	(56)	(76)	14	(56)	(76)	14
2031	5,523	0.150	0.128	6,103	469	6,572	3,978	2,594	1,049	669	380	315	201	114	734	469	266	734	469	266
2032	5,706	0.159	0.135	7,017	498	7,514	4,532	2,982	1,808	1,091	718	543	327	215	1,266	763	502	1,266	763	502
2033	6,203	0.159	0.135	7,615	498	8,112	4,876	3,236	1,909	1,132	777	573	340	233	1,336	792	544	1,336	792	544
2034	6,128	0.159	0.135	8,267	498	8,765	5,251	3,513	2,637	1,197	1,440	791	359	432	1,846	838	1,008	1,846	838	1,008
2035	6,995	0.159	0.135	8,980	498	9,477	5,661	3,816	2,482	1,112	1,371	745	333	411	1,737	778	959	1,737	778	959
2036	6,322	0.159	0.135	9,705	498	10,202	6,078	4,125	3,880	2,140	1,739	1,164	642	522	2,716	1,498	1,218	2,716	1,498	1,218
2037	6,485	0.159	0.135	10,493	498	10,990	6,531	4,459	4,506	2,461	2,044	1,352	738	613	3,154	1,723	1,431	3,154	1,723	1,431
2038	6,989	0.159	0.135	11,349	498	11,847	7,023	4,824	4,858	2,644	2,214	1,457	793	664	3,401	1,851	1,550	3,401	1,851	1,550
2039	7,921	0.159	0.135	12,279	498	12,777	7,558	5,219	4,855	2,358	2,497	1,457	707	749	3,399	1,651	1,748	3,399	1,651	1,748
2040	7,965	0.159	0.135	13,288	498	13,785	8,138	5,647	5,820	2,852	2,968	1,746	855	891	4,074	1,996	2,078	38,766	23,161	15,605

Appendix-5: Cash flows for financing the project 2016-2040 (US Dollar, million)

Debt Payment Projection											
Year		Out Flow (US$, million)				In Flow (US$, million)					Net Cash (USD, million)
		Project Cost for PSMP Electric	Loan		Total Out Flow	Electric Power Revenue	Finance			Total Inflow	
			Repayment	Interest			Equity	Debt	Total		
1	2016	1,066	0	7	1,073	922	45	106	151	1,073	0
2	2017	2,310	0	71	2,381	1,076	392	914	1,306	2,381	0
3	2018	4,051	0	219	4,270	1,254	905	2,111	3,016	4,270	0
4	2019	5,379	11	433	5,822	1,443	1,314	3,066	4,379	5,822	0
5	2020	5,002	102	568	5,671	2,791	864	2,016	2,880	5,671	0
6	2021	2,287	313	553	3,153	3,273	0	0	0	3,273	119
7	2022	3,374	620	585	4,578	3,494	325	759	1,084	4,578	0
8	2023	3,408	821	625	4,855	3,736	336	784	1,120	4,855	0
9	2024	3,508	821	674	5,003	4,006	299	698	997	5,003	0
10	2025	4,059	897	737	5,693	4,296	419	978	1,397	5,693	0
11	2026	3,529	976	765	5,270	4,598	201	470	672	5,270	0
12	2027	4,571	1,045	835	6,451	4,927	457	1,067	1,524	6,451	0
13	2028	5,044	1,143	917	7,104	5,281	547	1,276	1,823	7,104	0
14	2029	5,283	1,180	1,002	7,465	5,673	538	1,255	1,793	7,465	0
15	2030	6,159	1,205	1,117	8,481	6,102	714	1,665	2,379	8,481	0
16	2031	5,523	1,213	1,183	7,919	6,572	404	943	1,347	7,919	0
17	2032	5,706	1,243	1,212	8,162	7,514	194	453	647	8,162	0
18	2033	6,203	1,515	1,234	8,952	8,112	252	588	840	8,952	0
19	2034	6,128	1,811	1,234	9,172	8,765	122	285	408	9,172	0
20	2035	6,995	1,780	1,263	10,039	9,477	168	393	561	10,039	0
21	2036	6,322	1,836	1,259	9,418	10,202	0	0	0	10,202	784
22	2037	6,485	1,874	1,257	9,615	10,990	0	0	0	10,990	1,375
23	2038	6,989	1,885	1,256	10,130	11,847	0	0	0	11,847	1,717
24	2039	7,921	1,936	1,252	11,109	12,777	0	0	0	12,777	1,667
25	2040	7,965	1,876	1,257	11,098	13,785	0	0	0	13,785	2,687

Overall Debt						TANESCO Debt				
Year	Accumulated Loan	Loan Principal Payment	Year	Debt balance	Interest payment	Annual Debt	Annual Debt to GDP	Tanesco Debt Balance	PV Of TANESCO Debt	PV Of Debt to GDP
1	106		2016	106	7	53	0.11%	53	50	0.11%
2	1,020		2017	1,020	71	457	0.89%	510	463	0.90%
3	3,131		2018	3,131	219	1,056	1.92%	1,566	1,352	2.46%
4	6,197	11	2019	6,186	433	1,533	2.60%	3,093	2,545	4.32%
5	8,213	102	2020	8,111	568	1,008	1.60%	4,055	3,178	5.05%
6	8,213	313	2021	7,900	553	0	0.00%	3,950	2,947	4.37%
7	8,972	620	2022	8,352	585	379	0.53%	4,176	2,968	4.12%
8	9,756	821	2023	8,934	625	392	0.51%	4,467	3,024	3.92%
9	10,454	821	2024	9,632	674	349	0.42%	4,816	3,105	3.76%
10	11,432	897	2025	10,535	737	489	0.55%	5,267	3,234	3.66%
11	11,902	976	2026	10,926	765	235	0.25%	5,463	3,194	3.41%
12	12,969	1,045	2027	11,923	835	533	0.54%	5,962	3,320	3.35%
13	14,244	1,143	2028	13,101	917	638	0.61%	6,551	3,474	3.30%
14	15,499	1,180	2029	14,320	1,002	627	0.56%	7,160	3,616	3.24%
15	17,165	1,205	2030	15,959	1,117	833	0.70%	7,980	3,838	3.25%
16	18,107	1,213	2031	16,894	1,183	471	0.38%	8,447	3,870	3.09%
17	18,560	1,243	2032	17,317	1,212	226	0.17%	8,659	3,778	2.84%
18	19,149	1,515	2033	17,634	1,234	294	0.21%	8,817	3,664	2.60%
19	19,434	1,811	2034	17,623	1,234	143	0.10%	8,812	3,487	2.34%
20	19,827	1,780	2035	18,047	1,263	196	0.12%	9,023	3,401	2.15%
21	19,827	1,836	2036	17,990	1,259	0	0.00%	8,995	3,229	1.94%
22	19,827	1,874	2037	17,953	1,257	0	0.00%	8,977	3,069	1.76%
23	19,827	1,885	2038	17,942	1,256	0	0.00%	8,971	2,921	1.60%
24	19,827	1,936	2039	17,891	1,252	0	0.00%	8,946	2,774	1.44%
25	19,827	1,876	2040	17,951	1,257	0	0.00%	8,975	2,650	1.31%

CHAPTER SEVEN

7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

Discovery of new natural resources such as deep water natural gas in the southern part of Tanzania, development of coal mines (Mchuchuma, Ngaka, Kiwira and Rukwa) and uranium mining (Mkuju – Ruvuma); and acceleration of industrial activities are changing the structure of Tanzania's economy. All these pose pressure on the electricity demand in the country. Despite the endowment of enormous resources for power generation, critical challenges exist including mobilization of adequate financial resources to implement the proposed power projects and inadequate requisite human resources, skills and knowledge for developing power resources.

Other general challenge, especially in the preparations of this Plan, is related to data issue. Some data and information were found to be inconsistent, outdated and insufficient. Some of the identified projects have not been studied to feasibility level while others have outdated feasibility study reports, thus render it difficult to make meaningful decision on the project implementation. Furthermore, most generation resources are located in the south-west and south-east part of the country while huge loads are located in the north-west and north-east of the country. This implies the need for long transmission lines to deliver power from sources to load centers.

The system expansion plan considered all energy resources available within the country which includes hydro, natural gas, coal, solar, wind and geothermal as well as the import of electric power from neighboring countries to ensure adequate, reliable power and security of supply over the planning horizon.

The development of generation expansion plans covered the six scenarios following the three cases of load forecast, namely, high, base and low. The PSMP2016 Update sought the optimal generation expansion plan using the least cost generation planning software named WASP. LOLP (Loss Of Load Probability) was used as a criteria for power supply reliability, the same as previous PSMP which is 5days/year. Hydro-thermal share was not fixed even though it was targeted to be 40:60 in PSMP2012. In the six generation expansion scenarios, different shares of several power resources such as natural gas, coal, hydro and renewable energy were set and each scenario was evaluated from the aspects of economy, energy balance and environment. As a result, Scenario-2 which has the energy generation mix of 40% gas, 35% coal, 20% hydro and 5% renewable and others was selected to be the best among six scenarios.

The optimal generation plan (scenario-2) has a total installed generation capacity of 5,011MW (excluding renewable and import) by 2020 which is beyond the government target of 4,915MW by 2020. It will increase up to 22,595MW by 2040 consisting of 5,093MW hydro, 10,253MW gas-fired generation, 6,000MW Coal, 850MW renewable and 400MW import.

This Plan suggests countermeasures to satisfy rapidly increasing power demand in the short, medium and long term including the integration of isolated grids and un-electrified areas into the national grid. While the short-term plan requires immediate decision and actions, the mid - long term plans require coordinated planning and project development studies to ensure that future electricity supply utilizes the least cost projects in consistent with sound planning criteria in order to address national interests. It should be noted that associated transmission infrastructure should be constructed in a timely manner in order to evacuate power from the sources to end users.

In view of the above, the country will need a total of US$11.6 billion in the short term (2016-20), US$5.9 billion in the mid-term (2021-2025) and US$31.7 billion in the long term (2026-2040). The cost includes investment on generation, transmission and substation. Generation accounts for almost 80% of total investment cost. The following table shows the summary of investment costs.

Table 7-1: Summary of investment costs

Cost of	Five-year investment cost (million USD)					Total
	2016-2020	2021-2025	2025-2030	2031-2035	2036-2040	
Generation	6,671	4,660	9,459	10,325	7,883	**38,998**
Transmission Lines	3,717	814	714	1,197	152	**6,593**
Substation	1,207	465	417	422	1,126	**3,637**
Total	**11,595**	**5,939**	**10,590**	**11,945**	**9,160**	**49,229**
% of Each Period	24%	12%	22%	24%	19%	100%

7.2 Recommendations

7.2.1 General Recommendations

The following are recommendations for successful implementation of the PSMP2016 updates.

a) For a sustainable development of power sector, there is a need to firm up project implementation schedule as proposed by PSMP 2016 Update particularly those which have element of PPP and IPP arrangements;

b) There is a need to ensure that strategic power projects are studied to full feasibility level to reduce project implementation lead time and to properly evaluate the viability of the projects in order to make the least cost plan;

c) To speed up geothermal power development, there is a need to enhance capacity of Tanzania Geothermal Development Corporation (TGDC) to carry out detailed surveys and studies for geothermal resources;

d) For the Gas-fired power that intends to contribute 40% in total energy generation, investment on gas wells development together with processing and transportation facilities is inevitable to satisfy projected high demand of gas for power generation.

Following power demand projections, not later than the year 2018 new gas processing facilities are needed in addition to the current processing capacity of 465mmscfd. In the same course, not later than the year 2030 new gas processing and transportation facilities are needed to meet the increased gas demand for power generation. The recommendations above are made based on the assumption that 85% of total gas transported is allocated to power generation up to 2025 and 70% after 2025.

e) There is a need to promote the development of renewable power projects (Wind, geothermal, Solar, and Biomass) to supplement exhaustible resources;

f) Most of the projects proposed under PSMP 2012 Update have not been completed or commenced as of December 2016. This delay is attributed to (i) the lack of sufficient financing, (ii) the lack of legal binding to implement a proposed project under a private sector, (iii) long approval process and (iv) environmental and social issues which require consent from various stakeholders. These challenges need to be addressed by the measures recommended in this chapter. Particularly, this document should be used as one of working tools during the preparation of annual budgets.

g) To ensure effective implementation of PSMP2016 Update, the Government may need to establish a monitoring and evaluation unit which is dedicated to accelerate the planned projects. The unit should be consisted of inter-ministerial members so that all stakeholders of power development are deeply involved in the project implementation; and

h) Capacity building: In order to internalize and broaden up experts of formulating plan of this nature and improve local expertise, the government needs to maintain and retain the core team that will be responsible for the preparation of future Plan. More capacity is required to enhance the process of formulating, reviewing and updating PSMP. This will include training of the core team, procuring of the modelling packages and sharing leaf of experience with institutions involved in related to similar planning works.

7.2.2 Specific Recommendations

A. Generation

i. Huge investment will be required to implement planned generation expansion, particularly, for the period 2016 - 2020 in order to achieve government target. In order to relieve financial burden to the government on power development, private participation in generation sector should be accelerated. For this purpose, it is recommended to study the experiences of other countries which have successfully introduced IPPs to extract meaningful lessons. However, pros and cons of introducing private sectors in power generation should be carefully examined based on such lessons. The following table shows the examples of incentives for IPPs introduced in Asian countries to accelerate private participation in generation sector. Government guarantee and ensuring payment to purchased power seemed to be key elements to relieve risks from investors.

Table 7-2: Examples of incentives for IPPs introduced in Asian countries

	Philippines	Thailand	Indonesia
Fuel supply	National Power Corporation (NPC) guarantees free fuel supply to IPPs (in case of coal)	Petroleum Authority of Thailand provides fuel supply guarantee for gas firing IPPs	N/A
Power Purchase	NPC guarantees to purchase certain amount of electricity from IPPS or pay the amount for which NPC cannot purchase	Electricity Generating Authority of Thailand (EGAT) guarantees to purchase certain amount of electricity from IPPs	PLN (state owned electric utility) guarantees to purchase certain amount of electricity from IPPs
Policy change	The government guarantees to buy back IPP power plants if policy changes obstruct project implementation	EGAT guarantees to buy back IPP power plants if policy changes obstruct project implementation	The government guarantees to buy back IPP power plants if policy changes obstruct project implementation
Tax exemption	Income tax (6years for coal and geo-thermal), customs, VAT	Income tax, customs (depend on location)	Customs, grace period for VAT and sales tax

ii. In order to avoid power shortages, projects earmarked for implementation in the short term (2016 - 2020) should be strictly adhered to as there is no room to maneuver.

iii. Two hydro projects will require removal of significant obstacles before becoming firm candidates for implementation:

a) **Songwe project** is a multipurpose project located on the border between Tanzania and Malawi, its development will involve trade-offs between two countries and various competing uses of the water resource. It is necessary to expedite joint discussions on the best way to develop the project.

b) **The Stiegler's Gorge** is located within the Selous Game Reserve; its development is constrained by the Algiers Conventions which defines the developments possibilities within national parks and game reserves. It is therefore important to redefine the game reserve borders and to introduce any other possible mitigation measures.

B. Transmission and distribution requirements

i. Continue implementation of earmarked Transmission lines projects in parallel with generation projects to ensure power evacuation. Wayleave compensation should be taken into consideration in budgeting the construction for transmission lines.

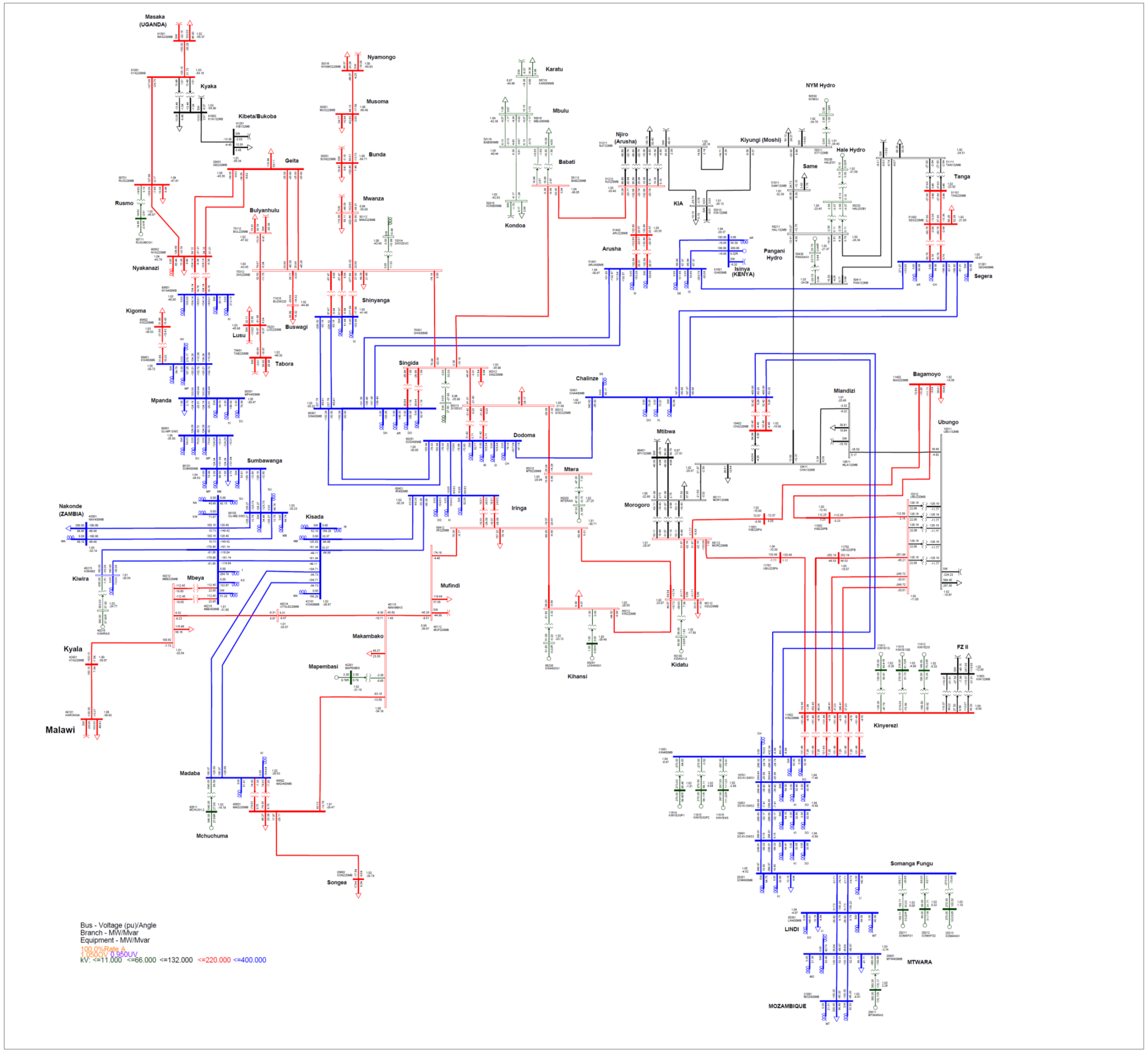
ii. Reinforce distribution network to meet electrification targets and to accommodate increased power supply.

C. Financial and Economic Perspective

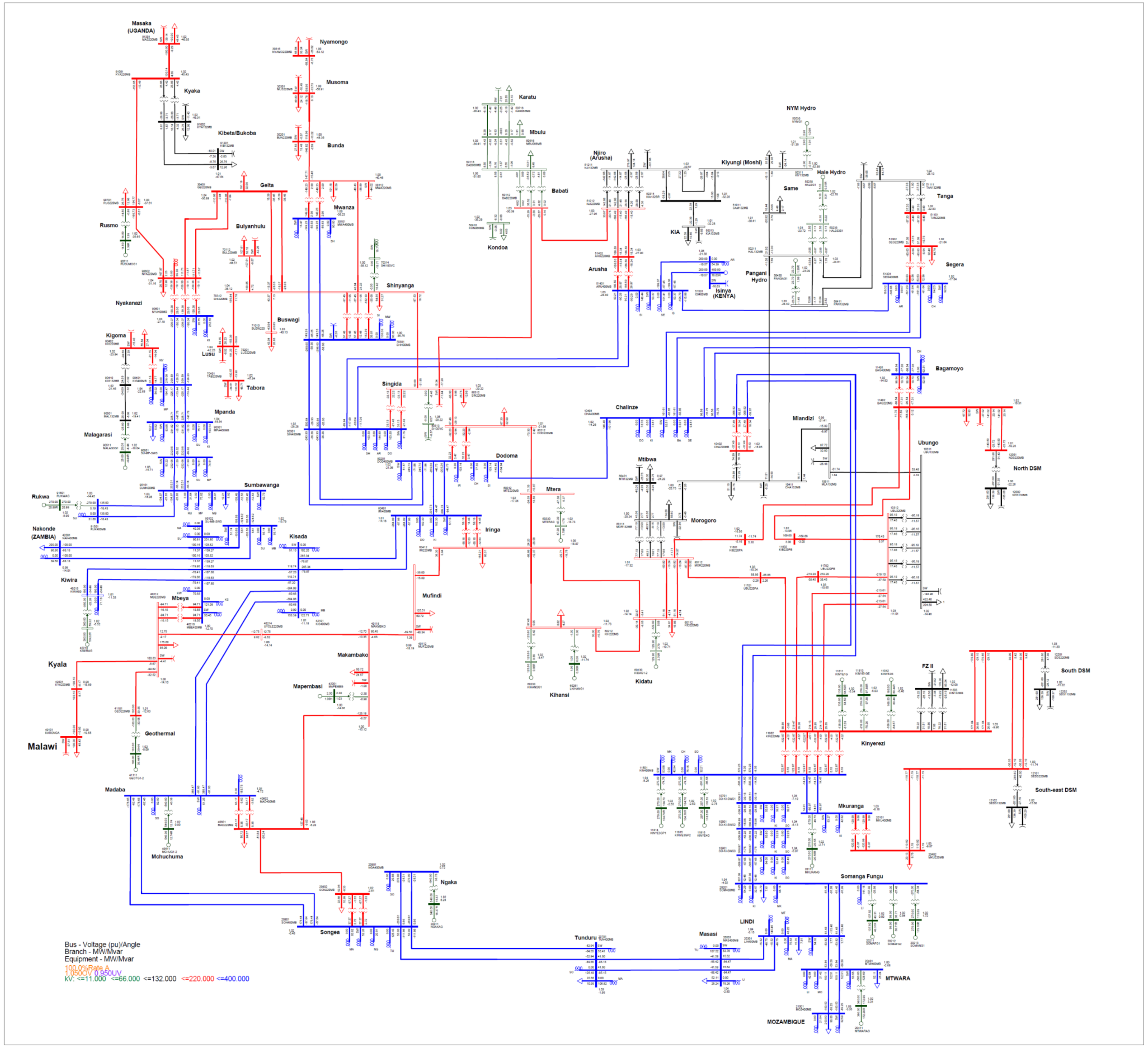
i. Implementation of projects planned under PSMP2016 Update requires huge financial resources. Concerted efforts to be exercised in mobilizing required financing for both power generation, transmission and distribution;

ii. The Government should continue with efforts to invest in power infrastructure to meet long term power demand and at the same time create conducive environment to attract private investment in the power sector.

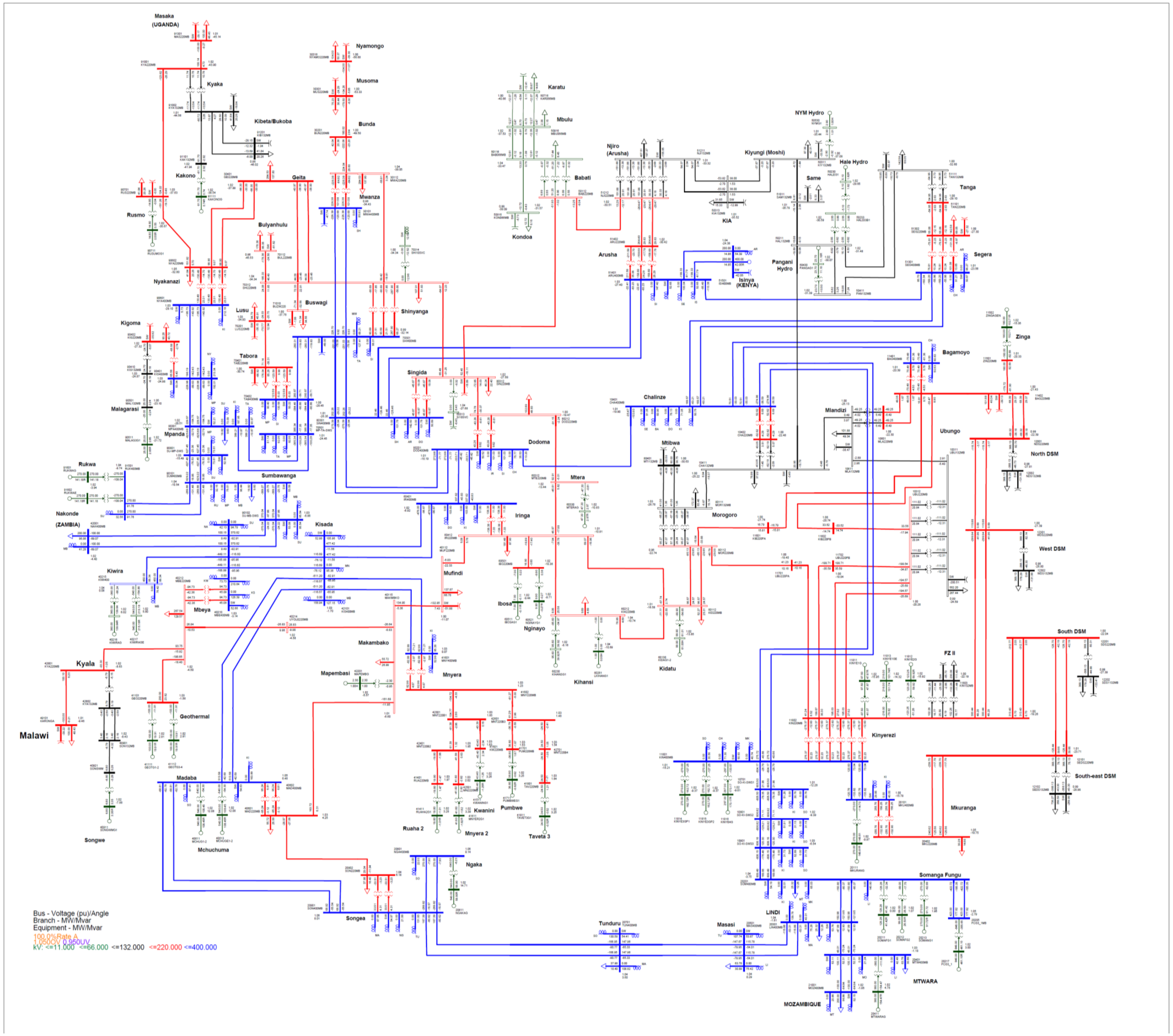
Load Flow for the Tanzanian interconnected power system - Year 2020 during peak load conditions



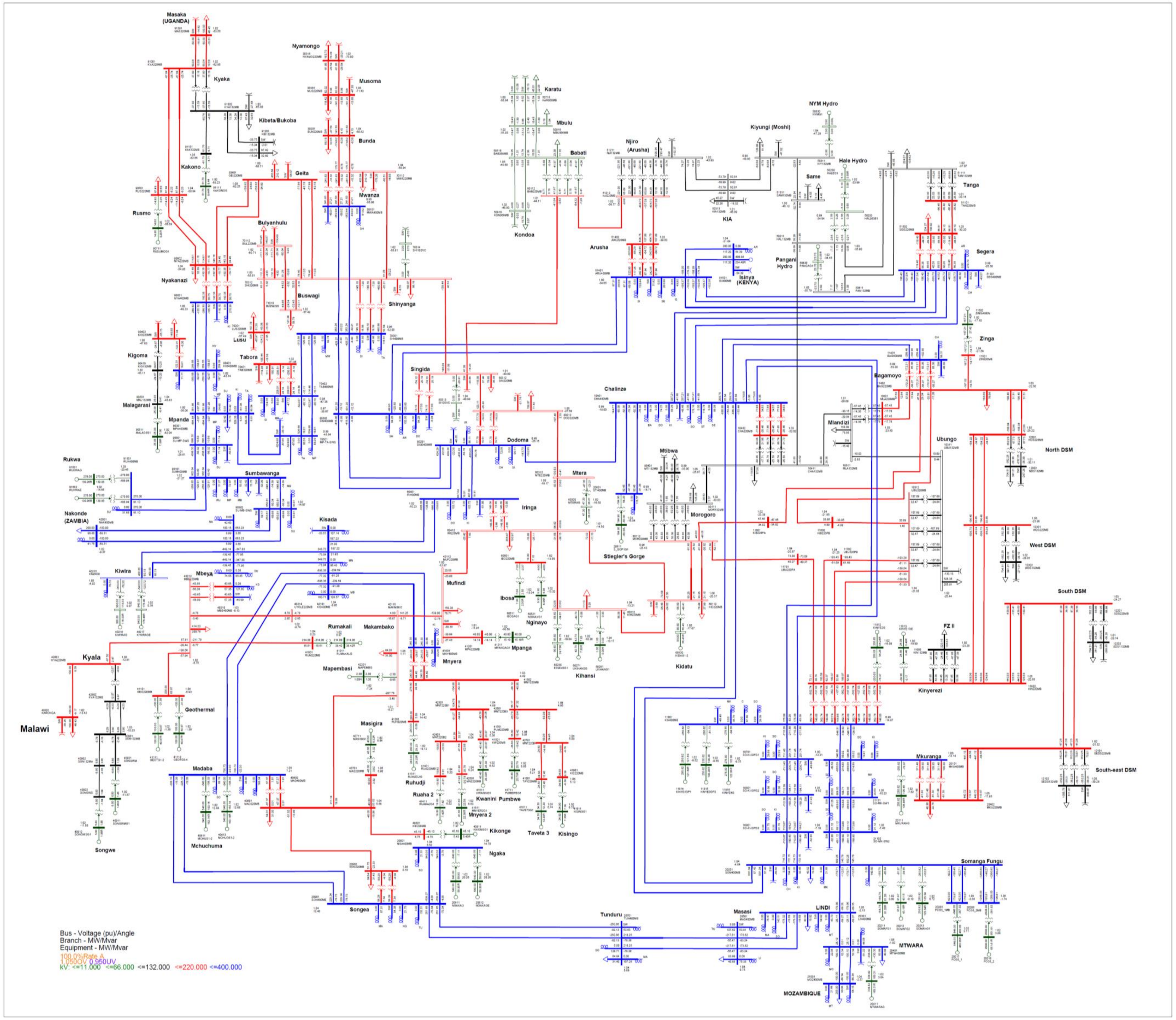
Load Flow for the Tanzanian interconnected power system - Year 2025 during peak load conditions



Load Flow for the Tanzanian interconnected power system - Year 2030 during peak load conditions



Load Flow for the Tanzanian interconnected power system - Year 2035 during peak load conditions



Load Flow for the Tanzanian interconnected power system - Year 2040 during peak load conditions