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

FINAL REPORT
ON
THE PROJECT FOR
FORMULATION OF POWER SYSTEM MASTER PLAN IN DAR ES SALAAM AND COAST REGIONS AND REVIEW OF POWER SYSTEM MASTER PLAN 2012
IN
THE UNITED REPUBLIC OF TANZANIA

REVIEW OF POWER SYSTEM MASTER PLAN 2012

MARCH 2017

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.

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Abbreviations

AfDB	African Development Bank
BICO	Bureau for Industrial Cooperation
BOO	Build Own Operate
BOT	Build Operate Transfer
CBD	Convention on Biological Diversity
CCGT	Combined Cycle Gas Turbine
CIF	Climate Investment Funds
CITES	Convention on International Trade of Endangered Species
CRIDF	Climate Resilient Infrastructure Development Facility
DART	Dar es Salaam Rapid Transit
EEPCO	Ethiopian Electric Power Corporation
EAC	East African Community
EHS guidelines	Environmental, Health, and Safety guidelines
EIA	Environmental Impact Assessment
EIPC	Electricity Infrastructure Procurement Coordinator
EIS	Environmental Impact Statement
EMA 2004	Environmental Management Act 2004
EPC	Engineering, procurement, Construction
EPP	Emergency Power Producer
ESI	Electricity Supply Industry
ESIA	Environmental and Social Impact Assessment
EWURA	Energy and Water Utilities Regulatory Authority
EPZ	Export Processing Zone
FEED	Front End Engineering Design
FID	Final Investment Decision
F/S	Feasibility Study
FYDP	Five Year Development Plan
GCC	Grid Control Center
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIP	Gas In Place
HFO	Heavy Fuel Oil
IDO	Industrial Diesel Oil
IEA	International Energy Agency
IFC	International Finance Corporation
IMF	International Monetary Fund
IMTC	Inter-Ministerial Technical Committee
IPP	Independent Power Producer
IPP	Independent Power Producer
IRR	Internal Rate of Return

ISO	Independent System Operator
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
LOLP	Loss Of Load Probability
MBREMP	Mnazi Bay Ruvuma Estuary Marine Park
MEM	Ministry of Energy and Minerals
MNRT	Ministry of Natural Resources and Tourism
MOIT	Ministry of Industry and Trade
MCPP	Managed Co-lending Portfolio Program
MEAs	Multi-lateral Environmental Agreements
NCA	Ngorongoro Conservation Area
NCAA	Ngorongoro Conservation Area Authority
NDC	National Development Corporation
NEAC	National Environmental Advisory
NEMC	National Environment Management Council
NGUMP	Natural Gas Utilization Master Plan
NPs	National Park Service
PID	Project Information Document
PPA	Power Purchase Agreement
PPP	Purchasing Power Parity
PPP	Public Private Partnership
PRG	Partial Risk Guarantees
PSC	Production Sharing Contract
PSMP	Power System Master Plan
R/D	Record of Discussions
REA	Rural Energy Agency
REME	Regional Environmental Management Expert
RERE	Renewable Energy for Rural Electrification
RPU	Revenue Protection units
SADC	Southern Africa Development Community
SAGCOT	Tanzania's south agricultural growth corridor
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SPC	Special Purpose Company
SPP	Small Power Producer
SPP	Small Power Purchase
SREP	Scaling-Up Renewable Energy Program
STAMICO	State. Mining Corporation
Ses	Sector Environment Sections
TANAPA	Tanzania National Parks Authority
TANESCO	Tanzania Electric Supply Company Limited

TDV2025	Tanzania Development Vision 2025
TEDAP	Tanzania Energy Development and Access Expansion Project
TGDC	Tanzania Geothermal Development Company
TTCL	Tanzania Telecommunications Company Limited
TPDC	Tanzania Petroleum Development Corporation
TRC	Tanzania Railways Corporation
USBR	US Bureau of Reclamation
VPO	Vice President's Office
WASP	Wien Automatic System Planning Package
WMAs	Wildlife Management Areas
WTM	West Texas Intermediate
ZTK	Zambia-Tanzania Kenya Transmission Line project

Chapter 1 Introduction

1.1 Background

Tanzania has marked a steady economic growth rate of 6 to 7% a year as the government strives to realize strong economy by indicating the direction of the country's development in the "Tanzania Development Vision 2025". "The Tanzania Five Year Development Plan" announced in June 2011 attempts to take advantage of the country's environment blessed with natural gas and mineral resources, sets a goal of shifting the focus of economic base from agriculture to industry and aims for development of key infrastructure.

Demand for electric power that supports this economic growth in Tanzania is said to be growing at more than 10% a year which is higher than the rate of economic growth. However, augmentation of facilities consistent with expansion of demand and maintenance of existing facilities was not performed properly during the period from the trial privatization of electric supply company in 1992 to its termination in 2006 due to stagnation of public support from the government and donors. For this reason, many of the existing facilities owned by Tanzania Electric Supply Company Limited (hereafter "TANESCO"), which single-handedly supplies electricity to all of Tanzania with the exception of Zanzibar Island, became superannuated and placed under chronic overload. As a result, TANESCO was forced to restrict its power supply and caused frequent power outage from inadequate maintenance, turning shortage of TANESCO's power supply capacity into a major hindrance to socio-economic activities.

As of May 2014, TANESCO cumulatively owns 1,583 MW (561MW hydroelectric, 1,022 MW thermal) of power generation output, 4,866km of high-voltage line (220kV, 132kV and 66kV, as of November 2013) and 22,396km of medium-voltage transmission line and distribution line (33 and 11kV, as of November 2013). Despite the expansion of its electric power system utilizing domestic and donor funds to cope with the acceleration of demand for electric power in the recent years, large gap between demand and supply continues to exist as the company struggles to catch up with rehabilitation of aforementioned superannuated facilities. Dissatisfaction is voiced by the consumers of electric power as alleged causes of such power shortage included persistently high purchasing price of electric power from IPPs (independent power producers) and EPPs (emergency rental power generator operators), financial distress of TANESCO, improper maintenance of facilities and repeated occurrence of accidents due to inadequate power protection system.

In 2007, the Government of Tanzania developed a vision for the 25 years period starting in 2008 entitled the Power System Master Plan (PSMP) to improve the situation. The plan was updated in 2009 with the assistance of outside consultants in technical areas to advance reinforcement of power generation facilities and upgrading of key transmission line. PSMP updated in 2012 (hereafter "PSMP 2012") formulated a master plan that continued to 2035 in accordance with technical updates made among Ministry of Energy and Minerals (hereafter "MEM"), TANESCO and Tanzanian government officials.

However, PSMP 2012 is inadequate in terms of its power demand estimation, power supply development, system analysis and system planning analysis in addition to its reliance on premature methods. Proper update and establishment of update method unique to Tanzania is therefore needed in order to stabilize the quality and quantity of power supply amid TANESCO's current financial distress. As increase in demand for electricity following economic development is expected to continue in Dar es Salaam, Tanzania's largest commercial city which is home to 10% of Tanzania's population and believed to account for nearly 50% of country's demand, the Government of Tanzania is aiming for strategic national policy with focus on shifting its commerce and industry to adjacent coastal area.

JICA implemented a Study on “Rehabilitation of Power Distribution Facilities in Major Cities of Tanzania (hereafter "Master Plan for Power Transmission and Distribution in Major Cities")” in 2002 and formulated the master plan for upgrading the power transmission and distribution system in Dar es Salaam, Arusha and Kilimanjaro. However, the plan has not been updated since then, and does not fully reflect the recent power demand in Dar es Salaam where considerable economic development has taken place in the recent years. Preparation of master plan for power system including expansion, rehabilitation and new plans for the power transmission and distribution system in the Dar es Salaam region including the aforementioned coastal area that fully reflects the power demand in the recent years will be indispensable.

Under these circumstances, the Government of Tanzania has requested technical assistance to Japan for the purpose of enhancing the capacity for PSMP formulation. JICA implemented a detailed plan formulation study in October 2013 in response to this request, and this project was launched after R/D (Record of Discussions) was exchanged between JICA and the Tanzania side in January 2014.

Regarding Progress Report 2 submitted in March 2015 as the final report of the first year, Tanzania side made several comments and requests on it. The main points of them are as follows.

・To review the power demand forecast after conducting regional power demand survey

・To redo the update of PSMP as a collaborative work with counterparts of Tanzania side

Therefore, JICA Experts and Tanzanian counterparts discussed how to implement the update of PSMP during the first field survey of the second year, and signed minutes of meeting on August 10, 2015. (refer to Attachment 1)

Thereafter, Tanzania side strongly requested JICA to update PSMP in line with the manifesto of the new government, i.e., achieving 4,915 MW generation capacity by 2020, and both sides agreed to finalize the update of PSMP in the third year.

1.2 Contents of the survey and target area

Contents	Target area	Target year	Work period (Original plan)
1. Review and update of PSMP2012 Update ① Power demand forecast ② Generation planning ③ System planning ④ Economic and financial analysis ⑤ Environmental and social considerations ⑥ Database construction	Whole Tanzania (Interconnection with Eastern and Southern Africa Power Pool is taken into consideration)	2015-2040 (25 years)	From June 2014 to March 2015
2. Formulation of Power System Master Plan in Dar es Salaam and coast regions ① Power demand forecast ② System planning ③ Distribution planning ④ Economic and financial analysis ⑤ Environmental and social considerations ⑥ Database construction	Dar es Salaam and coastal districts including Bagamoyo, Kibaha, Kisarawe and Mukuranga	2016-2031 (15 years)	From April 2015 to January 2016 (Data collection will start from June 2014)

1.3 Schedule and work flow

Figure 1.3-1 shows the schedule and work flow of the project.

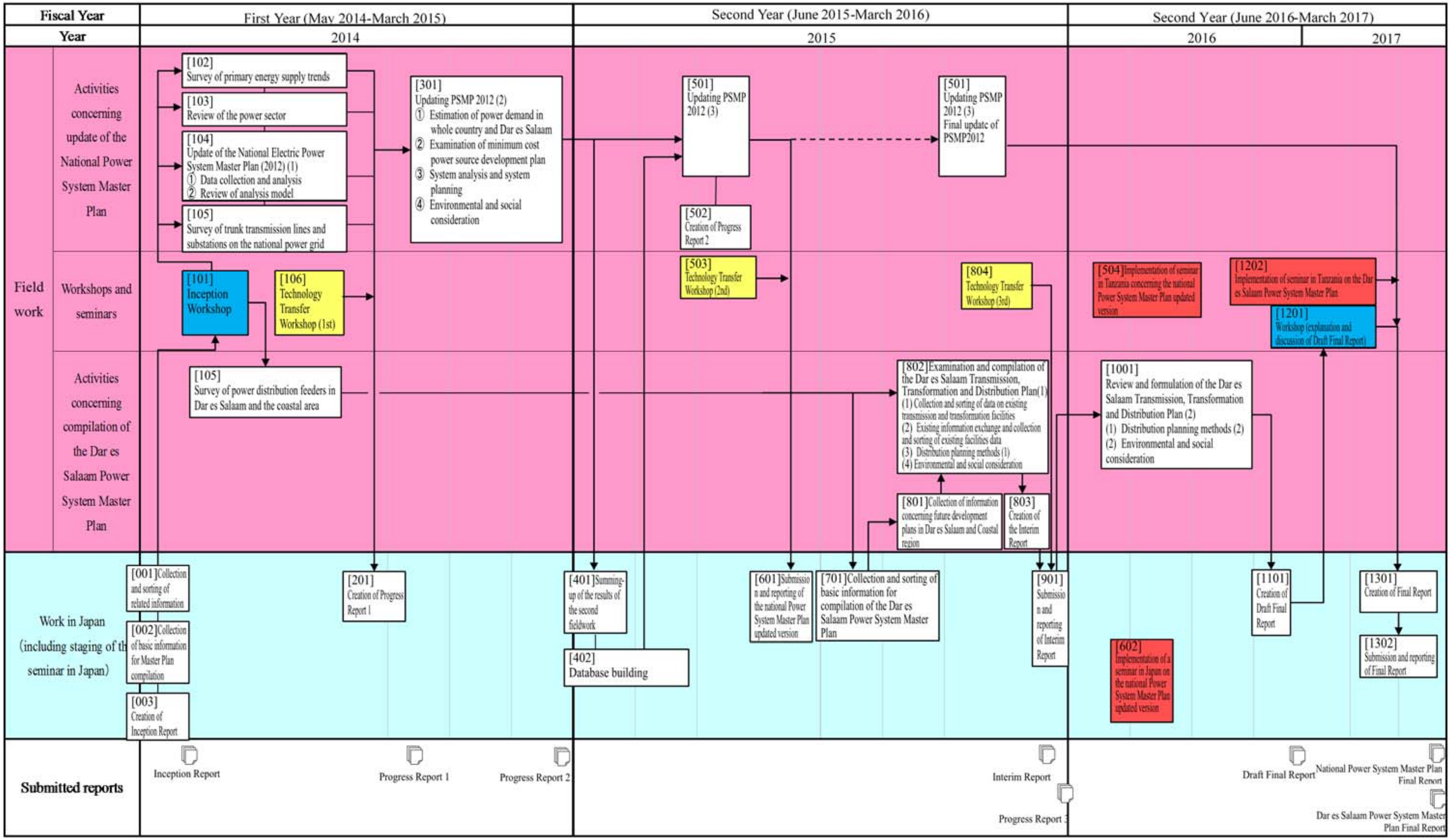
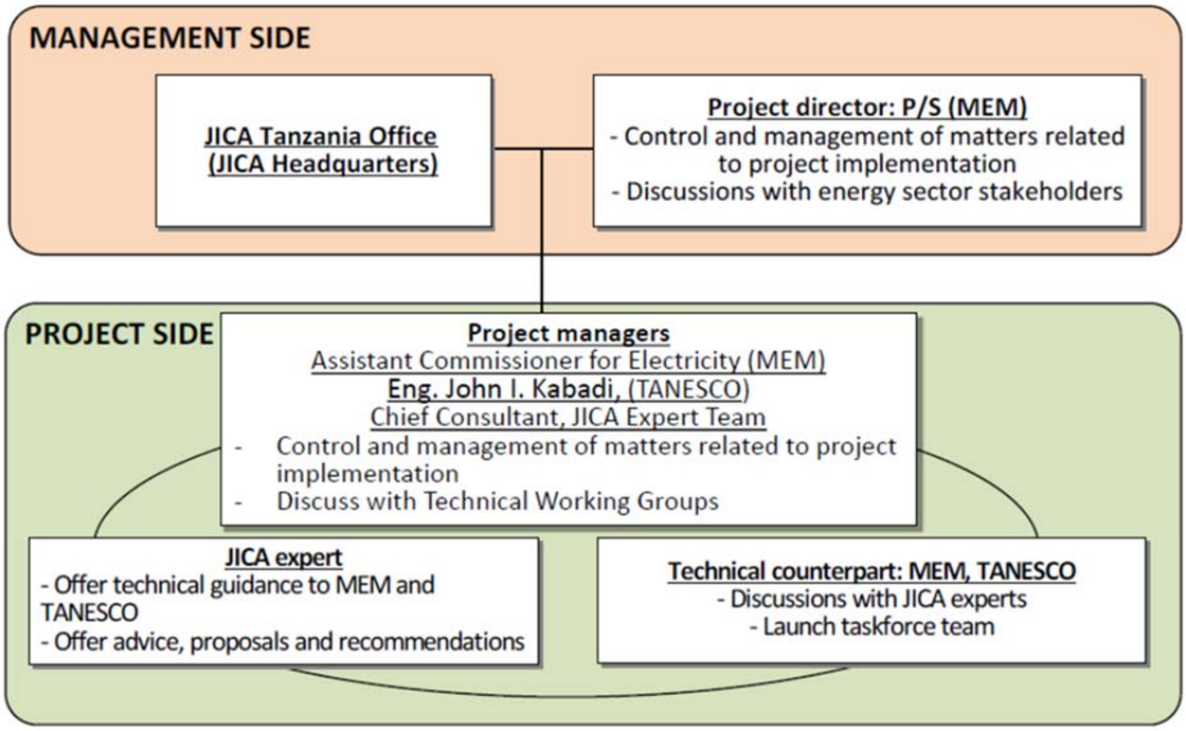


Figure 1.3-1 Work flow chart

1.4 Project implementation setup

This project will be implemented as a collaborative work between JICA Experts and Tanzanian counterpart team in order to transfer technology through master plan formulation. Figure 1.4-1 and Figure 1.4-2 show the project implementation setup.



P/S: Permanent Secretary
M/D: Managing Director

Figure 1.4-1 Project implementation organization

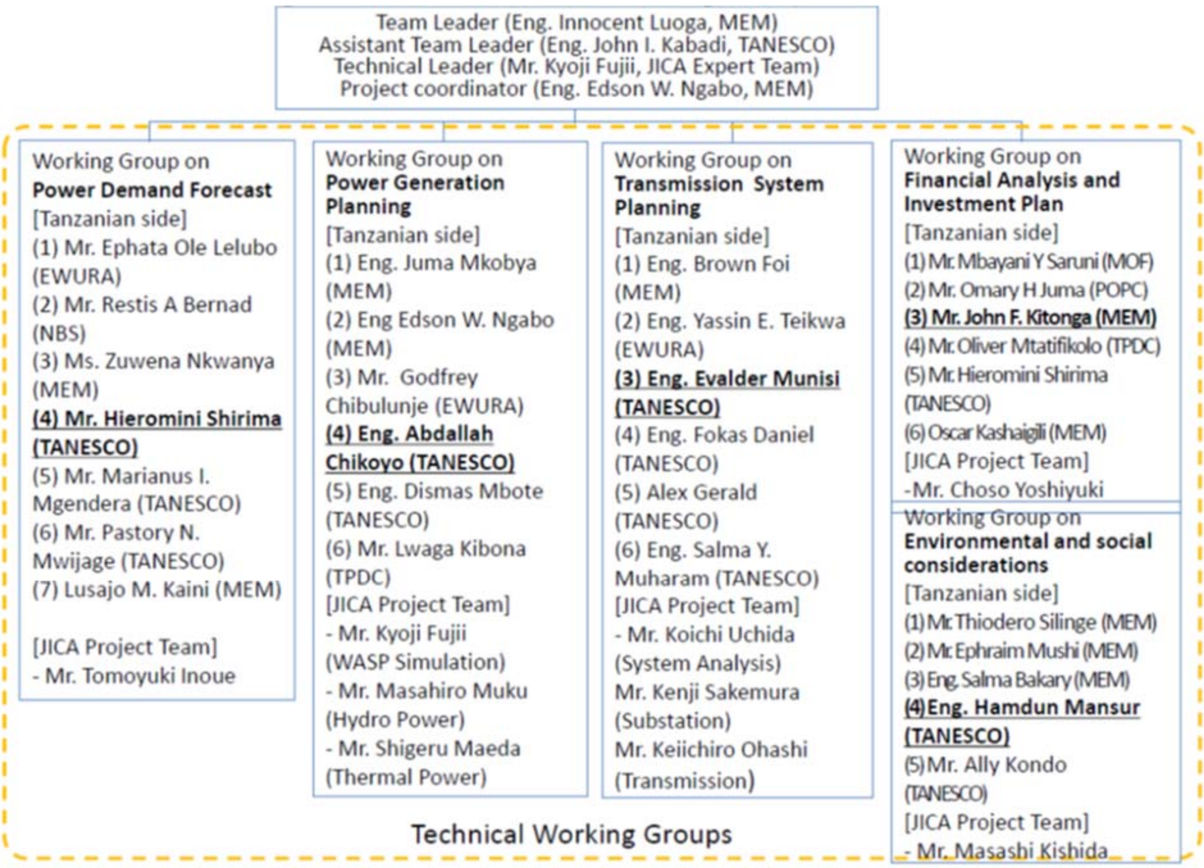


Figure 1.4-2 JICA Experts and Counterpart Members

Chapter 2 Tanzania's Economy

2.1 Population and Labor

2.1.1 Population

The total population of Tanzania was 45 million including 22 million males and 23 females according to the results of "2012 Population and Housing census". And a member of household is 4.8 person per one unit, and the average population density of Tanzania was 51 persons per square kilometer.

The population survey in 2012 shows that approximately 15 million Tanzanians, or 27 % of the total population, live in urban area of Tanzania. This is a significant increase when comparing it to 1990. The urban population was only 4.5 million, or 18 % of the total population in 1990.

One of the means to distinguish between rural area and urban area would be on the basis of population density, according to the study provided by World Bank in 2009. It can be estimated that the approximately 45 % of the population live in the area with a population density higher than 150 people per square kilometer. And it is estimated that the population living in such higher density area will reach 45 million by 2030, it is estimated by World Bank.

Many Tanzanian people are migrating from rural areas to urban areas. Residents of rural areas move to cities because educational and employment opportunities are limited in rural area, of cause dweller's life is better in urban areas than in rural areas. As evidenced better life in urban area, the poverty rate of Dar es Salaam stands at 4.1 % compared to an average of 33.3 % in rural area of the country.

2.1.2 Labor Statistics

The total labor force was 19.7 million (age from 10 years old to more than 55 years old) in 2006, which is studied by "Integrated Labor Force Survey 2006". The paid employees were 1.8 million, the self-employees were 2.4 million and the unpaid labors were 15.5 million. Because agriculture / fishing sector has 75.9 % of the working population, while, urban workers are more likely to settle in wage employment in the private and public sectors or to establish more profitable business. When comparing electrification rate between urban area and country average as of March 2014 published by TANESCO, the rate is 36 % in the whole country, but Dar es Salaam has high electrification rate with 89 %. The difference of the rate shows different business environment between urban area and rural area.

Table 2.1.2-1 Population as of August 2012 (Results 2012 census survey)

Mainland regions		Status	1988 Aug	2002 Aug	Unit person 2012 Aug	Growth rate % 2002/1988	2012/2002
10101	**Dodoma**	Region	1,235,328	1,692,025	2,083,588	2.3	2.1
10102	Bahi	District	...	...	221,645		
10103	Chamwino	District	...	...	330,543		
10104	Chemba	District	...	...	235,711		
10105	Dodoma Municipal	Municipality	202,665	322,811	410,956	3.4	2.4
10106	Kondoa	District	...	...	269,704		
10107	Kongwa	District	163,446	248,656	309,973	3.0	2.2
10108	Mpwapwa	District	176,051	253,602	305,056	2.6	1.9
10201	**Arusha**	Region	744,479	1,288,088	1,694,310	4.0	2.8
10202	Arusha	District	...	...	323,198		
10203	Arusha City	City	132,861	281,608	416,442	5.5	4.0
10204	Karatu	District	111,605	177,951	230,166	3.4	2.6
10205	Longido	District	...	...	123,153		
10206	Meru	District	...	...	268,144		
10207	Monduli	District	...	...	158,929		
10208	Ngorongoro	District	69,101	129,362	174,278	4.6	3.0
10301	**Kilimanjaro**	Region	1,104,673	1,376,702	1,640,087	1.6	1.8
10302	Hai	District	...	...	210,533		
10303	Moshi (Rural)	District	342,891	401,369	466,737	1.1	1.5
10304	Moshi Municipal	Municipality	96,631	143,799	184,292	2.9	2.5
10305	Mwanga	District	97,003	115,145	131,442	1.2	1.3
10306	Rombo	District	200,912	245,716	260,963	1.4	0.6
10307	Same	District	169,718	211,738	269,807	1.6	2.5
10308	Siha	District	...	...	116,313		
10401	**Tanga**	Region	1,280,212	1,636,280	2,045,205	1.8	2.3
10402	Handeni	District	...	...	276,646		
10403	Handeni Town	Town	...	...	79,056		
10404	Kilindi	District	88,666	143,792	236,833	3.5	5.1
10405	Korogwe	District	...	...	242,038		
10406	Korogwe Town	Town	...	...	68,308		
10407	Lushoto	District	357,492	418,652	492,441	1.1	1.6
10408	Mkinga	District	...	...	118,065		
10409	Muheza	District	...	...	204,461		
10410	Pangani	District	37,670	43,920	54,025	1.1	2.1
10411	Tanga City	City	186,818	242,640	273,332	1.9	1.2
10501	**Morogoro**	Region	1,220,564	1,753,362	2,218,492	2.6	2.4
10502	Gairo	District	...	...	193,011		
10503	Kilombero	District	187,593	321,611	407,880	3.9	2.4
10504	Kilosa	District	...	...	438,175		
10505	Morogoro (Rural)	District	225,857	263,012	286,248	1.1	0.9
10506	Morogoro Municipal	Municipality	117,601	227,921	315,866	4.8	3.3
10507	Mvomero	District	204,345	259,347	312,109	1.7	1.9
10508	Ulanga	District	138,642	193,280	265,203	2.4	3.2
10601	**Pwani**	Region	636,103	885,017	1,098,668	2.4	2.2
10602	Bagamoyo	District	173,871	228,967	311,740	2.0	3.1
10603	Kibaha	District	...	...	70,209		
10604	Kibaha Town	Town	...	...	128,488		
10605	Kisarawe	District	78,290	95,323	101,598	1.4	0.6
10606	Mafia	District	33,079	40,557	46,438	1.5	1.4
10607	Mkuranga	District	114,973	186,927	222,921	3.5	1.8
10608	Rufiji	District	153,938	202,001	217,274	2.0	0.7
10701	**Dar es Salaam**	Region	1,360,850	2,487,288	4,364,541	4.4	5.8
10702	Ilala Municipal	Municipality	331,663	634,924	1,220,611	4.7	6.8
10703	Kinondoni Municipal	Municipality	627,416	1,083,913	1,775,049	4.0	5.1
10704	Temeke Municipal	Municipality	401,786	768,451	1,368,881	4.7	5.9
10801	**Lindi**	Region	646,494	787,624	864,652	1.4	0.9
10802	Kilwa	District	150,419	171,057	190,744	0.9	1.1
10803	Lindi (Rural)	District	...	...	194,143		
10804	Lindi Municipal	Municipality	...	...	78,841		
10805	Liwale	District	52,240	75,128	91,380	2.6	2.0
10806	Nachingwea	District	117,473	161,473	178,464	2.3	1.0
10807	Ruangwa	District	86,449	124,009	131,080	2.6	0.6
10901	**Mtwara**	Region	889,100	1,124,481	1,270,854	1.7	1.2
10902	Masasi	District	...	...	247,993		
10903	Masasi Town	Town	...	...	102,696		
10904	Mtwara (Rural)	District	169,304	204,157	228,003	1.3	1.1
10905	Mtwara Municipal	Municipality	76,686	92,156	108,299	1.3	1.6
10906	Nanyumbu	District	...	...	150,857		
10907	Newala	District	161,156	183,344	205,492	0.9	1.1
10908	Tandahimba	District	146,506	203,837	227,514	2.4	1.1
11001	**Ruvuma**	Region	779,875	1,113,715	1,376,891	2.6	2.1
11002	Mbinga	District	...	...	353,683		
11003	Namtumbo	District	137,038	175,051	201,639	1.8	1.4
11004	Nyasa	District	...	...	146,160		
11005	Songea (Rural)	District	...	...	173,821		
11006	Songea Municipal	Municipality	...	...	203,309		
11007	Tunduru	District	170,320	247,055	298,279	2.7	1.9
11101	**Iringa**	Region	...	840,404	941,238		1.1
11102	Iringa (Rural)	District	205,504	245,033	254,032	1.3	0.4
11103	Iringa Municipal	Municipality	84,501	106,371	151,345	1.7	3.6
11104	Kilolo	District	156,989	204,372	218,130	1.9	0.7
11105	Mafinga Town	Town	...	...	51,902		
11106	Mufindi	District	...	...	265,829		
11201	**Mbeya**	Region	1,476,278	2,063,328	2,707,410	2.4	2.8
11202	Chunya	District	164,493	205,915	290,478	1.6	3.5
11203	Ileje	District	88,562	109,847	124,451	1.6	1.3
11204	Kyela	District	135,091	173,830	221,490	1.8	2.5
11205	Mbarali	District	153,182	234,101	300,517	3.1	2.5
11206	Mbeya (Rural)	District	179,900	254,069	305,319	2.5	1.9
11207	Mbeya City	City	151,881	265,586	385,279	4.1	3.8
11208	Mbozi	District	...	...	446,339		
11209	Momba	District	...	...	196,818		
11210	Rungwe	District	271,516	306,380	339,157	0.9	1.0
11211	Tunduma Town	Town	...	...	97,562		
11301	**Singida**	Region	792,387	1,086,748	1,370,637	2.3	2.3
11302	Ikungi	District	...	...	272,959		
11303	Iramba	District	...	...	236,282		
11304	Manyoni	District	135,390	204,482	296,763	3.0	3.8
11305	Mkalama	District	...	...	188,733		
11306	Singida (Rural)	District	...	...	225,521		
11307	Singida Municipal	Municipality	81,528	114,853	150,379	2.5	2.7
Source: National Bureau of Statistics Tanzania (web).							

Mainland regions		Status	1988 Aug	2002 Aug	Unit person 2012 Aug	Growth rate % 2002/1988	2012/2002
11401	**Tabora**	Region	1,036,150	1,710,465	2,291,623	3.6	3.0
11402	Igunga	District	203,367	324,094	399,727	3.4	2.1
11403	Kaliua	District	...	...	393,358		
11404	Nzega	District	296,085	415,203	502,252	2.4	1.9
11405	Sikonge	District	78,633	132,733	179,883	3.8	3.1
11406	Tabora	Municipality	143,148	188,005	226,999	2.0	1.9
11407	Urambo	District	...	...	192,781		
11408	Uyui	District	126,836	281,101	396,623	5.8	3.5
11501	**Rukwa**	Region	...	729,060	1,004,539		3.3
11502	Kalambo	District	...	...	207,700		
11503	Nkasi	District	107,239	207,311	281,200	4.8	3.1
11504	Sumbawanga	District	...	...	305,846		
11505	Sumbawanga	Municipality	90,703	146,842	209,793		3.6
11601	**Katavi**	Region	...	408,609	564,604		3.3
11602	Mlele	District	...	...	282,568		
11603	Mpanda	District	...	...	179,136		
11604	Mpanda Town	Town	...	...	102,900		
11701	**Kigoma**	Region	856,770	1,674,047	2,127,930	4.9	2.4
11702	Buhigwe	District	...	...	254,342		
11703	Kakonko	District	...	...	167,555		
11704	Kasulu	District	...	...	425,794		
11705	Kasulu Town	Town	...	...	208,244		
11706	Kibondo	District	...	...	261,331		
11707	Kigoma	District	...	...	211,566		
11708	Kigoma-Ujiji	Municipality	84,704	144,257	215,458	3.9	4.1
11709	Uvinza	District	...	...	383,640		
11801	**Shinyanga**	Region	...	1,249,226	1,534,808		2.1
11802	Kahama	District	...	...	523,802		
11803	Kahama Town	Town	...	...	242,208		
11804	Kishapu	District	192,549	239,305	272,990	1.6	1.3
11805	Shinyanga	District	212,847	276,393	334,417	1.9	1.9
11806	Shinyanga	Municipality	98,682	134,523	161,391	2.2	1.8
11901	**Kagera**	Region	...	1,791,451	2,458,023		3.2
11902	Biharamulo	District	...	...	323,486		
11903	Bukoba	District	...	...	289,697		
11904	Bukoba	Municipality	46,503	80,868	128,796	4.0	4.8
11905	Karagwe	District	...	...	332,020		
11906	Kyerwa	District	...	...	321,026		
11907	Missenyi	District	...	...	202,632		
11908	Muleba	District	273,329	385,184	540,310	2.5	3.4
11909	Ngara	District	...	...	320,056		
12001	**Mwanza**	Region	...	2,058,866	2,772,509		3.0
12002	Ilemela	Municipality	...	...	343,001		
12003	Kwimba	District	236,443	314,925	406,509	2.1	2.6
12004	Magu	District	...	...	299,759		
12005	Misungwi	District	191,283	256,133	351,607	2.1	3.2
12006	Nyamagana	Municipality	109,985	209,806	363,452	4.7	5.6
12007	Sengerema	District	303,897	498,993	663,034	3.6	2.9
12008	Ukerewe	District	172,946	260,831	345,147	3.0	2.8
12101	**Mara**	Region	946,418	1,363,397	1,743,830	2.6	2.5
12102	Bunda	District	201,164	258,930	335,061	1.8	2.6
12103	Butiama	District	...	...	241,732		
12104	Musoma	District	...	...	178,356		
12105	Musoma	Municipality	68,437	107,855	134,327	3.3	2.2
12106	Rorya	District	...	...	265,241		
12107	Serengeti	District	111,689	176,057	249,420	3.3	3.5
12108	Tarime	District	...	...	339,693		
12201	**Manyara**	Region	604,035	1,037,605	1,425,131	3.9	3.2
12202	Babati	District	...	...	312,392		
12203	Babati Town	Town	...	...	93,108		
12204	Hanang	District	113,270	204,640	275,990	4.3	3.0
12205	Kiteto	District	74,460	152,296	244,669	5.2	4.9
12206	Mbulu	District	156,058	237,280	320,279	3.0	3.0
12207	Simanjiro	District	52,895	141,136	178,693	7.3	2.4
12301	**Njombe**	Region	...	648,464	702,097		0.8
12302	Ludewa	District	100,206	128,155	133,218	1.8	0.4
12303	Makambako	Town	...	...	93,827		
12304	Makete	District	102,617	105,775	97,266	0.2	(0.8)
12305	Njombe	District	...	...	85,747		
12306	Njombe Town	Town	...	...	130,223		
12307	Wanging'ombe	District	...	...	161,816		
12401	**Simiyu**	Region	...	1,317,879	1,584,157		1.9
12402	Bariadi	District	...	...	422,916		
12403	Busega	District	...	...	203,597		
12404	Itilima	District	...	...	313,900		
12405	Maswa	District	220,432	304,402	344,125	2.3	1.2
12406	Meatu	District	159,272	248,214	299,619	3.2	1.9
12501	**Geita**	Region	...	1,337,718	1,739,530		2.7
12502	Bukombe	District	...	...	224,542		
12503	Chato	District	...	...	365,127		
12504	Geita	District	...	...	807,619		
12505	Mbogwe	District	...	...	193,922		
12506	Nyang'hwale	District	...	...	148,320		
			22,455,000	33,461,849	43,625,354	2.9	2.7

Zanzibar regions		Status	1988 Aug	2002 Aug	2012 Aug	2002/1988	2012/2002
20101	**Urban West**	Region	208,571	390,074	593,678	4.6	4.3
20102	Magharibi	District	50,945	184,204	370,645	9.6	7.2
20103	Mjini [Town]	Town	157,626	205,870	223,033	1.9	0.8
20201	**North**	Region	137,189	185,326	211,732	2.2	1.3
20202	Micheweni	District	61,064	83,266	103,816	2.2	2.2
20203	Wete	District	76,115	102,060	107,916	2.1	0.6
20301	**South**	Region	127,623	175,471	195,116	2.3	1.1
20302	Chake Chake	District	60,051	82,998	97,249	2.3	1.6
20303	Mkoani	District	67,572	92,473	97,867	2.3	0.6
20401	**North**	Region	96,989	136,639	187,455	2.5	3.2
20402	Kaskazini A	District	59,990	84,147	105,780	2.4	2.3
20403	Kaskazini B	District	36,999	52,492	81,675	2.5	4.5
20401	**South**	Region	70,313	94,244	115,588	2.1	2.1
20402	Kati [Central]	District	45,252	62,391	76,346	2.3	2.0
20403	Kusini	District	25,061	31,853	39,242	1.7	2.1
			640,685	981,754	1,303,569	3.1	2.9

Source: NBS web

Table 2.1.2-2 Number of persons Age 10 years and above by employment status (Mainland in 2006)

Paid employees (1000 persons)

Sector	Males	Females	Total	Shares(%)
Agriculture/ hunting/Forestry/fishing	163	46	209	11.8
Mining & Quarry	24	3	27	1.5
Manufacturing	117	37	154	8.7
Electricity, Gas & Water	12	3	15	0.8
Construction	104	6	110	6.2
Wholesale & Retail Trade	151	44	195	11.0
Hotels & Restaurants	35	55	90	5.1
Transport/storage & Communication	178	12	190	10.7
Financial Intermediation	11	6	17	1.0
Services	448	315	763	43.1
Total	1,244	528	1,772	100.0

Self employees (1000 persons)

Sector	Males	Females	Total	Shares(%)
Agriculture/ hunting/Forestry/fishing	23	10	33	1.4
Mining & Quarry	60	10	70	2.9
Manufacturing	216	186	402	16.7
Electricity, Gas & Water	2	0	2	0.1
Construction	96	0	96	4.0
Wholesale & Retail Trade	748	594	1,342	55.7
Hotels & Restaurants	61	214	275	11.4
Transport/storage & Communication	66	1	67	2.8
Financial Intermediation	0	0	0	0.0
Services	80	43	123	5.1
Total	1,352	1,059	2,411	100.0

Unpaid workers & helpers (1000 persons)

Sector	Males	Females	Total	Shares(%)
Agriculture/ hunting/Forestry/fishing	6,958	7740	14,698	94.9
Mining & Quarry	8	1	9	0.1
Manufacturing	8	14	22	0.1
Electricity, Gas & Water	0	0	0	0.0
Construction	5	0	6	0.0
Wholesale & Retail Trade	24	43	67	0.4
Hotels & Restaurants	4	12	16	0.1
Transport/storage & Communication	2	0	2	0.0
Financial Intermediation	0	0	0	0.0
Services	140	535	675	4.4
Total	7,150	8,345	15,495	100.0

Total

Sector	Males	Females	Total	Shares(%)
Agriculture/ hunting/Forestry/fishing	7,144	7796	14940	75.9
Mining & Quarry	92	14	106	0.5
Manufacturing	341	237	578	2.9
Electricity, Gas & Water	14	3	17	0.1
Construction	205	6	212	1.1
Wholesale & Retail Trade	923	681	1604	8.2
Hotels & Restaurants	100	281	381	1.9
Transport/storage & Communication	246	13	259	1.3
Financial Intermediation	11	6	17	0.1
Services	668	893	1561	7.9
Total	9,746	9932	19,678	100.0

Source: National Bureau of statistics (Integrated Labor Force Survey 2006) in year book 2012

2.2 Macro-economic Performance

2.2.1 Economic growth trends

The real GDP of Tanzania recorded an average growth rate of about 7 % over the 2002-2013 in the following table created by World Bank Tanzania data. The growth slowed down in 2009 to 6.0 %, largely due to the sharp deceleration of the global economy. However, it rebound to 7 % level after 2010.

Table 2.2.1-1 Tanzania real GDP Trends

	Market price	Market price	At 2005 price	Real GDP Growth	At 2001price	PPP, Current Internl $	PPP at 2001 Internl $
Unit	Million USD	Billion TZS	Million USD	%	Billion TZS	Million USD	Million USD
2000	10,186	8,153	10,061	4.9	8,585	27,319	34,428
2001	10,384	9,100	10,664	6.0	9,100	29,621	36,493
2002	10,806	10,445	11,428	7.2	9,752	32,231	39,107
2003	11,659	12,107	12,215	6.9	10,424	35,139	41,800
2004	12,826	13,972	13,171	7.8	11,240	38,929	45,072
2005	14,142	15,965	14,142	7.4	12,068	43,138	48,394
2006	14,331	17,941	15,095	6.7	12,881	47,460	51,654
2007	16,826	20,948	16,174	7.1	13,802	52,202	55,347
2008	20,715	24,782	17,377	7.4	14,828	57,180	59,463
2009	21,368	28,213	18,423	6.0	15,721	61,090	63,044
2010	22,915	32,293	19,720	7.0	16,829	66,184	67,484
2011	23,874	37,533	20,992	6.4	17,914	71,836	71,836
2012	28,242	44,708	22,432	6.9	19,142	78,105	76,763
2013	32,450	51,367	24,002	7.0	20,482	85134	82,136

Source: World bank country data, and 2013's data are added by JICA Study team

Tanzanian key economic indicators are the following table. The indicators of gross investment share, balance of payments and foreign direct investment from 2005 to 2013 shows comparatively good economic activities in Tanzania.

Table 2.2.1-2 Tanzanian key economic indicators

	Per Capita Income	Gross Domestic Savings	Gross Investment	Inflation	Exchange Rate	Balance of Payments	Foreign Direct Investment
Unit	USD / person	% of GDP	% of GDP	%	TZS / USD	Million USD	Million USD
2005	390.7	16.2	23.9	4.4	1,129	55.5	691.5
2006	382.2	15.3	26.4	7.3	1,252	346.2	671.8
2007	441.3	13.6	28.7	7.0	1,245	232.6	495.0
2008	524.1	14.6	29.7	10.3	1,197	500.2	917.4
2009	525.2	16.6	29.4	12.1	1,320	18.1	1,102.7
2010	538.1	19.3	30.6	7.2	1,432	477.6	991.1
2011	550.1	19.3	34.5	12.7	1,580	100.7	1,012.8
2012	570.0	18.0	35.5	16.0	1,572	199.6	1,633.9
2013	625.0	18.8	34.4	7.9	1,598	457.4	1,793.8
2013/05	6.0%	1.9%	4.7%	9.4%	4.4%	30.2%	12.7%

Balance: Overall balance as of the end 30th June
Source: "Tanzania Economic Update June 2014" by World Bank and Ministry of finance, Tanzania

As shown in the following table, the sub-sectors that recorded growth rates of more than the average growth rate with 7 % in 2013 were manufacturing (7.7%), construction (8.6%), trade, hotels & restaurants (8.0%), transport & communication (13.4 %) and financial business (12.2 %). In the recent years, the growth rates of the above subsectors have kept higher growth than other sectors. These growth rates are one of the typical growth pattern in many developing counties.

Table 2.2.1-3 Sectoral GDP growth rate

Unit: %

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Agriculture & fishing	4.4	3.9	4.0	4.6	3.2	4.1	3.4	4.2	4.2
Industry & construction	10.4	8.5	9.5	8.6	7.0	8.2	6.9	7.8	7.5
Mining & Quarrying	16.1	15.6	10.7	2.5	1.2	2.7	2.2	7.8	6.9
Manufacturing	9.6	8.5	8.7	9.9	8.0	7.9	7.8	8.2	7.7
Electricity	9.4	-1.9	10.9	5.4	8.4	10.2	1.5	6.0	4.4
Water	4.3	6.2	6.5	6.6	5.6	6.3	4.0	5.4	4.9
Construction	10.1	9.5	9.7	10.5	7.5	10.2	9.0	7.8	8.6
Services	8.0	7.8	8.1	8.5	7.2	8.2	7.9	8.0	8.2
Trade, Hotels & Restaurants	6.5	8.7	9.0	9.2	7.1	7.9	7.6	7.3	8.0
Transport & communication	9.4	8.6	10.1	10.8	11.0	12.2	11.3	12.5	13.4
Financial business	10.8	11.4	10.2	11.9	9.0	10.1	10.7	13.2	12.2
Real estate & biz service	7.5	7.3	7.0	7.1	6.8	7.0	6.5	6.7	6.4
Public administration	11.4	6.5	6.7	7.0	4.4	6.5	6.8	5.8	5.1
Total	7.4	6.7	7.1	7.4	6.0	7.0	6.4	6.9	7.0

Source: "Tanzania Economic Update June 2014" by World Bank and Ministry of Finance, Tanzania

By the following GDP contribution table, Tanzania's economy is depended on service sector so much. Although the most of the labors are worked for agriculture & fishing sector, however, the around 44 % of GDP is produced in service sector. While, the contribution of Industry sector was 22 %, agriculture & fishing sector is 26 % in 2013. The contributions of industry sector and agriculture & fishing sector are almost the same.

Table 2.2.1-4 Contribution of Sectoral GDP (without tax)

Unit: %

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Agriculture & fishing	29.0	27.6	27.2	26.9	26.6	26.4	26.0	26.1	25.9
Industry & construction	20.8	20.8	21.2	21.0	21.2	21.5	21.9	22.1	22.2
Mining & Quarrying	2.9	3.2	3.5	3.4	3.3	3.3	3.3	3.5	3.3
Manufacturing	7.9	7.8	7.8	7.8	7.9	8.1	8.4	8.4	8.5
Electricity	1.7	1.5	1.6	1.7	1.7	1.8	1.8	1.9	1.8
Water	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Construction	7.8	7.8	7.8	7.7	7.9	8.0	8.0	8.1	8.3
Services	42.5	43.3	43.3	43.8	43.8	43.9	44.0	43.9	44.3
Trade, Hotels & Restaurants	13.4	14.0	14.2	14.2	14.1	14.4	14.5	14.5	14.6
Transport & communication	6.2	6.4	6.6	6.7	7.0	7.2	7.5	7.6	8.2
Financial business	1.7	1.7	1.6	1.6	1.7	1.8	1.8	1.8	1.8
Real estate & biz service	9.5	9.6	9.5	9.6	9.3	8.8	8.6	8.5	8.4
Public administration	8.0	8.0	7.9	8.2	8.1	8.0	8.0	7.8	7.8
Others	3.7	3.6	3.5	3.5	3.6	3.7	3.6	3.7	3.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: "Tanzania Economic Update June 2014" by World Bank and Ministry of Finance, Tanzania

2.2.2 GDP per capita

GDP per capita (Unit: US$ at 2011 price converted by Purchasing Powered Parity) of the selected countries are the following tables. GDP per capita of Tanzania in 2011 is around $1,500 per capita. It is 1.5 times when comparing to the year of 2000, the growth rate is 4.0 % per year from 2000 to 2011.

It can consider on Tanzania GDP growth that the average growth rate of 7 % in the past ten years consists of the population growth rate with around 3 % and productivity growth rate with 4 %.

Table 2.2.2-1 GDP per capita of Selected countries

Unit: US$ at 2011 PPP per person

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Tanzania	1,006	1,026	1,056	1,103	1,149	1,207	1,262	1,313	1,370	1,434	1,480	1,543
Saudi Arabia	36,169	35,581	34,857	36,930	39,247	41,020	42,284	43,787	46,385	46,147	46,181	49,230
Ghana	2,240	2,273	2,316	2,374	2,443	2,521	2,613	2,711	2,865	2,906	3,065	3,446
Malaysia	15,688	15,436	15,943	16,543	17,335	17,921	18,574	19,386	19,959	19,312	20,390	21,075
South Africa	9,488	9,550	9,706	9,863	10,178	10,576	11,023	11,482	11,741	11,410	11,606	11,848
China	3,611	3,882	4,207	4,599	5,033	5,569	6,242	7,091	7,732	8,401	9,230	10,041
United States	45,956	45,935	46,319	47,204	48,546	49,713	50,548	50,966	50,340	48,502	49,307	49,854
Japan	32,177	32,221	32,239	32,712	33,473	33,906	34,485	35,237	34,888	32,997	34,561	34,266

Source: World Bank country data

Table 2.2.2-2 GDP per capita divided by Tanzania

Unit: Times based on Tanzania =1.0

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Tanzania	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Saudi Arabia	35.9	34.7	33.0	33.5	34.2	34.0	33.5	33.4	33.9	32.2	31.2	31.9
Ghana	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.1	2.0	2.1	2.2
Malaysia	15.6	15.1	15.1	15.0	15.1	14.9	14.7	14.8	14.6	13.5	13.8	13.7
South Africa	9.4	9.3	9.2	8.9	8.9	8.8	8.7	8.7	8.6	8.0	7.8	7.7
China	3.6	3.8	4.0	4.2	4.4	4.6	4.9	5.4	5.6	5.9	6.2	6.5
United States	45.7	44.8	43.9	42.8	42.3	41.2	40.0	38.8	36.7	33.8	33.3	32.3
Japan	32.0	31.4	30.5	29.7	29.1	28.1	27.3	26.8	25.5	23.0	23.3	22.2

Source: calculation by JICA Study team

When referring the following Fig.s, the relative position of South Africa and Japan to Tanzania are declined from 2000 to 2011. Otherwise China position has increased .

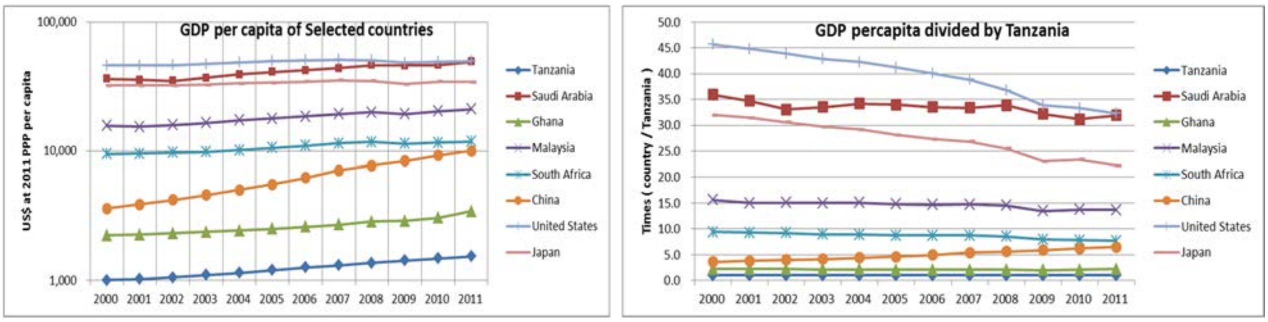


Figure 2.2.2-1 GDP per capita Selected countries and relative position to Tanzania

2.3 Infrastructure and Production Activities

According to Five Year Development Plan (FYDP) 201/12-2015/16 and the World Bank's reports such as "Tanzania's Infrastructure" (by Maria Shkartan, Feb. 2012) and "Tanzania Economic Update" (May 2013 and Jun. 2014), the recent challenging issues of infrastructure (excluding power because it is the object of this study) and production activities are as follows;

2.3.1 Infrastructure

(1) Road Transport

Tanzania has the lowest road density in the East Africa Region (only 103 m/km²), and only 7.4 m/km² are paved roads. Available statistics shows that only 28 % of the rural population is living within 2 km of an all-weather road. Trunk roads have a total length of 12,786 km, the share of the paved road is only 40.4 % to the total length.

Catalyst investments like the Dar es Salaam Rapid Transit (DART) are central for transforming the city's growth, improving mobility, and providing better quality services (and alternatives to cars). Further investments in urban roads are needed, also with a priority on securing future right of ways before they are lost to encroachment. The DART project should improve urban mobility by: (i) improving the mode of collective transportation; and (ii) constructing trunk roads, bus stations and terminals, and pedestrian walkways. In Dar es Salaam, it is important to improve existing transportation service networks with better systems for payment collection, assuring riders of seats, an expansion of routes, marked buses, and a central mechanism for user feedback/complaints.

(2) Railway Transport

Tanzania's rail corridors are key conduits for bulk freight in the region. They ease the pressure on roads, in particular on the north-east corridor connecting Sudan-Ethiopia-Kenya-Tanzania-Uganda; the east-south corridor connecting Tanzania-Rwanda-Democratic Republic of Congo-Uganda and as Dar Es Salaam-Kigoma-Burundi; and the east-south corridor connecting Tanzania-Zambia-Zimbabwe-Mozambique-South Africa. Although freight traffic density in Tanzania was substantially lower than in South Africa, as of 2006 it was on a par with neighboring Kenya, Uganda, and Zambia.

Over the past decade, the performance of the railways has declined substantially. The decline is explained by a deserted infrastructure such as the following items.

- Inadequate investment in maintenance and rehabilitation of railways
- Old locomotives and wagons
- Outdated permanent ways leading to high maintenance costs

As a result, Tanzania railways have been out-performed in trade by other regional corridors.

In addition, Tanzania's rail concession has run into difficulties. The Tanzania Railways Corporation (TRC) concession was awarded to India's RITES in September 2007 for a period of 25 years, giving the concessionaire a 51 percent stake in the company. The contract has since experienced labor conflicts and financial distress, due to lower than anticipated traffic flows. By the end of the first year of the concession TRC's operational and financial performance indicators had fallen below pre-concession levels. Both the concessionaire and the government have made several proposals to renegotiate the contract, but in the end the contract was terminated.

(3) Marine Transport

Dar es Salaam is a major regional port. Alongside Mombasa, it is one of the key transshipment centers for the East Africa region. Dar es Salaam's performance indicators compare well to those of other eastern and southern Africa ports. It has a low container dwell time of seven days, low truck processing time of 5 hours, and high crane productivity of 20 containers or tons per crane hour. This strong performance can be explained by Dar es Salaam's sizable terminal operations, specialized container handling equipment, and adoption of a container terminal concession to incorporate private management of operations. As a result, the port leads Sub-Saharan Africa in container handling productivity and ranks among the top in general cargo handling. Despite its achievements in productivity, Dar es Salaam suffers from significant capacity constraints and congestion following double digit growth in the container sector during the 2000s. Its demand to capacity ratio is 140 percent in the container sector (demand of 350,000 TEU/year and capacity of 250,000 TEU/year) and 93 percent in the general cargo sector (demand of 3.8 million tons/year and capacity of 4.1 million tons/year). These are the highest ratios in Africa after Mombasa. In fact, Dar es Salaam took responsibility for transshipments that Mombasa could not handle due to severe capacity constraints and operational inefficiencies. As a point of reference, once a port's capacity ratio surpasses the 80 percent mark, congestion becomes a serious issue that reduces the effectiveness of the port, and Dar es Salaam is already well past this level. New capacity needs to be introduced to solve this problem, not only in the port itself, but also in upstream linkages to ensure that cargo can be efficiently moved on to road and rail infrastructure. .

(4) Air Transport

The basic airport infrastructure and facilities for most of the airports in Tanzania are generally in poor condition. Despite this, there was a slight increase in the number of domestic and international passengers. The average increase rate over from 2006 to 2011 was 5.3 %. This performance does not correspond to the available potential, given Tanzania's strategic geographical location. The main challenge is to have improved and sustained air transport facilities and services including carriers and airport services to meet the domestic and international air transport needs. The growing tourism, horticulture and fishing industries are some of the opportunities the sector can exploit.

Dar es Salaam airport is currently operating at the margins its design capacity. There are currently constraints in terminal capacity and air side infrastructure, such as taxiways and aprons. In 2007, passenger traffic at the airport was estimated to be 1.2 million passengers, compared with a terminal capacity of 1.5 million passengers. Runways, aprons, and taxiways have been completely revamped and are up to global standards, however, the main terminal will soon become a constraint. The government is evaluating options for increasing air traffic handling capacity at the airport.

Tanzania's biggest challenges are typical for Sub-Saharan Africa in that they in the sector lie in (a) the overall safety oversight system, and (b) the role of the nationally owned flag carrier, Air Tanzania. Tanzania has gone through important institutional reforms with regards to its CAA and airports

authority, but still lacks the overall technical capabilities for full oversight, as do many of its neighbors.
Air Tanzania is not financially sustainable and may be the host of serious governance problems. There is a risk that domestic economic regulation on air routes may in fact distort the market in Air Tanzania's favor, out of fear that the successful private operator, Precision Air, is turning into a monopoly. The correct policy would be to continue building an environment where additional private carriers may compete with Precision, rather than having an unsustainable government-owned carrier provide attempt to balance the market.

Table 2.3.1-1 Transport Statistics

Transport	Items	2005	2012
Road transport (Trunk Roads)	Paved road length Unpaved road length Total road length		5,823 km (19 %) 4,459 km (14 %) 31,193 km (100 %)
Railway transport (Railway length)	Tanzania Railways Corp. Tanzania Zambia Railway	2707 km length 1860 km length	2707 km length 1860 km length
Marine transport (Dar es Salaam Port)	No. of passengers No of cargo handled	1072 persons 4307 Dwt	374,530 persons 10,122 Dwt
Commuter Busses (No. of buses)	Dodoma Arusha Dar es Salaam Mwanza	220 buses 837 buses 7,000 buses 886 buses	437 buses 1,181 (in 2011) 6,713 (in 2011) 1,868 buses
Air Transport	No. of domestic passengers	1,011,265 persons (in 2006)	1,311,522 persons (in 2011)

Source: Statistical abstract 2012 by NBS

(5) Water Supply and Sanitation

Tanzania has relatively low reliance on surface water and open defecation compared to its peers. Reliance on unsafe surface water is at 24 percent, compared to 34 percent in the peer group. Open defecation is practiced by 14 percent, compared to 37 percent in the peer group. Tanzania has achieved these outcomes largely by focusing on intermediate options such as wells and boreholes and traditional latrines that are the dominant forms of service provision in the country.
Access to safe water has been declining during the 2000s. According to household survey evidence, access to safe water decreased from 90 percent in 2000 to 80 percent in 2007 in urban areas and from 46 percent in 2000 to 40 percent in 2007 in rural parts of the country. Similarly, urban access to safe water within 30 minutes from home decreased from 81 percent in 2000 to 75 percent in 2007.
In addition, Tanzania's utilities are highly inefficient. Distribution losses are typically around 45 percent, compared with 33 percent among peers. At around $0.40 per cubic meter, Tanzania's water tariffs are substantially lower than those found in other African countries, covering only two thirds of the cost of service provision. The hidden costs of these inefficiencies are very substantial amounting to 145 percent of sector revenues.
There is significant performance variation across Tanzania's utilities. System losses range from 33 to 52 percent. Collection ratios range from 85 to over 100 percent. Cost recovery ratios range from 32 to

60 percent. Only the better performers (Dodoma, Mwanza) have hidden costs around the level of the low income country benchmark for Africa, while the worst performers (Dawasco, Mbeya, Moshi) have hidden costs in excess of 200 percent of revenues. In absolute terms, the hidden costs associated with Dawasco dwarf those of the other utilities amounting to US$47 million annually.

(6) Irrigation

A spatial simulation exercise undertaken to explore economic viability concluded that rates of return on large scale irrigation schemes in Tanzania appear to be relatively low—no more than about 3 percent on average. On the other hand, there is substantial potential to develop close to 300,000 hectares of small scale irrigation, which would more than double the area irrigated today. These areas are concentrated in the northwest and southeast of the country. The associated investment cost would be around $1 billion with an average rate of return of as high as 27 percent.

(7) Information and Communication Technologies (ICT)

One key issue affecting the mobile sector in Tanzania is the relatively high tax of 28% (18% VAT and 10% special excise tax on mobile airtime), which significantly affect the viability of more marginal rural services. Another issue is the availability of wireless spectrum with demand by operators higher than what has been made available. More efficient spectrum management and allocation can make operator investment in rural areas more viable.

Tanzania has had difficulty privatizing its fixed line telecom incumbent. In 2001, the Government sold part of Tanzania Telecom Co. Ltd. (TTCL) to private investors. The company was later divided into a mobile and fixed line operator in 2007. The fixed line operator was renationalized and a management contract awarded to a Canadian operator was later cancelled. Analysis suggests that the fixed line operator has high levels of employment relative to its size, and that these additional hidden costs amount to as much as 0.3 percent of GDP. Efficiency in TTCL operations is particularly critical given that it has been mandated to manage the national fiber optic backbone, which is priced relatively high by regional standards.

As a result of infrastructure analysis above, it is stated that Tanzania incurs losses to inefficiency of $500 million a year. By far the largest source of inefficiency is the national power utility, which wastes $350 million a year through underpricing of power and losses in distribution. The second largest source of inefficiency is undercollection of the fuel levy for road maintenance, which represents a loss on the order of $100 million a year.

Even if inefficiencies could be fully captured, a funding gap of $0.7 billion a year (or 5 percent of 2006 GDP) would remain. The largest component of the annual funding gap is the $380 million shortfall for meeting the Millennium Development Targets in water and sanitation. Smaller, but nonetheless substantial, funding gaps also exist for power ($200 million a year) and transport ($100 million a year).

2.3.2 Production Activities

(1) Agriculture Sector

Although the share of agriculture in GDP has showed a declining trend in recent years, it remains the single highest ranking employer in the country. Currently, agriculture contributes about 25.9 % of the GDP in 2013, but absorbs 74 % of the labor force. The annual agricultural growth is 4.0 % per year from 2005 to 2013. It must involve substantial growth of agricultural productivity and make the most of the rural population to get the benefit from such growth through selling the products to domestic and export markets.

- It is a problem that 74 % of the labor force only represents a 25.9 % share in the national economy, which is an explanation for the low productivity due to the existence of surplus labor.
- On the other hand, this is an opportunity as it provides room for the surplus labor force to be employed in alternative economic activities without undermining agricultural productivity.

(2) Manufacturing Sector

In general, Tanzania's manufacturing is small and no specific industrialization pattern. It contributed only to about 8.5 % of GDP up to 2006, before rising to 22.2 % in 2013. Its performance in recent years has experienced impressive trends.

- The contribution of manufactured exports to total exports increased from 6.9 % in 2003 to 13.4 % in 2013
- Its share of employment is estimated at one third of non-agricultural private employment (industry and services). Although the sector is currently small, it has the potential to create better-paying jobs relative to those in agriculture
- Most impressive developments have occurred in consumer goods, food, beverages, edible oils, textiles and garments, and metals. In some sub-sectors, there have been virtual declines, in particular wood, paper, furniture and machinery
- Manufacturing exports have generally remained lower knowledge and lower technology, as the results, the export products are low added value products

This is a real challenge for the country to attain development agendas. A wide range of opportunities exist for the Tanzanian manufacturing sector.

- The strategic geographical location of the country, providing easy access to overseas markets and markets of land-locked neighboring countries (like Burundi, Congo, Malawi, Rwanda, Uganda, and Zambia)
- The creation of Special Economic Zone (SEZ) and Export Processing Zone (EPZ) schemes, which will boost the sector's development and investments
- The fact that the country is an active member of the East African Community (EAC) and Southern Africa Development Community (SADC), which ensures an easy access to regional markets

(3) Mining Sector

Tanzania is one of the mining giants of Africa, owing to its mineral resources. This development can be mainly explained by high gold production from less than a ton in 1998 to around 40 tons in 2010, it making Tanzania the third largest gold producer in Africa. With all these impressive developments, the mining sub-sector contributes small portion to economic structure. And the sector's contribution to GDP and Government revenue, remained small, at about 3 % and 1.5 %, respectively, over the decade. Nevertheless, its share of total exports is substantial, accounting for 25.1 % of total exports in 2013. The sector's performance could be enhanced through improved management. The challenges will be addressed systematically including weak linkages to the rest of the economy, low local participation (both in production and provision of related services), small added value to GDP and the negative environmental impacts by pollutants.

The World Bank's "Economic Update" (Jun. 2014) expresses that as with recent years, economic growth in 2013 was driven by growth in a few select sectors, particularly the ICT, financial services, construction, trade and mining sectors. With the exception of mining, activities within these sectors are largely concentrated in urban areas. They are also relatively capital intensive, creating a limited number of jobs, except through construction activities. By contrast, the rate of growth of the labor-intensive agricultural sector, which employs three quarters of the workforce and contributes to approximately 25 percent of GDP, remained lower than that of the overall economy. The consistently lower-than-average rate of growth of the agricultural sector explains the relatively slow decline of poverty in rural areas and the accelerated pace of migration from rural to urban areas. Because these two phenomena have had and will continue to have a significant impact on Tanzania's economic and demographic profile

2.4 Middle and Long term economic plan

According to Five Year Development Plan (FYDP) 201/12-2015/16, the Long and middle term economic plans of Tanzania are as follows;

2.4.1 Tanzania Development Vision (TDV) 2025

By what mentioned in "Tanzania Five Year Development Plan 2011/2012-2015/2016", the outline of TDV 2025 and the review of the TDV 2025 until 2010 are as the followings.

(1) The Outline of TDV 2025

The preparation of TDV 2025 started in 1994 and the Government finally launched the TDV 2025 in 1999. The goals of TDV 2025 are that Tanzania should have gone through an unprecedented economic transformation and development to achieve middle-income status by 2025; characterized by high levels of industrialization, competitiveness, quality livelihood, rule of law; and having an educated society. Specifically, the Tanzania TDV 2025 outlined the country's social, economic and political aspirations for the first quarter of the 21st century; a per capita income will be reached to USD 3,000 (in nominal terms) by 2025. It means that the country becomes the middle-income country. It is designed that TDV 2025 is implemented through a series of five year development plans. Regarding national economic targets, the following items are adopted.

- A diversified and semi-industrialized economy with a substantial industrial sector comparable to typical middle- income countries
- Macroeconomic stability manifested by a low inflation economy and basic macroeconomic balance
- A growth rate 8 % per annual or more
- An adequate level of physical infrastructure needed to cope with the requirements of TDV 2025 in all sectors
- A competitive player in the regional and world markets has to be promoted for national interests and to adjust quickly to regional and global market shifts

(2) Review of TDV 2025

More than ten years have passed over since TDV 2025 was launched in 1999. The reviews on economic affaire are as following;

- Outlines of the macro economy

  Though there has been relatively high economic growth, low inflation and drastic improvement in the management of the macro-economy over the past two decades, these growths have remained below the necessary level to meet TDV 2025 goals and poverty reduction has remained, especially for the rural area. Although most of the inflation has remained low, the weather conditions to agricultural sector, rising fossil fuel prices and food prices have led the inflation.
- Getting economic opportunities

  The country has promising opportunities from its rich natural resources, advantageous geographical location and its active participation in regional and global economic integration schemes.

- Existing weak infrastructure

  Efforts taken to transform the country's supply structure to enable Tanzania to realize the benefits of globalization are hampered by the existence of a weak supportive infrastructure (Especially, power and transport). And poor transport infrastructure have also prevented the country from optimally exploiting its geographical comparative advantage as a regional trade gateway and transport logistical hub.

- Slow growing private sector

  The privatization of Tanzania's state-owned industrial sector was followed by a rather slow-growing, which faced high global competition and high costs of doing business domestically. As a result, the growth in job creation has not matched the needs of the national economy and its people.

- Agricultural development

  Agricultural development has not lived up to the expectations of the rural, agricultural-dependent households still using ancestral techniques, depending on increasingly unpredictable weather conditions, with limited access to credit and extension services, etc.

2.4.2 Five Year Development Plan

(1) Scheme of Five Year Development Plan

The target period of the first Five Year Development Plan (FYDP I) is 2011/12- 2015/16. Further future medium term plans are prepared as FYDP Ⅱ (2015/16 -2020/21) and FYDP Ⅲ (2020/21-2025/26). These series of plans will chart out the growth path, which is dynamically consistent with the realization of the status of a semi-industrialized country, which is capable of increasing competition in the domestic, regional, and global markets.

(2) Contents of FYDP I

The overall goals of FYDP I are to promote the country's resource potentials in order to fast-track the provision of the basic conditions for broad-based growth. The targeted average GDP growth rate for the FYDP I is 8 % per annum, even though it is estimated by 7 % during FYDP I (from 2011/12 to 2013/14), and thereafter consistently maintaining growth rates of at least 10 % per annum from 2014/15 to 2015/16. The targeted growth has been calculated by taking into account Tanzania's growth record over the past fifteen years, and experiences of countries that managed to reach middle-income status in the last 30 years. In order to generate this growth momentum, five elements will be needed.

- Large investments in energy and transport infrastructure
- Strategic investments to expand the cotton textile industry, high value crops, targeting maize and rice cultivation for food self-sufficiency and exports; fertilizer production tapping the large natural gas and phosphate deposits, development of Special Economic Zones (SEZs) to foster manufacturing growth, and increase the number of cement factories as well as the development of coal and steel industries
- Enhancing skills development

- Drastically improving the business environment
- Institutional reforms for an effective implementation, monitoring and evaluation of the Plan

This will also require sustaining the following sectoral transitions:

- Agriculture to increase its average annual growth rate from 4.4 % to 6.0 %,
- Manufacturing from 8 % to 12.1 %,
- Industry from 8.6 % to 9.4 %
- Services from 7.5 % to 7.8 %

However, it will also be important to closely monitor the developments in terms of income inequality to ensure that growth is broad-based. The country will have to create a strong competitive base and to efficiently use its comparative advantages (geographical location, rich natural resources, macro-economic stability, peace and political stability) so as to enhance growth even further in the future.

2.5 Recent Economic Prospects

According to "Tanzania Economic Update June 2014" published by World Bank, the recent developments and prospects are as follows;

2.5.1 Recent economic climate from 2012 to 2015

In 2013, Tanzania continued to achieve rapid, stable economic growth. The rate of the growth stood at approximately 7 %, which is consistent with Tanzania's past three year average, and it is significantly higher than the rate of growth achieved by neighboring Uganda and Kenya. The economic growths of Tanzania were driven by Information and Communication Technology (ICT), financial services, construction, trade and mining subsectors.

Table 2.5.1-1 Recent real GDP growth rates of neighboring countries

Countries	2012	2013	2014
Tanzania	6.9 %	7.0 %	7.0 %
Uganda	2.8 %	5.2 %	6.6 %
Kenya	4.6 %	5.0 %	5.1 %

Note: GDP growth rate in 2014 are estimated by World Bank

Source: World bank country data

- The activities within these sectors are largely concentrated in urban areas except mining sub-sector. As they are also relatively capital intensive, creating jobs are limited comparatively. By contrast, the growth rate of the labor intensive agriculture sector, which employs three quarters of the workforce and contributes approximately 25 % of GDP. The lower-than-average growth rate of the agriculture sector explains the relatively slow decline of poverty in rural areas and the accelerated pace of migration from rural to urban areas. Because these two phenomenon will continue to have a significant impact on Tanzania's economic climate.

According to the economic survey to Tanzanian business people by the KPMG /World Bank, Tanzanian business people remain optimistic regarding the overall performance of the economy, with 64 % of survey respondents stating that the economy will be performed better or the same in 2014 than in the previous year. The majority of the survey respondents were also positive regarding the prospects of their own business in 2014. However, only half of these respondents express the belief that economic climate in 2015 would be better than 2014.

2.5.2 Outlook short to medium term prospects

- The economy is projected to achieve a growth rate of approximately 7 % in the next few years, a Figure consistent with its historical trends. However, it will be challenging for the authorities to make the necessary adjustments to preserve fiscal space, particularly given the government's ambitious public investment program.

Table 2.5.2-1 Tanzanian macro- economic projection by World Bank

	2012/13	2013/14	2014/15	2015/16
Real GDP Growth (%)	7.0	7.0	7.0	7.0
Inflation rate (%)	11.3	6.1	5.3	5.1
Investment to GDP (%)	34.4	33.4	32.1	31.5
Overall balance to GDP (%)	-6.8	-5.2	-4.9	-4.0

Source: Page 15 in "Tanzania Economic Update" June 2014 Original source: World Bank and IMF

- The economic growths are driven by the same sectors that have driven growth in the near past. The communications, finance and retail sectors should continue to benefit from the sustained increases in domestic demand resulting from technological change and from the process of urbanization. The contribution of the construction sector should be increasingly significant, as a result of the execution of large investment projects funded by the public sector and through Public and Private Partnership. Some of them include the reconstruction of the port of Dar es Salaam, the rehabilitation of the railways on the central corridor and the construction of several energy plants. The development of the natural gas industry should also drive growth, although this impact is unlikely to be significant before 2016.
- Tanzania's labor force is expanding rapidly, with an average of almost one million new workers entering the labor market every year. Three quarters of these new entrants into the workforce are absorbed by the agriculture sector. However, with the rapid pace of urbanization, this phenomenon is changing fast. The process of urbanization is evident in the country's cities. According to some reckonings, Dar es Salaam is the second rapidly expanding city in the world, with secondary cities such as Arusha and Mwanza also growing fast. The 2012 population survey shows that approximately 15 million Tanzanians, or 27 %of the total population, live in urban area. This is a significant increase compared to 1990, when the urban population was only 4.5 million or 18 % of the total population.
- The population of Dar es Salaam has increased at an average rate of 5.8 % annually from 2.5 million to 4.4 million from 2002 to 2012. At this rate, Dar es Salaam's population will reach 10 million by the 2027. In generally, the increased population has been absorbed by outward expansion, and its form shaped by informality. This is leading to the expansion of unplanned areas, the creation of slums and congestion in the city.

Table 2.5.2-2 Population growth rate Dar es Salaam & Mainland

Area	Unit	1967-78	1978-88	1988-2002	2002-2012
Dar es Salaam	%	7.8	4.8	4.3	5.8
Mainland Tanzania	%	3.2	2.8	2.9	2.7

Source: "Population growth and Spatial Expansion of Dar es Salaam" by Urban Africa 2013

Chapter 3 Policy and Organization of the Energy/Electricity Sector

In Tanzania, electricity is supplied by the state-owned Tanzania Electric Supply Company Limited (TANESCO) except that 1) in Zanzibar, Zanzibar Electricity Corporation (ZECO), a privately held company, distributes electricity mainly supplied by TANESCO via subsea cable connecting the island and the mainland, and 2) Rural Energy Agency (REA), a government agency, is promoting various rural electrification programs in the areas not covered by the national grid or TANESCO's independent systems. In 1964, three years after independence, the Government bought two private electricity companies operating in Tanzania. In 1975, two companies were merged to form the current TANESCO with the government as the sole shareholder. Since then, the company has been responsible for electricity supply in the country for half a century.

In the 1990s, the government included TANESCO in the list of parastatal organizations for privatization. After various attempts to vitalize the electricity sector, in June 2014, the Government announced Electricity Supply Industry Reform Strategy and Roadmap 2014-2025.[1] The new Magufuli Administration started November 2015 has revised power development plan significantly upward in this new plan following its pledge to strongly promote electrification. It stipulates to increase the generation capacity from 1,501MW in 2015 to 4,915MW in 2020 and the electricity connection ratio from 24% in 2015 to 60% in 2020. It further pledges to expand the generation capacity to 10,000MW in 2025 raising annual per capita electricity consumption to 490kWh. It also proposes to unbundle the present integrated single market system and introduce a deregulated electricity market stepwise by 2025 to establish a reliable and efficient electricity supply system.

In December 2015, "The National Energy Policy 2015" was also announced, which consolidates previous documents and discussions on energy policy clarifying present issues and resultant policy objectives of each energy sub-sector. In May 2016, "The Tanzania Five Year Development Plan II 2016/17 - 2020/21" was announced. In this second version of the national development plan, the concept of the above Electricity Supply Industry Reform Strategy and Roadmap 2014-2025 is cited to illustrate the pathway for unbundling the electricity subsector.[2]

3.1 Energy and Electricity Policy

3.1.1 Electricity Supply System

TANESCO is a state-owned integrated monopoly for electricity supply in Tanzania and is in principle controlled under the Electricity Act of 2008 and the Energy and Water Utilities Regulatory Authority Act, 2001. It is a public organization under the Ministry of Energy and Minerals (MEM); Board of Directors is appointed by the government, which exercises control through MEM. [3]

[1] Ministry of Energy and Minerals, "Electricity Supply Industry Reform Strategy and Roadmap 2014-2025, June 2014
[2] Ministry of Finance and Planning, "National Five-Year Development Plan 2015/16-2020/21", June 2016.
[3] Tanzania Electric Supply Company Limited, "Corporate Business Plan 2014," December 2013

MEM is mainly responsible for formulation of energy and electricity policy, and management of TANESCO.

The Energy and Water Utilities Authority (EWURA) created in 2005 by the Energy and Water Utilities Regulatory Act is mandated to oversee and regulate the operations of TANESCO granting following licenses:

a. Electricity Generation License
b. Electricity Transmission Cross Border Trading License
c. Electricity Distribution and Cross Border Trading License
d. Electricity Supply License

Presently, each license is for a term of twenty years commencing from 1st March 2013.
The company has business licenses to all regions granted by the Ministry of Industry and Trade under the Department of Revenue Collection Trade Licenses.

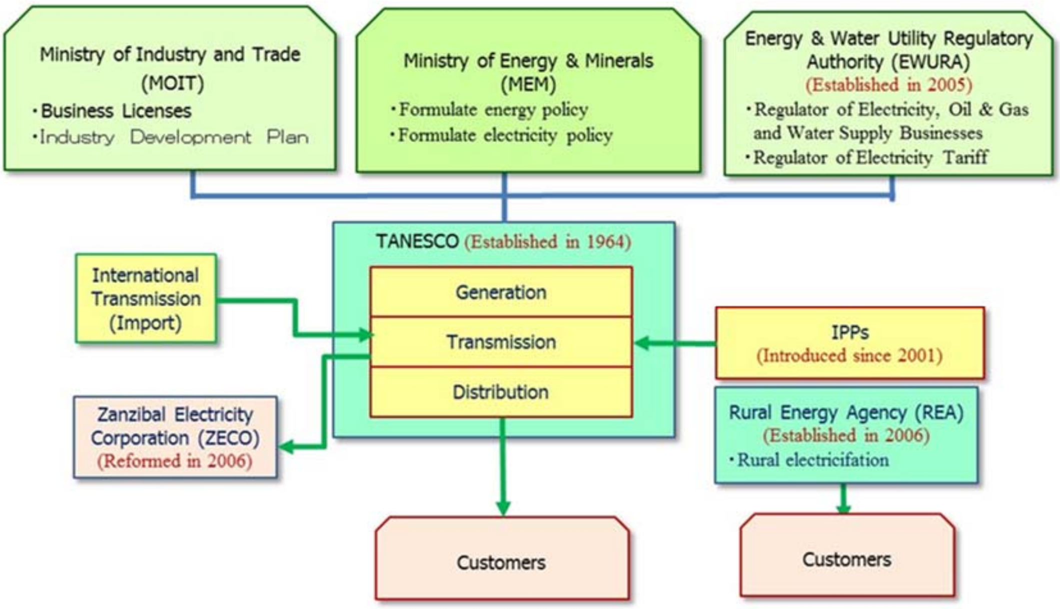


Figure 3.1.1-1 Structure of Electricity Supply System

As shown in Figure 3.1.1-1, TANESCO operates in all segments of generation, transmission and distribution; operates its own power generation stations, purchases electricity from IPPs/EPPs, imports electricity from neighboring countries (Uganda, Kenya and Zambia), sells electricity to Zanzibar Electricity Corporation and distributes electricity to its customers. In 1992, the National Energy Policy was formulated opening up the electricity supply industry (ESI) to the private sector. In 1997, TANESCO was specified for privatization and was prohibited to invest in any development on its systems or improvements, and IPPs were introduced proactively. However, economic and technical problems arising in the electricity supply, it was de-specified from the list in 2005.

After 2000 thermal plants have been built by IPPs and TANESCO, but they could not adequately cover the rapidly growing electricity demand. A severe drought in 2010 incurred serious supply shortage in the power system traditionally dependent on hydropower. To bridge the electricity supply gap in the country, TANESCO was forced to contract with Emergency Power Producers (EPP) in 2011 at expensive rates. At its peak, they amount to more than one third of the country's thermal generation capacity, which have significant impact on TANESCO's financial status. TANESCO needed to be released from this excessive financial burden to cope with various investment needs more flexibly for healthy development of the electricity industry; all EPPs have been terminated by 2016.

Table 3.1.1-1 EPPs Temporary Introduced into Tanzania

Category	Power Station	Fuel	Unit	Capacity		Installed	Retirement
				MW	%		
Rental Units (IPPs)	Symbion Ubungo	Gas/Jet A1	5	120.0	13.2	2011	2016
	Aggreko (Ubungo)	GO		50.0	5.5	2011	2012
	Aggreko (Tegeta)	GO		50.0	5.5		2014
	Symbion (Dodoma)	HFO		55.0	6.1	2012	2014
	Symbion (Arusha)	HFO		50.0	5.5	2012	2014
	Sub-total			325.0	35.8		
Total Thermal Capacity in 2014				908.7			

Excluding isolated small plants.

Source: Power System Master Plan 2012 Update, TANESCO Corporate Business Plan- 2014

TANESCO's arrears caused by the serious drought were expected to reduce thanks to upward revision of the electricity tariff made in February 2015 and termination of expensive EPPs. However, it has started to increase again in 2016. In view of the worsening financial status, TANESCO applied in 2016 for an electricity tariff increase of 15.9%. EWURA approved 8.5% hike in December, but the approval was cancelled by the President next day; the tariff is presently kept as it was.

At the end of 2016 TANESCO owned a total generating capacity of 1,343MW linked to the national grid including hydro and thermal stations. In addition, it owns isolated smaller plants of 77.4MW which includes two gas thermal power plants at Somanga (7.5MW) and Mtwara (18MW) and 16 diesel plants ranging 250kW～12,500kW driven by diesel/HFO. All of these isolated plants are scheduled to be linked to the national grid by around 2020. As all EPP thermal plants were terminated, the share of hydro power exceeds 40% at present. However, to accommodate increasing electricity demand, substantial expansion of thermal power capacity is scheduled in the near future; its share in the power mix will increase rapidly.

Table 3.1.1-2 Power Generation Capacity in Tanzania

Category	Power Station	Fuel	Unit	Capacity		Installed	Retirement
				MW	%		
IPP Units	Songas1	Gas	2	42.0	5.4	2004	2023
	Songas 2	Gas	3	120.0	15.4	2005	2024
	Songas 3	Gas	1	40.0	5.1	2006	2025
	Tegeta IPTL	HFO	10	103.0	13.3	2002	2021
	Sub-total			305.0	39.3		
TANESCO	Ubungo I	Gas	12	102.0	13.1	2007	2026
	Tegeta GT	Gas	5	45.0	5.8	2009	2028
	Ubungo II	Gas	3	105.0	13.5	2012	2031
	Zuzu	IDO	1	7.0	0.9		2014
	Nyakato		1	63.0	8.1		
	Kunyerezi-1		3	150.0	19.3	2015	
	Sub-total			472.0	60.7		
Thermal				777.0	100.0	*57.9%*	
Hydro (7 power stations)				566.0		*42.1%*	
Total				1343.0		*100.0%*	

Excluding isolated small plants.

Source: Power System Master Plan 2016 Update, TANESCO

Presently IPPs are limited to those plants using natural gas and liquid fuels. As discussed in Chapter 2, however, several IPPs are emerging to use coal at mine mouth thermal stations in the interior area where rich coal resources are identified. They are expected to enhance electricity supply at reasonable prices in the interior regions where supply of natural gas and liquid fuel is difficult and expensive.

3.1.2 Energy and Electricity Policy

Economic development strategies and policies in Tanzania have been developed based on the Tanzania Development Vision (TDV) 2025[4] set out in 1995, which envisages Tanzania to become a middle income country with a high level of human development. To this end, the economy should achieve an annual per capita income of at least US$3,000 by 2025 through transformation from a low productivity agricultural economy to a semi-industrialized one. A solid foundation for a competitive and dynamic economy with high productivity should be laid with an adequate level of physical infrastructure. Based on this concept, the ESI Reform Strategy and Roadmap 2014-2025 stipulates that, to achieve the target under the TDV, fast economic growth is needed which must be propelled by adequate, accessible, reliable, affordable and environmentally friendly electricity supply. Among others, the Strategy aims at improving access levels to electricity from 24% as of March 2014 to 30% by 2015, 50% by 2025 and 75% by 2033. This plan is further advanced in the second five year plan to achieve the access level of 60% by 2025. To achieve this, huge amount of capital investment is needed. While the government and TANESCO have been the primary financiers in the past, the projected growth exceeds existing resources. Thus, the private capital investment becomes an important option to bridge the financing gap.

[4] Planning Commission, "The Tanzania Development Vision 2025", 1995

Present strategies and policies relating to the electricity industry is summarized in Table 3.1.2-1 The National Energy Policy was first formulated in 1992, and was revised in 2003 which among other things aims at promoting affordable energy supplies to support national development goals. The Electricity Act enforced in 2008 sets a platform for re-organization of the ESI, under which the MEM Minister may restructure the ESI to foster competition for increased efficiency, enhanced development of private capital investment and promote regional electricity trading.

Table 3.1.2-1 Laws, Strategies and Polices relating to Electricity Industry

Laws	The Electricity Act, 2008
	The Rural Energy Act, 2005
	The Energy and Water Utilities Regulatory Authority Act, 2001
Strategy & Plan	Tanzania Development Vision 2025
	National Strategy for Growth and Reduction of Poverty (Mkukuta II), 2005
	The National Energy Policy, 2003
	The Tanzania Five Year Development Plan 2011/12 - 2015/16
	The Tanzania Five Year Development Plan II 2016/17 - 2020/21 (May 2016)
	Strategic Plan 2011/12 - 2015/16
	The National Natural Gas Policy of Tanzania - 2013
	Electricity Supply Industry Reform Strategy and Roadmap, 2014
	Sustainable Energy for All (December 2015)
	National Energy Policy 2015

As explained above, the ESI Reform Strategy and Roadmap was announced in June 2014. Its contents will be explained in Section 3.3. In the course of implementing the reform, the present Electricity Act and other relevant laws need to be reviewed and amended, accordingly.

Under the circumstance, “The National Energy Policy 2015” was announced in December 2015。 It is the second version of the national energy plan and consolidates previous documents and discussions on energy policy clarifying present issues and resultant policy objectives of each energy sub-sector. It sets out specific objectives of the electricity sub-sector as below;

a. Improving security of supply through effective use of energy resources and cross-border trading;
b. Enhancing power reliability and coverage of transmission and distribution networks;
c. Enhancing utilisation of renewable energy resources so as to increase its contribution in electricity generation mix;
d. Accelerating rural electrification to foster socioeconomic transformations; and
e. Increasing private sector participation in electricity supply industry.

It recognizes that the present issue of the power generation is to secure sufficient power for the domestic market and implement participation in cross-border trading, and the following issues are identified for each subsector.

a. Oil and Gas: A number of gas fired power stations are being developed to add 1,500MW by

2019, although power generation is not the most efficient and economical use of natural gas. Imported liquid fuel is also used for power generation.

b. Coal: It is one of major indigenous energy sources, but coal has not been optimally harnessed due to financial constraints, limited local expertise and other reasons.

c. Uranium: Availability pf uranium in Ruvuma and Dodoma regions provides an opportunity for nuclear power generation. Though there are various challenges, the Policy envisages developing nuclear power in line with international standards.

d. Hydro: Despite huge potential of 4.7GW, only 12% has been utilized due to various challenging issues.

e. Non-hydro Renewable Energies: These include solar, wind, biomass, geothermal. Significant exploitation has been made on solar and biomass whose technologies are already commercialized.

f. Regional Power Pools: Based on energy resources potential Tanzania stands to meet its domestic electricity demand through regional power pools. The benefits of regional interconnections include security of supply system stability.

Major challenges facing electricity sub-sector include improving quality, reliability and security of supply inadequate private sector participation; mobilizing adequate financial resources to develop the sub-sector; and reducing technical and non-technical losses.

To improve security of supply to meet the demand, the Government shall;

a. Ensure cost reflective tariff to attract private investments;
b. Ensure effective use of energy resources;
c. Facilitate cross-border power trading; and
d. Create enabling environment for nuclear electricity generation.

As for the transmission and distribution sector, the present issues are reliability and coverage of transmission and distribution networks.

Existing transmission system comprises grid substations interconnected by transmission lines, utilizing system voltages of 220 kV; 132 kV; and 66 kV. The existing transmission system capacity is severely constrained particularly during peak hours due to aged infrastructure, high power technical losses, lack of proper rehabilitation and maintenance and system overload. Challenges for enhancing transmission networks include vandalism of transmission network; land and way-leaves acquisition.

The distribution systems include 33kV, 11kV and 0.4kV lines. Achievement of national electricity connection level and access targets requires expansion of power distribution networks. Challenges facing distribution networks include dilapidated networks, vandalism, outages as well as technical and non-technical losses.

To enhance power reliability and coverage of transmission and distribution networks, the government shall;

a. Ensure timely investment in construction, rehabilitation and expansion of the transmission and distribution infrastructure;
b. Support interconnection with neighbouring countries;
c. Ensure establishment of appropriate legal and regulatory framework for an Independent System Operator and Independent Market Operator;
d. Ensure reduction of power losses in transmission and distribution networks; and
e. Establish a framework to allow open access to distribution networks.

The above elements listed in the National Energy Plan are deemed to be the core principles of the electricity industry policy. In the Power System master Plan 2016 Update, development plans for generation capacity and transmission/delivery systems are formulated incorporating these principles. In addition, the pathway of the industry reform is shown in the ESI Reform Strategy and Roadmap to be discussed in Section 3.3.

3.2 Organization and Functions of Electricity Sector

3.2.1 Ministry of Energy and Minerals

The organization of the Ministry of Energy and Minerals (MEM) comprises, in addition to the administrative/supportive divisions and units, three divisions and units which are responsible for strategies and policies on energy, gem stones and mineral resources as shown in Figure 3.2.1-1.

In the Energy Division, there are five sections under the Commissioner, namely, Petroleum Section, Electricity Section, New and Renewable Energy Section, Energy Development Section and Natural Gas Utilization Section. Oil and gas upstream activities are covered by Petroleum Section and natural gas downstream activities are developed under Natural Gas Utilization Section. Electricity businesses are controlled by Electricity Section and related policies are developed jointly by Electricity Section and Energy Development Section, while New and Renewable Energy Section is in charge of rural electrification utilizing new and renewable energies. Coal mining is controlled by the Minerals Division including licensing of mining rights. Tansort Unit is responsible for management of resources yielding gem stones.

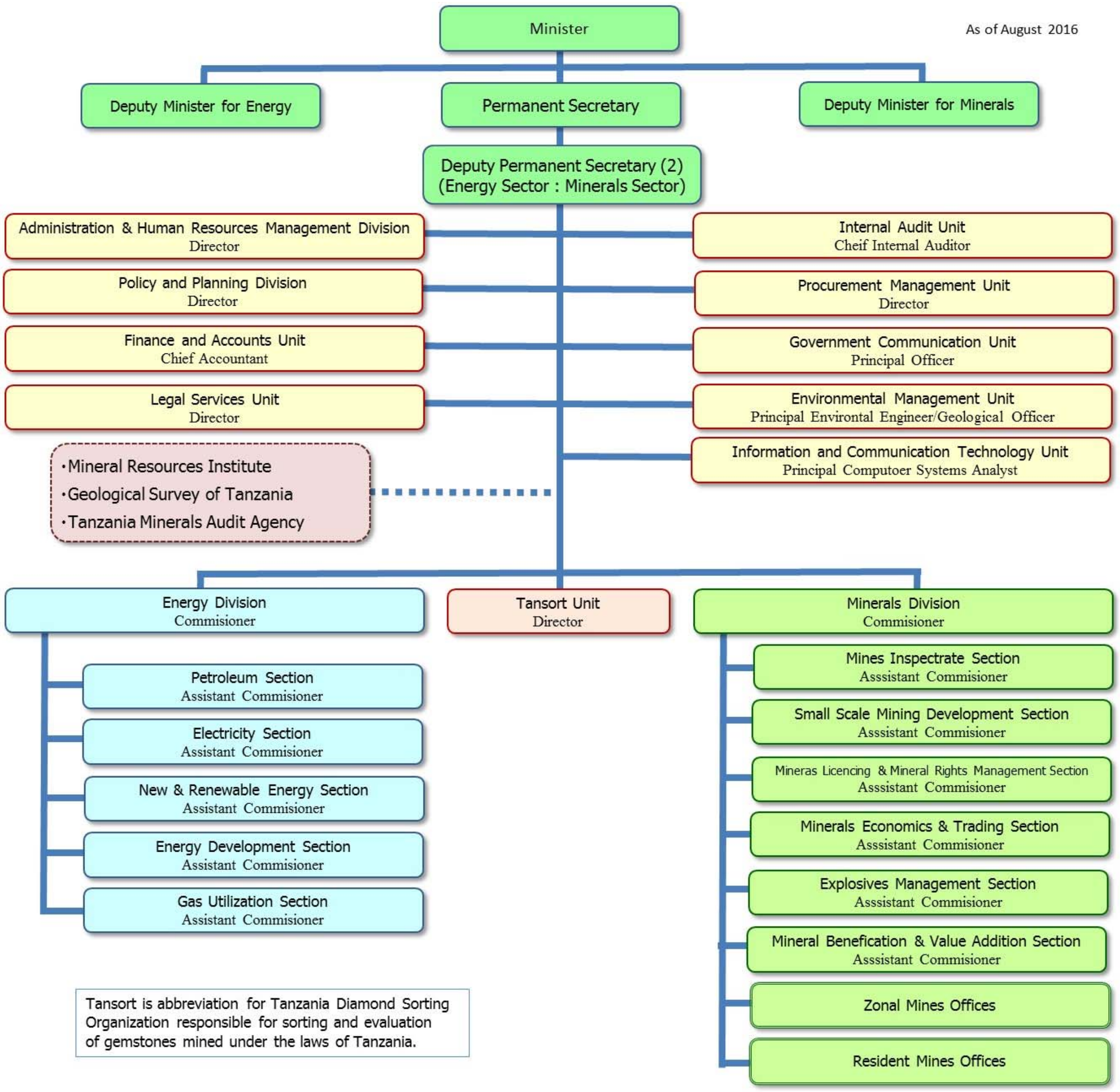


Figure 3.2.1-1 Organization Chart of the Ministry of Energy and Minerals

There are also affiliate organizations, Mineral Resources Institute, Geological Survey of Tanzania, and Tanzania Minerals Audit Agency, attached to MEM.

3.2.2 TANESCO

The organization of Tanzania Electric Supply Company Limited comprises, in addition to administrative/supporting sectors, four divisions under supervision of Deputy Managing Directors; Generation, Transmission, Investment and Distribution & Customer Services as shown in Figure 3.2.2-1.

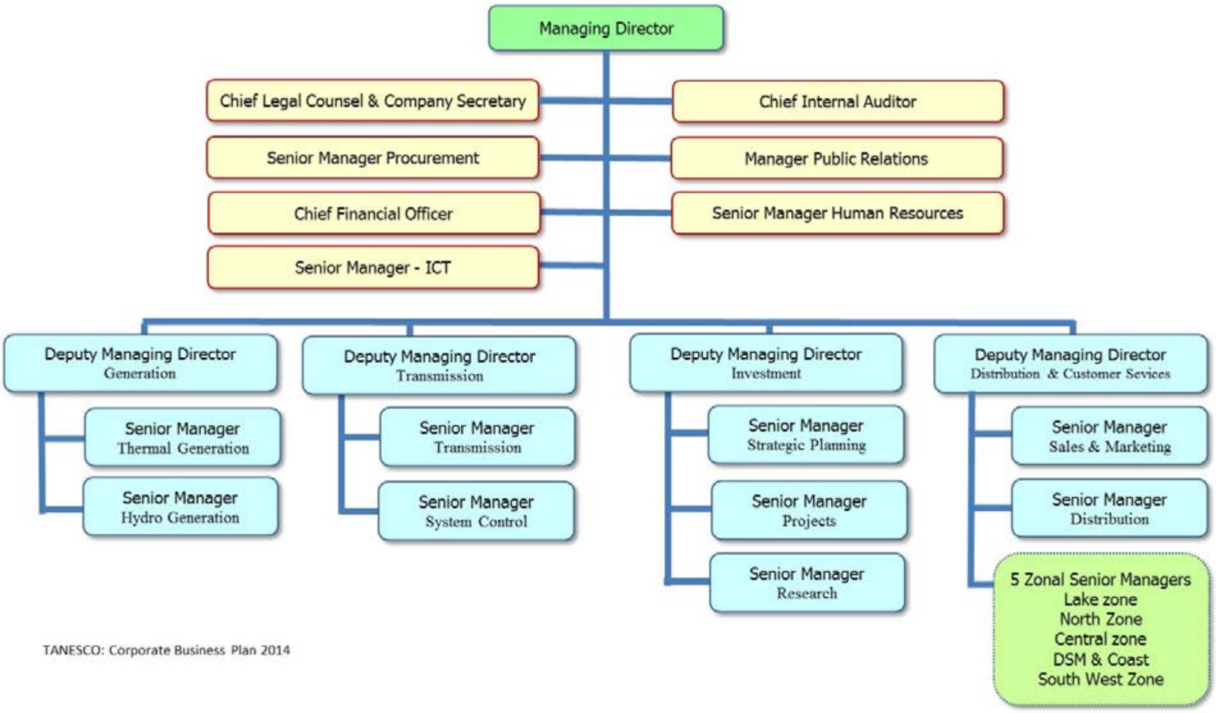


Figure 3.2.2-1 Organization Chart of TANESCO

Generation Division is responsible for all power generation functions owned by TANESCO both National Grid connected and off-grid stations.

Transmission Division is responsible for optimal operation and maintenance of the national grid transmission network.

Distribution and Customer Services Division is responsible for the distribution network system consisting of 33kV and 11kV supply voltage that serves distribution transformers stepping down to 400/230 volts for residential, light commercial and light industrial supply. Commercial and heavy industries are supplied directly at 33kV and 11kV. There are five zonal offices covering Lake Zone, North Zone, Central Zone, Dar es Salaam and Coastal, and South West Zone.

Investment Division is responsible for three major functions; conducting research, strategic planning and managing the implementation of major projects.

3.3 Principal Activities of TANESCO

The company's principal activities are electricity generation, purchasing, transmission, distribution and selling of electricity to Mainland Tanzania as well as bulk supply to Zanzibar and neighboring countries. According to the latest annual report of TANESCO which was released in December 2016, profile of the company's principal activities is as follows.[5]

3.3.1 Operating Performance

As at June 2015;

1) Electricity is generated at 7 hydro plants and 23 thermal power plants. All hydro power plants and 5 thermal power plants are connected to the National grid.
2) It imports power from Uganda, Kenya and Zambia and, in turn, exports power to Kenya.
3) It has long term power purchase agreements with Independent Power Producers (IPPs), namely Independent Power Tanzania Limited (ITPL), Songas Limited, Tanganyika Wattle Company Limited (TANWAT) TPC Limited, Andoya, Mwenga and Ngobeni.
4) It purchased power from Emergency Power Producers (EPPs) namely Aggreko and Symbion. (These EPP contracts were terminated by 2016.)

Outline of the principal activities performed during the last fiscal period is shown in Table 3.1.2-1.

3.3.2 Projects implemented during 18 month to 30th June 2015

Major projects implemented and/or continued during the period are as follows:

1) Expansion of distribution networks and reinforcement of grid substations in 7 regions (Kigoma, Mwanza, Dodoma, Morogoro, Tanga Iringa and Mbeya)
2) Electrification projects in all regions of Mainland Tanzania that will reach 2,500 villages in 133 districts. The implementation is still ongoing, involving construction of 6 step up substations. Under the project, the company will undertake construction of 13,600km of medium voltage power distribution lines, 7,000km of low voltage lines, installation of 3,100 distribution transformers and connection of 250,000 initial customers. The company expects to connect 1.25 million new customers with the new infrastructure. The total cost for this project funded by the Government through Rural Energy Fund (REF) is estimated to be Tzs 881 billion.
3) Tanzania Energy Development and Access Expansion Project (TEDAP) is ongoing with the objective to improve the quality and efficiency of the provision of electricity service in the country and to establish a sustainable base for energy access expansion. It is financed by IDA Credit of SDR 67.7 million, of which SDR 49.8 million is allocated to TANESCO as a grant.

[5] National Audit Office, "Report of the Controller and Auditor General on the consolidated financial statements of Tanzania Electricity Supply Company Limited for the 18-month period ended 30th June 2015." The company changed the reporting period to 30th June from 31st December to align its financial year to the Government's fiscal year as per Treasury circular number 11 of fiscal year 2014/2015. The first new period is 18 months to 30th June 2015. This paper is the latest report outlining the profile of the company. The company used to release "Corporate Business Plan (CBP)," but the last version "CBP 2015" was released in December 2014 and its contents are a bit old now.

Table 3.3.2-1 Principal Activities of TANESCO during 18 Month to 30th June 2015.

	Plan 18 months to 30th June 2015	Actual 18 months to 30th June 2015	Actual 12 months to 31st Dec 2013	Percentage change from prior year
Sevices lines completed during the period /year	375,000	309,250	143,113	116.09
Number of pending service line applications	-	55,196	63,273	-12.77
Units sold during the period/year (million)	8,620	7,727	4,776	61.79
Additional 33kv and 11kv lines during the period/year (km)	489	1,148	3,843	-70.13
Total length of 33kv and 11kv distribution lines completed during the period/year (km)	23,562	20,852	23,073	-9.63
Total lengh of low voltage lines by the end of the period/year	36,935	40,822	35,309	15.61
Distribution transformers installed during the period/year	3,761	1,214	444	173.42
Total number of distribution transformers by the end of the period/year	14,887	12,340	11,126	10.91
Total number of consumers by the end of the period/year	1,538,967	1,473,217	1,163,967	26.57
Total number of staff	7,488	6,328	5,990	5.64
Customer/staff ratio	206	241	194	24.23

Source: TANESCO's Annual Report (National Audit Office, "Report of the Controller and Auditor General on the consolidated financial statements of Tanzania Electric Supply Company Limited for the 18-month period ended 30th June 2015)

4) Electricity V project to construct distribution lines in Mwenza, Simiyu, Geita, Shinyanga regions and rehabilitation of substations in Dar es Salaam and Arusha regions. The project is financed by the African Development Bank (AfDB) worth Unit of Accounts (UA) 26.68 million. The construction of distribution lines 91.5 % complete and substations 68%.
5) Project for rehabilitation of substations and construction of new lines and substations in Dar es Salaam, funded by JICA. The project started in February 2015 and involves installation of 2x60MVA 132/33kV transformers and stringing of the second circuit on 132 kV from Ubungo to Ilala second line, expansion of Msasani substation through installation of 1x15MVA 33/11 kV transformer and construction of 3 new substations of 1x15MVA 33/11 kV at Jangwani beach, Muhimbili and Mwananyamala. The project is expected to complete in June 2017.
6) Rolling out of Geological Information System (GIS) database in 4 regions of Ilala, Kinondoni North, Coast and Temeke started in February 2015 after completion of rollout in Kinondoni South region in 2013. The database will be used for network planning, network analysis, network operations, optimization of the network as well as asset management.

7) The Makambako to Songea 220 kV project is ongoing involving electrification of the districts of Njobe, Namtumbo and Mbinga. The Project is financed by the Government of Sweden.
8) The Backbone Transmission Investment project is ongoing to construct the 400 kV transmission line and its substations from Iringa to Shinyanga. It also includes rural village electrification initiative component along the Backbone project. The project is financed by the Government and multilateral donor agencies.

3.3.3 Transmission/Distribution Loss

Substantial improvements are seen in reducing losses in transmission and distribution, being achieved through following activities;

1) Replacement of post-paid meters with pre-paid meters
2) Energy metering at substations, feeders boundary and transformer
3) Replacement of defective meters
4) Enforcement of meter inspections
5) Enhance maintenance

Table 3.3.3-1 Energy Loss: 2010-2015

	2010	2011	2012	2013	2015
	12 months to 31st December				18 months to 30th June
Distribution Loss	17.8%	15.3%	15.8%	12.8%	12.1%
Transmission Loss	5.6%	6.1%	6.1%	6.2%	6.1%
Total	23.4%	21.4%	21.9%	19.0%	18.2%

Source: TANESCO

Company's Revenue Protection units (PRUs) continued to carry out the operational campaigns against energy theft in all regions. Out of the 211,361 customers inspected, 3,631 customers had metering discrepancies. A total of Tzs 9,170 million was established as revenue loss. The company billed the amounts and the same is being collected.

Company also continued to strengthen the national task force by improving collaboration with the communities including providing incentives to citizens who provide information on vandalism and power theft. It continued to pursue the following activities in the front.

1) Public sensitization and education on effects of vandalism to infrastructure
2) Frequent patrol and inspection by TANESCO and Police Force on various transmission and distribution lines
3) Installation of dry transformers especially in areas where transformer oil theft was rampant
4) Enhance the Village Guarding Contracts along transmission lines

3.3.4 Number of Customer and Customer/Staff Ratio

The total numbers of customer has been increasing as shown in Table 3.3.4-1. However, as the number of employees has increased in the latest fiscal period to promote electrification with proactive power system development, the customer/staff ratio has increased slightly.

Table 3.3.4-1 Customer/Staff Ratio

	2007	2008	2009	2010	2011	2012	2013	2015
	End of year							End of June
Total number of customers	667,490	723,823	783,311	849,236	932,385	1,020,854	1,163,967	1,538,967
Total number of company staff	4,695	5,527	5,550	5,664	5,885	5,915	5,990	7,488
Customer/Staff Ratio	142	131	141	150	158	173	194	206

Source: TANESCO

3.4 Electricity Sector Industry Reform

With regard to the ESI reform and Roadmap, MEM engaged PWC (PricewaterhouseCoopers) as consultant. During the first half of 2014, its report has been discussed with various stakeholders including MEM, TANESCO, MCC, REA, President Office, EWURA, TUICO, EDPG and MoF. After discussion with Cabinet Secretariat, it was discussed with Inter-Ministerial Technical Committee (IMTC) on 18 June 2014, and the "Electricity Supply Industry Reform Strategy and Roadmap 2014-2025" was approved by the Cabinet on 20 June 2014. The concept of the above Electricity Supply Industry Reform Strategy and Roadmap 2014-2025 is cited in The Tanzania Five Year Development Plan II 2016/17 - 2020/21to illustrate the pathway for unbundling the electricity subsector.[6]

3.4.1 Electricity Supply Reform Strategy

Tanzania's Development Vision 2025 was announced in 1995 that the country should become a middle income country building a strong and resilient economy and achieving quality and good life for all. In pursuit of this goal, however, Electricity Supply Industry (ESI) in Tanzania faced enormous challenges in the past two decades including: capacity shortage and backlog investment, attracting private investment in the electricity sub-sector; increasing connection and access level to electricity; increasing security and reliability of the power supply; reducing technical and non-technical losses; diversifying power generation sources; and improving TANESCO's financial performance.

The government of Tanzania has embarked on various reforms to address these challenges. To supplement previous reform strategies, new Electricity Supply Reform Strategy has been developed through comprehensive consultations with key stakeholders, reviewing existing laws and institutions, past studies and experiences. The Strategy resultantly recommends gradual unbundling of TANESCO into independent generation, transmission and distribution companies with emphasis of private sector participation in the supply chain except for transmission segment. A Roadmap is also established to provide detailed activities necessary for smooth implementation of reforms.

[6] The Tanzania Five Year Development Plan II 2016/17 - 2020/21, p.109.

The main objective of the reform is to improve the governance and performance of the ESI for sustainable socio-economic transformation and environment protection through quality service delivery, improving environment for private investment in generation and distribution and increasing electricity connection and access levels. The specific reform objectives are:

a. Creating ESI that supports the National Development Goals
b. Establishing efficient ESI in an environmentally sound and sustainable manner
c. Promoting financial and commercial viability of the sector
d. Attracting private sector investments to the sector
e. Ensuring availability of adequate, reliable and affordable electricity supply

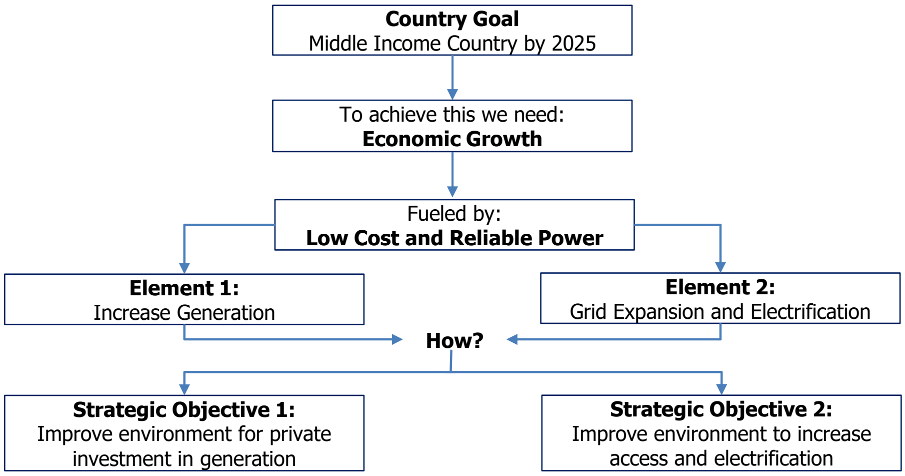


Figure 3.4.1-1 ESI Primary Reform Objectives

Key activities of the reform include TANESCO operational and financial turnaround, strengthening the governance and performance of the sector and attracting investment. The Strategy aims to create an environment conducive to attracting investment in the ESI to support the country's development goal. The strategy is further explained in the Roadmap which details individual sub-activities, time frames and funding requirements.

3.4.2 Optional Models

Four optional models for electric supply industry are considered as summarized in the Figure 3.4.2-1.

Under the Integrated Monopoly Model, a single entity handles every operation and no competition exists. In a general form a state-owned utility company provides all the utility services.

In the Single Buyer Model, competition in generation is introduced but no choice of supplier exists. IPPs may sell only to a single purchasing agency based on the Power Purchase Agreement (PPA). The purchasing agency transmits to distribution companies who have a monopoly relationship with the final consumer. Main purpose of this model is to attract investment to relieve capacity shortages inviting private investors to construct power plants. This is the present market structure in Tanzania.

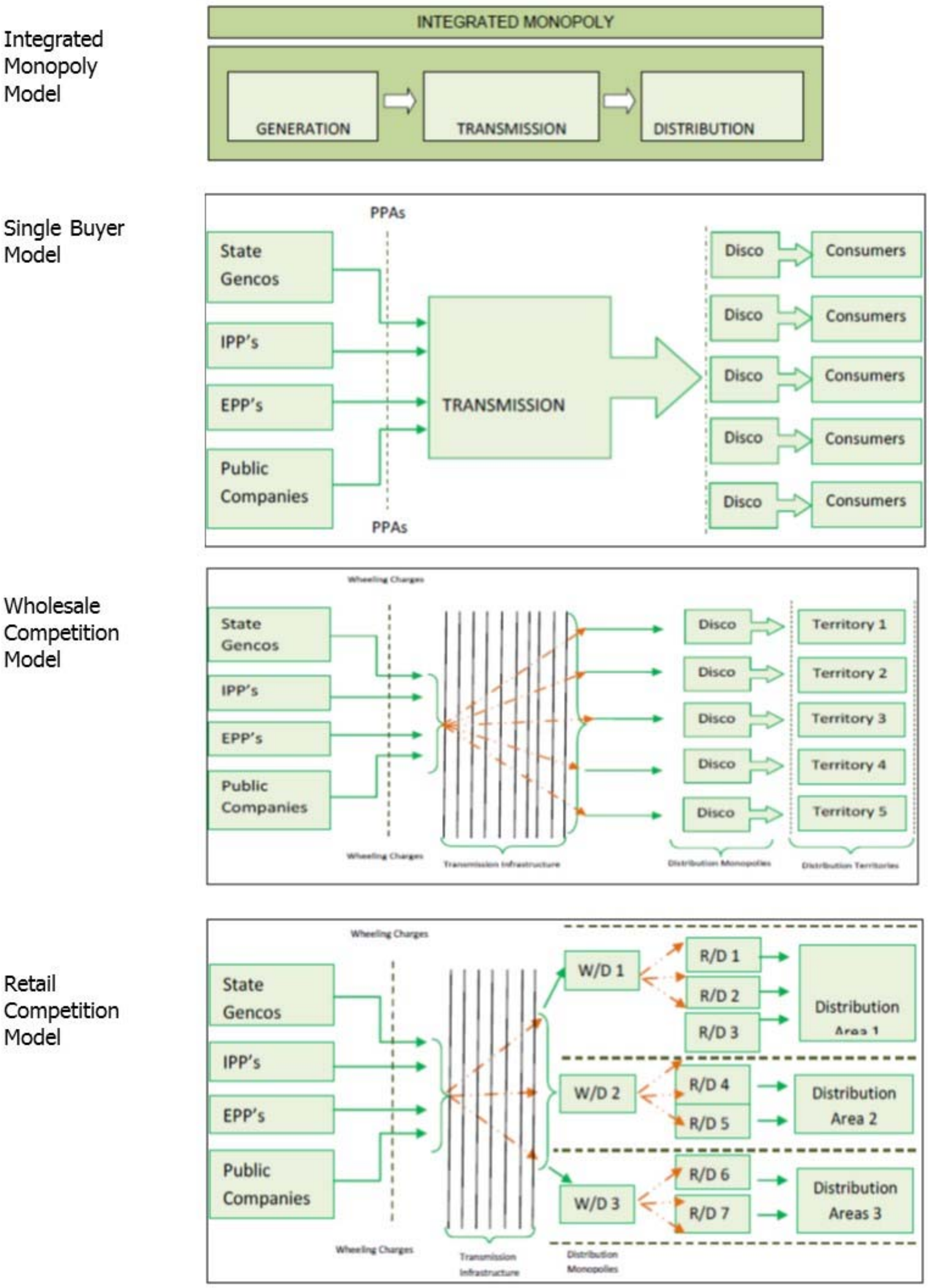


Figure 3.4.2-1 Optional Models for Industry Structure

In the Wholesale Competition Model, all generators have open access to a transmission network and generators compete in selling directly to a variety of distribution companies. Trading arrangements are devised to allow exchange of power on a network to span differences between contractual arrangements and actual demand and supply. Distribution companies continue to have a monopoly over final consumers.

Under the Retail Competition Model, generators compete in selling directly to distributors, retailers and final consumers; customers choose the supplier. Distribution may be separated from the retail of electricity, though some distributors may also be retailers. Generators have access to both transmission and distribution wires based on regulated prices. Trading rules and arrangements are required for both transmission and distribution. Final customers may purchase power from a retailer, a retailer/distributor or directly from a generator.

3.4.3 Roadmap

Presently, Tanzania ESI operates on the single buyer model. The proposed reforms envision ESI in Tanzania to graduate from this model toward retail completion model gradually. To implement this, the Roadmap provides an overview of the electricity market in the next decade. It aims to:

a. Increase investment from both private and public sector
b. Enhance private sector participation
c. Increase connection and access levels to electricity
d. Diversify sources of energy for electricity generation and supply
e. Enhance affordability and reliability of electricity supply
f. Reduce system losses
g. Establish a competitive wholesale and retail electricity market

The strategy proposes a gradual four stage process to achieve a fully competitive electricity market structure by 2025; namely, Immediate Term (July 2012 – June 2015), Short Term (Jul y 2015 –June 2018), Medium Term (July 2018 – June 2021) and Long Term (July 2021 – June 2025).

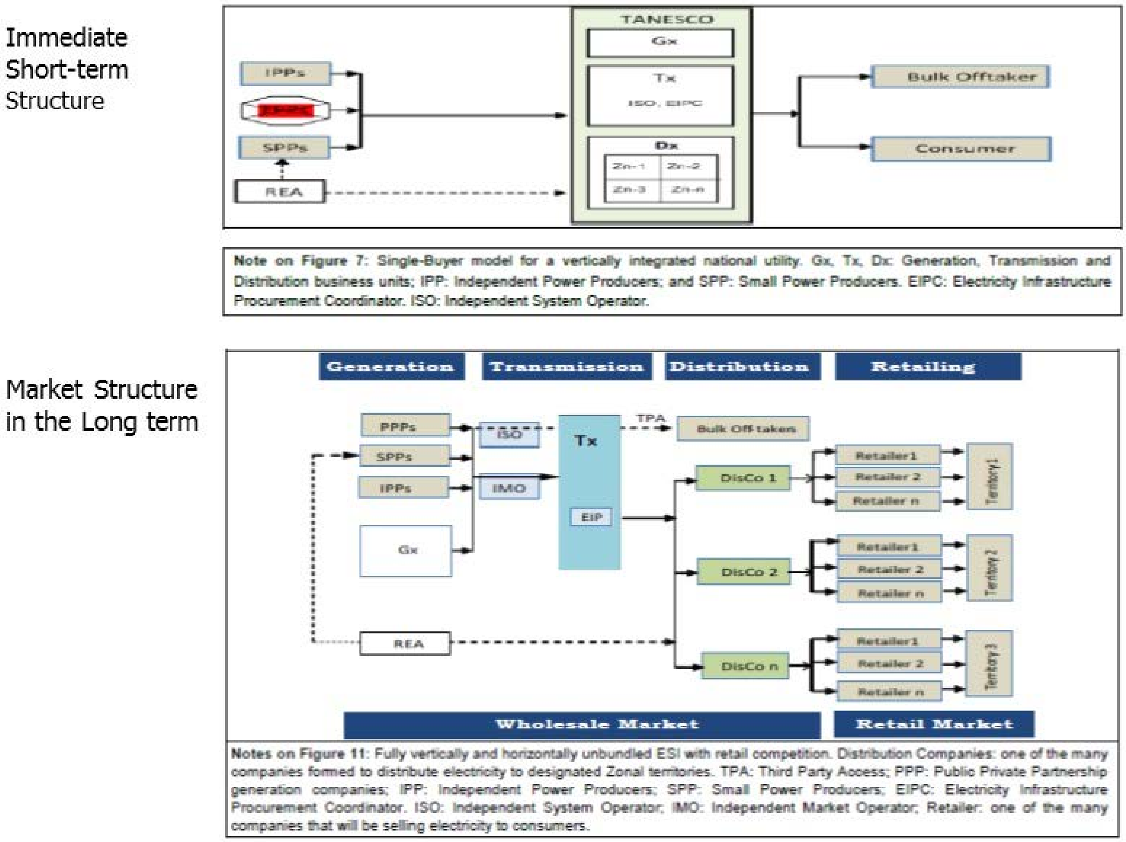


Figure 3.4.3-1 Market Structure aimed by ESI Reform

In the Immediate Term, TANESCO remains vertically integrated with ring fenced business units and Independent System Operator (ISO) and Electricity Infrastructure Procurement Coordinator (EIPC) embedded within transmission.

As shown in Figure 3.4.3-2, this structure will be transformed stepwise. By 2017, generation will be unbundled from transmission and distribution. By 2021, Distribution will be unbundled from transmission. And finally, with horizontal unbundling of distribution segment, a fully unbundled electricity market will be achieved in the long-term, which comprises of competitive power generation and retail segments.

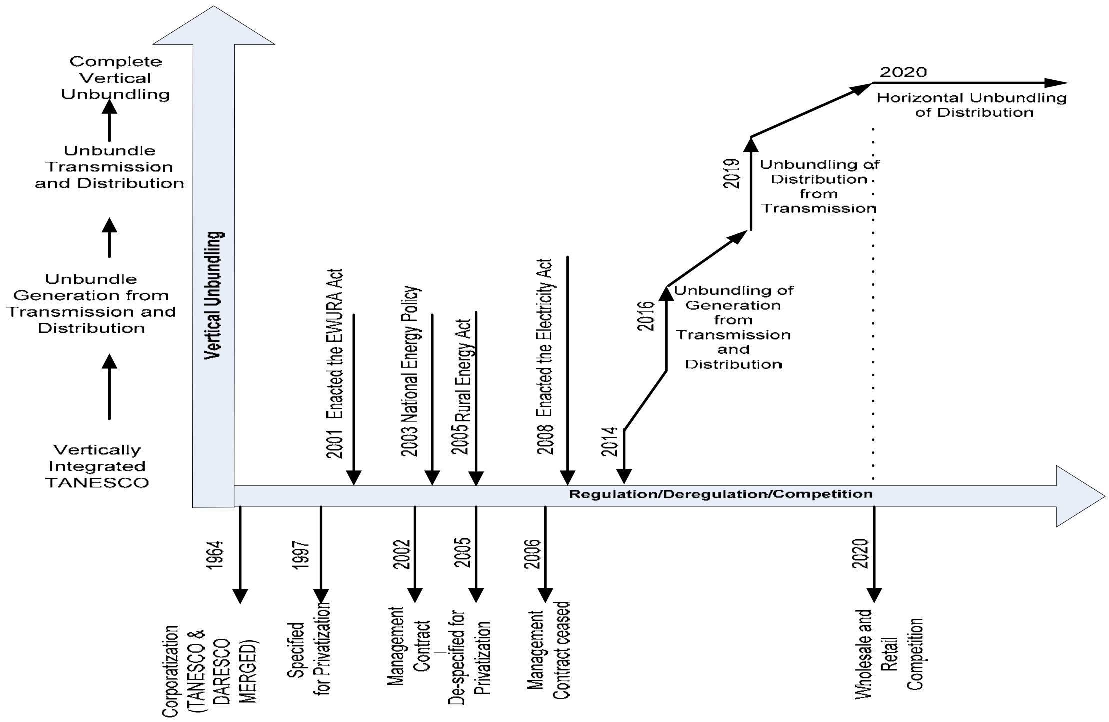


Figure 3.4.3-2 ESI Reform Path for Tanzania

The proposal notes that the Roadmap is a living document which shall be reviewed periodically to address prevailing challenges taking into sector reform progress and market conditions. It also warns that ESI Strategy is exposed to a number of risks that may impair its implementation such as:

a. Delay in implementing the Strategy may not improve the ESI situation.
b. If the number of power companies would not increase, the situation will degenerate into a private monopoly worse than public monopoly.
c. Unbundling small power systems may increase overhead costs without achieving desired level of competition.
d. Availability of well-trained and skilled workforce is of paramount importance. The Government should implement human capital development extensively.
e. To ensure smooth transition and implementation, continuous consultative engagement with stakeholders is essential to eliminate resistances to change.
f. Delays in improving TANESCO's financial performance could adversely impact the timelines for achieving reform objectives.

In particular, successful implementation of the ESI Strategy depends on the availability of workforce with knowledge and skills and financial resources to accommodate the investment requirement. It is estimated that the ESI Reform Strategy will be implemented over a period of 11 years and will require about US$ 1.15 billion (Tzs 1.9 trillion). This amount will be used for paying TANESCO's debt (US$ 412 million), capacity charges for existing IPPs (US$ 635 million) and other expenses (US$ 101.2 million) as shown in Table 3.4.3-1.

Table 3.4.3-1 ESI Reform Path for Tanzania

Time frame	Major Activity	Amount
		US$ million
Immediate term	TANESCO turn-aroud and preparations for short tem	345.0
Short term	Unbundling of Generation from Transmission and distribution segments	386.9
Medium term	Unbundling of Distribution from Transmission segment	414.5
Long term	Introduction of Retail competition market and preparation for Listing Generation and Distribution Companies at DSE	344.9
Total		1491.3

3.4.4 Immediate Action and Required Budget

At a meeting with international donors held in June 2014, Mr. Maswi, Permanent Secretary of MEM, explained the main immediate actions scheduled in the Road Map as shown in the Table 3.4.4-1, and that, while the implementation of the Strategy will start in July 2014, the budget gap for financing the reform immediate activities is US$ 1,201 million. MEM requests that concerted efforts from all stakeholders are required to make the reform success.

Table 3.4.4-1 The Roadmap – Main Immediate Actions July 2014 – June 2015

Major Activities	Timeframe	Cost (US$ million)
Establish a Task Force with mandate to monitor the implementation of the Roadmap	Aug-14	100
Establish a Transformation and Change Management Team (TCMT) at TANESCO to manage the reform process	Aug-14	200
Initiate valuation of TANESCO's generation, transmission and distribution assets	Dec-14	300
Assess Human Capital Needs and prepare Capacity Building Programme	Mar-15	200
Carry out management information system audit	Jun-15	300
Reviewing of the Electricity Act 2008, in particular, Section 41(6)	Jun-15	0.5
Improve TANESCO financial performance	Dec-15	100
Designate Gird Control Center as Independent System Operator (ISO)	Dec-15	0.5
Review tariff structure and develop Grid Codes to guide transmission and distribution operations	Dec-15	100

3.4.5 Challenges to be Overcome

As repeatedly explained in the proposed Reform Strategy, the biggest challenges are how to secure the required fund and skilled workforce for its implementation. We should also take note of other important issues inferred from the basic economic principles inherent in the electricity industry such as trade-off between scale economy and supply stability and extremely long life of facilities.

An electricity supply system is a huge social apparatus that requires a significant amount of investment and long construction time, and investments are heavily affected by economics of scale, space and supply stability. Most facilities are of long life, not easy to replace once constructed. Restructuring the physical system is costly and time consuming. On the other hand, electricity is an essential element for a contemporary society which every citizen should be supplied at socially fair price. Neglecting these fundamental features of the industry, we should not expect that introduction of a free market system would automatically solicit adequate investment or competition would simply bring the most efficient and beneficial electricity supply system. There are many investment opportunities in the international market, and it is necessary to win the competition there in order to invite appropriate investments. Failure of this would repeat another bitter situation that was experienced in introduction of EPP power supply. In actuality, however, the huge arrears of TANESCO is still increasing, resolution of which is the most urgent issue for successful promotion of investment in the electricity industry.

If we look to the generation cost, today, most efficient thermal power plants in the world are in a size of 1,000MW; a most modern 1,000MW class combined cycle gas turbine (CCGT) plant realizes 60% generation efficiency against about 40% for a 200MW class single cycle gas plant; a most modern ultra-critical coal (USC) thermal plant realizes 45% efficiency against around 35% for a 200MW class sub-critical (SC) coal thermal plant. Over the whole plant life, more efficient plants greatly save fuel consumption and are cheaper.

There is a discussion that power plant capacity could not be very large in consideration of the system stability. However, it would not be beneficial to simply pursue a balance of a temporal small system when it is going to expand substantially, more than 18 times in next three decades. In case of developing mine mouth coal thermal, for example, electricity will flow one way for some time before a loop system is completed, and any trouble on the transmission line will incur loss of all plants on the line even if the individual plant size is small. The concept of supply reliability criteria such as LOLP of “N-1” may be applied across-the-board only when the system has reached certain stable stage. During the period when the system is expanding rapidly, more dynamic system management should be considered, in particular, giving priority to establishing an efficient system in the long run.

On the other hand, as the Reform Strategy envisages an electricity supply capacity of Tanzania at 10,000MW by 2025, with this size of market, should one world-class big plant of 1,000MW class is built, another big plant cannot come into the market as an immediate competitor. If a big plant is to cover wide service areas, service areas must be fully linked while transmission for remote areas may cost a lot. Economics of space would work adversely. System stability and reliability are also questionable if we adopt 1,000MW class plants in the 10,000MW system requiring a very high reserve ratio. Competition alone cannot systematically solve these problems facing the real business.

In addition, introducing sufficient number of players in the market so that market competition works effectively, the standard size of power plant may become smaller while overhead ratio remains greater. Smaller plants with inferior efficiency, once built, will continue to operate for 20 – 40 years unless we dare to replace them prematurely. Long-run optimization of the power supply system is very important to construct an efficient economy. Marketization must be pursued step by step considering the evolution of the market size and the appropriate size of the power supply system with a precondition that marketization realizes better efficiency toward the ultimate target to construct a highly efficient power supply system.

On the demand side, competition and universal service would not co-exist easily. Consumers living in a big market may enjoy comfortable services arising from suppliers' competition. However, consumers in rural areas may not benefit from such competition or would rather loose reliable supply at socially fair price. Introducing competition in the market, careful consideration must be paid to every aspect of the electricity supply industry and the market so that the spirit envisaged in the Tanzania Development Vision shall be materialized properly.

Chapter 4 Energy Demand

In this session, energy demand of Tanzania is analyzed. The targeted energies are fossil energies including coal and oil products, and renewable energies such as woods and charcoal. The used data are energy demand / supply from International Energy Agency (IEA), however, before using the data, the data have been revised by the latest data from Tanzanian authorities.

4.1 Energy balance

The following table is Tanzania energy balance. Energy balance table shows energy supply, energy consumption and production of transformation sector, and energy consumption in several consumption sectors in a country. As the energy supply sources, energy production, import and production from transformation sector are prepared. As the transformation sectors, there are power, oil refinery, coal production and woods and charcoal supply. As final energy consumption sector, there are industry, transport, agriculture/fishing, un-known use and none energy sectors in IEA database.

4.1.1 Energy balance features in Tanzania

The feature point of Tanzania is that the share of renewable energies including woods and charcoal is comparatively so higher than other countries. When looking at the available data in 2011, 95 % of the domestic energy supply is woods and charcoal, and the share of the domestic energy consumption (it is called "Primary energy consumption " in IEA data) is 88% in the country. The consumption of the woods and charcoal is 18 million toe (Oil Equivalence Ton), most of the woods and charcoal with 12.7 million toe are consumed as residential use. However, in internationality, the consumption of the woods and charcoal is being restrained for environmental protection. It can be estimated that the woods and charcoal consumed in residential sector of Tanzania will be converted to power, oil products and gases in future.

4.1.2 Energy consumption structure

Coal consumption in 2011 was 28 ktoe, it was only 0.1% contribution to the total consumption in Tanzania. Oil products was 1.5 million toe and the contribution of the oil products 7.1% in the total. The consumption sectors of the oil products are transportation sector with 72%, residential sector with 13% and industry sector with 12%. Natural gas is consumed with 7.1 million toe, 86% of the consumption is for power sector and the remain with 14 % is used as raw material for fertilizer factories in industry sector. The power generation from hydro is 2,615 GWh in 2011. The contribution of the power generation is 49% in the total power generation.

Table 4.1.2-1 Total energy balance of Tanzania in 2011

Unit: ktoe

Classification	Items	Coal and products	Oil products	Natural gas	Hydro	Biofuels and waste	Electricity	Total
Supply	Production	28	0	708	225	18,304	0	19,265
	Imports	0	1,644	0	0	0	0	1,644
	Exports	0	0	0	0	0	0	0
	Total primary energy supply	28	1,482	708	225	18,304	0	20,747
Transformation	Main producer electricity plants	0	-14	-606	-225	0	451	-394
	Autoproducer electricity plants	-17	0	0	0	0	5	-11
	Other transformation	0	0	0	0	-2,164	0	-2,164
	Energy industry own use	0	0	0	0	0	-5	-5
	Transformation Losses	0	0	0	0	0	-89	-89
Consumption	Total final consumption	11	1,468	102	0	16,140	354	18,075
	Industry	11	177	102	0	2,201	166	2,657
	Road	0	1,068	0	0	0	0	1,068
	Rail	0	0	0	0	0	0	0
	Residential	0	186	0	0	12,660	162	13,007
	Commercial and public services	0	0	0	0	0	0	0
	Agriculture/forestry	0	0	0	0	760	0	760
	Non-specified (other)	0	22	0	0	519	26	567
	Non-energy use	0	15	0	0	0	0	15
	Electricity output (GWh)	60	41	2,586	2,615	0	0	5,302

Source: International Energy Agency 2013 database

Table 4.1.2-2 The contribution of Energy supply and consumption in 2011

Unit: %

Classification		Coal and products	Crude, NGL and feedstocks	Oil products	Natural gas	Hydro	Biofuels and waste	Electricity	Total
Supply	Production	0.1	0.0	0.0	3.7	1.2	95.0	0.0	100
	Imports	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100
	Exports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Total primary energy supply	0.1	0.0	7.1	3.4	1.1	88.2	0.0	100
Transformation	Main producer electricity plants	0.0	0.0	-0.9	-85.6	-100.0	0.0	0.0	-1.9
	Autoproducer electricity plants	-60.7	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
	Other transformation	0.0	0.0	0.0	0.0	0.0	-11.8	0.0	-10.4
	Energy industry own use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Losses	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4
Consumption	Total final consumption	39.3	0.0	99.1	14.4	0.0	88.2	0.0	87.1
	Industry	39.3	0.0	11.9	14.4	0.0	12.0	0.0	12.8
	Road	0.0	0.0	72.1	0.0	0.0	0.0	0.0	5.1
	Rail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Residential	0.0	0.0	12.6	0.0	0.0	69.2	0.0	62.7
	Commercial and public services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Agriculture/forestry	0.0	0.0	0.0	0.0	0.0	4.2	0.0	3.7
	Non-specified (other)	0.0	0.0	1.5	0.0	0.0	2.8	0.0	2.7
	Non-energy use	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.1

Note: The contributions in Supply are Total =100, and transformation and consumption are Total primary energy =100.

Source: International Energy Agency 2013 database

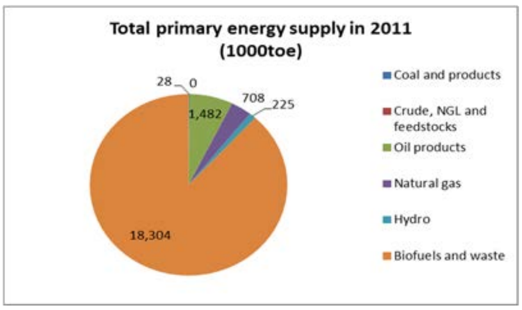


Figure 4.1.2-1 Primary energy supply

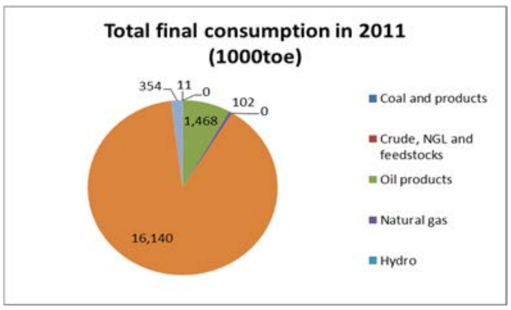


Figure 4.1.2-2 Final energy consumption

The power generation from coal is only 60Gwh in 2011. The contribution of the power consumption with 5,302 GWh are 37% for industry, 36% for residential, 6% for unknown use and 20% for T/D loss. As the above mentioned, the energies in descending order of consumption volume woods and charcoal, oil products, natural gas, hydro power and coal. However, the order will be changed in near future, due to the survey results of coal and natural gas reserves ij Tanzania. The contribution of hydro power generation is the highest in the total power generation and the second bigger power generation is natural gas, the generation is 2,586 GWh. And the power generation from natural gas is almost equivalent to hydro power generation.

4.2 Energy demand trends by energy

Regarding main energy demand, the analysis of the time series volatility are as the followings.

4.2.1 Coal and coal products demand

The coal demand in Tanzania is depend on the domestic production. Recently as there is on the trends that the coal production has been declined, the coal consumption also decreased. Although, the coal production was 49ktoein 2006, it became 45 ktoe in 2011. Now, the production incremental plan is being studied by Tanzanian coal authorities, related private companies and foreign ODA support. Therefore, there is possibility to increase coal consumption due that coal fired power plants are increased in near future.

Table 4.2.1-1 Coal demand supply balance

Coal & Coal products (ktoe)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011/06
Production	49	48	49	34	40	46	49	52	55	59	47	45	−1.7
Imports	0	0	0	0	0	0	0	0	0	0	0	0	
Domestic supply	49	48	49	34	40	46	49	52	55	59	47	45	−1.7
Transformation sector	19	26	30	21	25	28	30	32	34	36	28	27	−2.1
Power sector	19	26	30	21	25	28	30	32	34	36	28	27	−2.1
Final consumption	30	22	18	13	15	18	19	20	22	23	19	18	−1.1
Industry	30	22	18	13	15	18	19	20	22	23	19	18	−1.1
Transport	0	0	0	0	0	0	0	0	0	0	0	0	
Residential	0	0	0	1	0	0	1	1	1	0	0	0	
Commercial and public services	0	0	0	0	0	0	0	0	0	0	0	0	
Agriculture/forestry	0	0	0	0	0	0	0	0	0	0	0	0	
Electricity output (GWh)	67	90	105	73	86	99	106	113	119	125	97	96	

Source: International Energy Agency Database 2013

4.2.2 Natural gas

Domestic natural gas is produced in Songo Songo, and the natural gas with 86% to the total production is consumed in fired power plants in 2011. The remain is consumed as raw material of fertilizer factories in Tanzania. As it is expected that the domestic natural gas production is increased after 2025, the natural gas demand is increased drastically for fired power plant, chemical raw material, fuel energy for vehicles and substitution fuel for residential and industry sectors.

Table 4.2.2-1 Natural gas demand and supply balance

Natural gas (ktoe)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011/06
Production	0	0	0	0	97	334	413	446	460	543	715	787	13.8
Imports	0	0	0	0	0	0	0	0	0	0	0	0	
Total primary energy supply	0	0	0	0	97	334	413	446	460	543	715	787	13.8
Power sector	0	0	0	0	86	280	343	375	385	480	601	673	14.4
Final consumption	0	0	0	0	12	55	71	72	72	63	111	114	9.8
Industry	0	0	0	0	12	55	71	72	72	63	111	114	9.8
Transport	0	0	0	0	0	0	0	0	0	0	0	0	
Residential	0	0	0	0	0	0	0	0	0	0	0	0	
Commercial and public services	0	0	0	0	0	0	0	0	0	0	0	0	
Agriculture/forestry	0	0	0	0	0	0	0	0	0	0	0	0	
Electricity output (GWh)	0	0	0	0	415	1,149	1,330	1,513	1,600	1,677	2,097	2,349	

Source: International Energy Agency Database 2013

4.2.3 Gasoline and Diesel

As there is no oil refinery plants in Tanzania as of 2014, all oil products are imported. At the time, the oil products costs are international prices. Therefore, the costs for oil products consumers are higher than domestic energy costs such as natural gas and coal.

Gasoline and diesel are used as fuels for vehicles, and at the same time, diesel is used as fuel of diesel power plans. The demand growth rates of gasoline and diesel from 2006 to 2011 (5 years) are 12.9 %per year and 11.1 % per year respectively. When considering the GDP growth rate with 7 % in the same periods, the growth rates of the gasoline and diesel are higher than the national economic growth rate.

Table 4.2.3-1 Demand and supply of gasoline (Upper) and diesel (Lower)

Motor gasoline (ktoe)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011/06
Imports	0.0	123.9	168.7	193.5	207.7	223.0	238.4	253.7	330.0	333.0	416.0	437.0	12.9
Domestic supply	0.0	123.9	168.7	193.5	207.7	223.0	238.4	253.7	330.0	333.0	416.0	437.0	12.9
Road	0.0	123.9	168.7	193.5	207.7	223.0	238.4	253.7	330.0	333.0	416.0	437.0	12.9
Rail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Diesel oil (ktoe)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011/06
Imports	21.0	297.0	403.0	528.0	563.0	606.0	664.0	707.0	915.0	865.0	1071.0	1125.0	11.1
Domestic supply	21.0	297.0	403.0	528.0	563.0	606.0	664.0	707.0	915.0	865.0	1071.0	1125.0	11.1
Final consumption	21.0	297.0	403.0	528.0	563.0	606.0	664.0	707.0	915.0	865.0	1071.0	1125.0	11.1
Industry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Road	0.0	271.0	388.0	512.0	546.0	588.0	645.0	686.0	893.0	841.0	1051.0	1104.0	11.3
Rail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Commercial and public services	21.0	26.0	15.0	16.0	17.0	18.0	19.0	21.0	22.0	24.0	20.0	21.0	2.0
Agriculture/forestry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Source: International Energy Agency Database 2013

Usually the demand growth rate of vehicle fuels are higher than GDP growth rate in developing countries, the same trends are appeared in Tanzania. And as there are other problems such as inadequate transportation infrastructure and high cost vehicle fuels, it is expected to introduce substitution energies (Ex; ethanol and natural gas) for oil products. While, diesel consumption for commercial sector is used diesel power plants as back up for power shedding. By the reason, the diesel oil performs the important role in Tanzanian economy.

4.2.4 Kerosene

Much kerosene is consumed in residential sector. In Tanzania with low electrification rate, kerosene lamps are used in country wide. However, after 2010, the kerosene consumption are reduced due that electrification rates are increased gradually, it can be predicted that the kerosene consumption continues the reduction in line with the increases of the electrification in future.

Table 4.2.4-1 Kerosene demand and supply balance

kerosene (ktoe)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011/06
Imports	95.7	127.6	135.3	145.2	155.1	166.1	178.2	190.3	204.6	215.6	173.8	184.8	0.7
Domestic supply	95.7	127.6	135.3	145.2	155.1	166.1	178.2	190.3	204.6	215.6	173.8	184.8	0.7
Final consumption	95.7	127.6	135.3	145.2	155.1	166.1	178.2	190.3	204.6	215.6	173.8	184.8	0.7
Industry	0	0	0	0	0	0	0	0	0	0	0	0	
Transport	0	0	0	0	0	0	0	0	0	0	0	0	
Residential	95.7	127.6	135.3	145.2	155.1	166.1	178.2	190.3	204.6	215.6	173.8	184.8	0.7
Commercial and public services	0	0	0	0	0	0	0	0	0	0	0	0	
Agriculture/forestry	0	0	0	0	0	0	0	0	0	0	0	0	

Source: International Energy Agency Database 2013

4.2.5 Fuel oil

Fuel oil are used in industry sector, power sector and vessel. In 2011, the contribution of fuel oil is 75% for industry, 20% for vessels and 5% for power generation. By reduction of oil fuel consumption for power generation after the years of 2007, the consumption cannot be compared between before 2006 and after 2007. The growth rates from 2007 to 2011 (4 years) are 10.2 % for the import of fuel oil and 7.5% for domestic consumption of fuel oil. During the term, as GDP growth rate is 7 %, it can be considered that the growth rate of fuel oil is reasonable and acceptable.

Table 4.2.5-1 Fuel oil demand and supply balance

Fuel oil (ktoe)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011/07
Imports	133.3	119.6	120.6	127.5	135.3	312.7	338.2	171.6	182.4	192.2	237.7	253.0	10.2
International marine bunkers	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	46.9	50.0	23.3
Domestic supply	111.8	98.0	99.0	105.9	113.7	291.2	316.7	150.0	160.8	170.6	190.7	203.0	7.9
Power plants	0.0	0.0	0.0	0.0	0.0	169.6	187.3	10.8	11.8	12.7	14.3	15.3	9.1
Final consumption	111.8	98.0	99.0	105.9	113.7	121.6	129.4	139.2	149.0	157.8	176.5	187.7	7.8
Industry	111.8	98.0	99.0	105.9	113.7	121.6	129.4	139.2	149.0	157.8	176.5	187.7	7.8
Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Residential	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Commercial and public services	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Agriculture/forestry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Source: International Energy Agency Database 2013

4.2.6 LPG

LPG is important fuel for residential and commercial & service sectors. Although residential sector uses woods and charcoal so much, it can be considered that Tanzania residential sector use natural gas, power, LPG and briquette as substitution fuel of woods and charcoal. Especially, as urban area and collective houses are limited to use woods and charcoal, they will use natural gas and LPG for cocking as well as electric power. The growth rate of LPG in residential sector from 2006 to 2011 was 8.4 %, and the consumption was 10.8 ktoe in 2011. Current consumption of LPG is not so big, however, LPG consumption will be increased in residential sectors in future.

Table 4.2.6-1 LPG demand and supply balance

LPG(ktoe)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011/06
Imports	3.6	4.8	6	6	7.2	7.2	7.2	8.4	8.4	9.6	9.6	10.8	8.4
Domestic supply	3.6	4.8	6	6	7.2	7.2	7.2	8.4	8.4	9.6	9.6	10.8	8.4
Final consumption	3.6	4.8	6	6	7.2	7.2	7.2	8.4	8.4	9.6	9.6	10.8	8.4
Industry	0	0	0	0	0	0	0	0	0	0	0	0	
Residential	3.6	4.8	6	6	7.2	7.2	7.2	8.4	8.4	9.6	9.6	10.8	8.4
Commercial and public services	0	0	0	0	0	0	0	0	0	0	0	0	
Agriculture/forestry	0	0	0	0	0	0	0	0	0	0	0	0	

Source: International Energy Agency Database 2013

4.2.7 Woods and Charcoal

As bio energy and one of renewable energies, there are woods and charcoal. Generally, the word of "Bio" indicates new energies from biological origin resources and the word of renewable energies include new energies to use natural energies such as Photovoltaic system / Solar heat, Geothermal / Earth thermal, Wind power / Wave power, Tied / Water temperature variation.

However, it is no doubt that conventional woods and charcoal are one of bio and renewable energies. In IEA statistics, the conventional woods and charcoal are included in the category of renewable energy.

In Tanzania, the contribution of woods and charcoal occupied 88 % in the total energy supply (equivalent to total consumption). It is impressive contribution at the time of comparing it to the other developing countries. It means that the substitution energies of woods and charcoal should be sought in Tanzania when considering future urbanization and population expansion.

The growth rate of woods and charcoal from 2006 to 2011 was 14.3 % per year for power generation, 7.2 % for industry sector and only 2.7 % for residential use. It means that the growth rate of residential consumption is in proportion with growth rate of population or number of households, while, the consumption for power generation and industry sector is increased in line with their production activities. Under the situation, it is afraid that the shortage of woods and charcoal supply will become some constrain of the production activities.

There are many cases that the utilization of woods and charcoal are discussed at the time of considering environmental protection. Tanzania has big environmental allowance to use woods and charcoal, because there is the best weather and temperature for plant lives in the country. However, as it is predicted that the supply constrain of woods and charcoal is happened in future, therefore it is required to supply substitution energies for woods and charcoal.

Table 4.2.7-1 Woods and charcoal demand and supply

Woods & Charcoal (ktoe)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011/06
Production	12,463	13,088	13,662	14,189	14,719	15,256	15,780	16,242	16,733	17,211	17,763	18,311	3.0
Imports	0	0	0	0	0	0	0	0	0	0	0	0	
Total primary energy supply	12,463	13,088	13,662	14,189	14,719	15,256	15,780	16,242	16,733	17,211	17,763	18,311	3.0
Main producer electricity plants	184	224	234	219	203	153	123	216	228	239	240	240	14.3
Other transformation(charcoal)	1,997	2,310	2,545	2,737	2,901	3,046	3,165	3,197	3,231	3,264	3,298	3,331	1.0
Total final consumption	10,466	10,779	11,117	11,453	11,818	12,211	12,615	13,045	13,503	13,947	14,466	14,980	3.5
Industry	1,055	1,121	1,202	1,271	1,356	1,456	1,554	1,664	1,789	1,887	2,068	2,202	7.2
Residential	9,546	9,887	10,212	10,531	10,851	11,177	11,506	11,818	12,143	12,480	12,796	13,150	2.7
Commercial and public services	382	392	403	414	425	437	449	462	476	490	504	519	2.9
Agriculture/forestry	560	575	590	606	623	640	659	678	697	718	738	761	2.9
Electricity output (GWh)	428	521	544	509	472	356	286	502	530	556	558	558	14.3

Note: Woods and charcoal consumption for power generation in 2010 and 2011are estimated by JICA study team
Source: International Energy Agency Database 2013

4.3 Energy demand by sector

The country wide average growth rate of final energy demand of Tanzania is 4.0 % per year from 2006 to 2011. When looking at the sectoral growth rates, they are 3.0 % for agriculture / fishing sector, 7.4 % for industry sector (including mining & manufacturing sectors), 3.1 % for commercial & service sector, 3.5 % for government (to Zanzibar) sector, 11.3 % for transportation sector and 2.6 % for residential sector. The growth rates of industry (mining and manufacturing) sector and transportation sector are significant higher.

Table 4.3-1 Final energy demand by sector

Unit: ktoe

Sector	Energy	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2011/06
Agriculture	Fossil Total	590	606	623	640	672	692	712	734	755	779	3.0
	Diesel	0	0	0	0	0	0	0	0	0	0	
	Fuel oil	0	0	0	0	13	14	15	16	17	18	6.7
	Woods & Charcoal	590	606	623	640	659	678	697	718	738	761	2.9
Industry	Fossil Total	1,388	1,470	1,585	1,759	1,875	2,011	2,159	2,272	2,540	2,685	7.4
	Coal	18	13	15	18	19	20	22	23	19	18	-1.1
	Diesel	0	0	0	0	0	0	0	0	0	0	
	Fuel oil	99	106	114	122	129	139	149	158	176	188	7.7
	Natural gas	0	0	12	55	71	72	72	63	111	114	9.8
	Woods & Charcoal	1,202	1,271	1,356	1,456	1,554	1,664	1,789	1,887	2,068	2,202	7.2
	Power	68	80	88	108	102	116	127	141	165	165	10.1
Commercial	Fossil Total	429	441	452	466	479	496	512	529	543	558	3.1
	LPG	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
	Diesel	15	16	17	18	19	21	22.0	24.0	20.0	21.0	2.0
	Natural gas	0	0	0	0	0	0	0.0	0.0	0.0	0.0	
	Woods & Charcoal	403	414	425	437	449	462	475.8	489.8	503.6	519.0	2.9
	Power	11	11	10	11	11	13	14	16	19	18	11.3
Government	Total power	22.5	22.0	27.4	28.5	31.4	35.0	35.6	34.1	27.0	37.3	3.5
	Zanzibar	11.4	9.9	13.8	16.0	17.6	19.9	19.7	22.2	15.1	23.8	6.3
	Gold	11.1	12.2	13.6	12.6	13.8	15.1	15.9	11.9	11.9	13.4	-0.5
Transportation	Total	652	806	860	924	1,002	1,066	1,357	1,313	1,625	1,710	11.3
	Gasoline	169	194	208	223	238	254	330	333	416	437	12.9
	Diesel	388	512	546	588	645	686	893	841	1,051	1,104	11.3
	Jet fuel(Airplane)	74	79	85	91	97	105	112	118	111	119	4.2
	Fuel oil(Marine)	22	22	22	22	22	22	22	22	47	50	18.3
Residential	Total	10,439	10,018	10,342	11,274	11,097	11,304	10,420	11,349	10,415	12,647	2.6
	LPG	6	6	7	7	7	8	8	10	320	11	8.4
	Kerosene	135	145	155	166	178	190	205	216	174	185	0.7
	Woods & Charcoal	10,212	9,785	10,094	11,006	10,818	10,995	10,094	11,006	9,785	12,325	2.6
	Power	86	82	86	95	94	110	114	118	136	127	6.0
Final energy	Total	13,520	13,364	13,890	15,092	15,156	15,604	15,196	16,232	15,905	18,416	4.0

Note: The sector categories in IEA statistics are ①Agriculture/ fishery, ②Industry (Mining and manufacturing), ③Commercial & services, ④Transportation, ⑤Residential, ⑥International aviation fuels, ⑦International marine fuels. It is ①~⑤ for domestic energy consumption and it is ①~⑦ for domestic final energy demand.

Source: IEA Database 2013 と MEM、TANESCO

And the energies with growth rates more than 10% per year from 2006 to 2011 are electric power in industry sector (10.1%), electric power in commercial & service sector and gasoline (12.9%) and diesel (11.3%) in transportation sector. The growth rates of electric power and fuels in transportation are significant higher. It is typical phenomenon in developing countries.

4.4 International comparison for energy demand

By comparing energy demand of Tanzania to other countries, the future energy demand of Tanzania can be predicted. In this analysis, the comparisons are studied by "Figure of GDP per capita and primary energy consumption per capita" and "Figure of GDP per capita and power consumption per capita". The used data are from 2000 to 2011. The countries compared in the Fig.s are Tanzania, Ghana, South Africa, Saudi Arabia, Malaysia, Japan, USA and China.

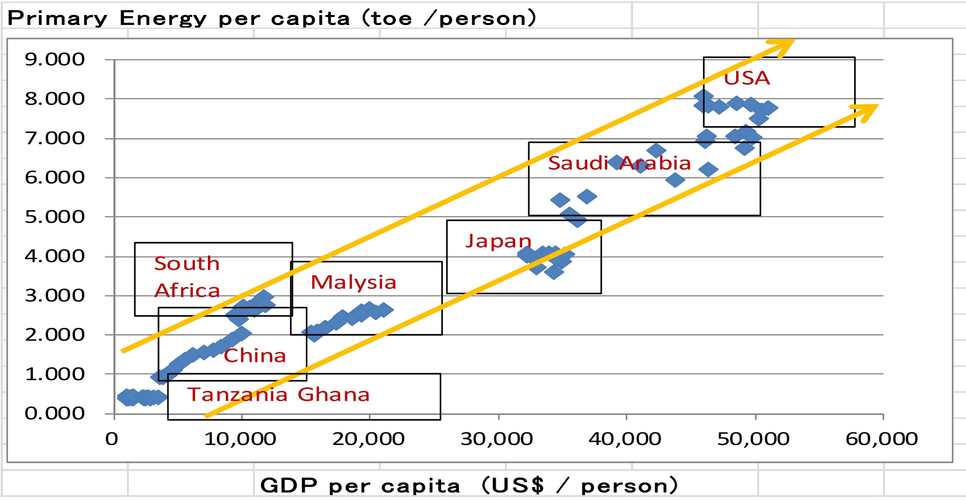


Figure 4.4-1 GDP per capita and primary energy consumption per capita

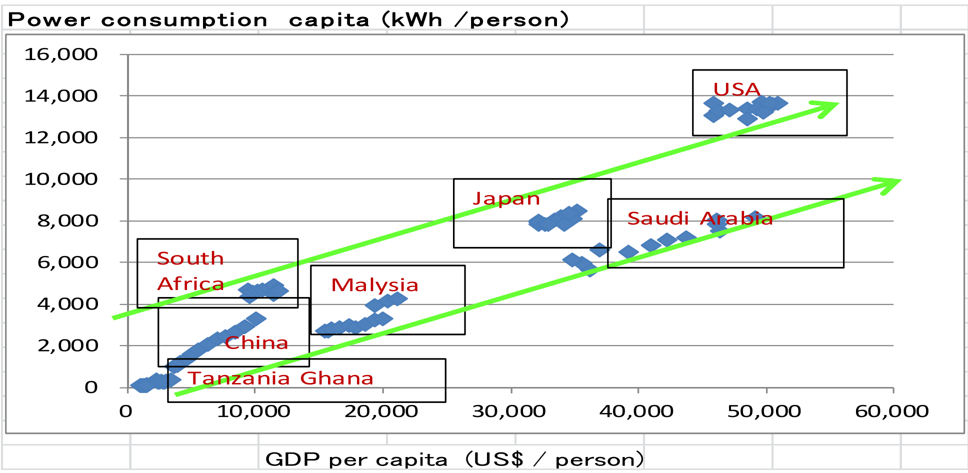


Figure 4.4-2 GDP per capita and power consumption per capita

When comparing between Japan and Tanzania in 2011, GDP per capita of Japan is around 22.2 times to Tanzania, and primary energy consumption per capita of Japan is 8.3 times to Tanzania and power consumption per capita of Japan is 66.6 times to Tanzania.

When comparing between Ghana and Tanzania, GDP per capita of Ghana is 2 times to Tanzania, and primary energy consumption per capita of Ghana is 1.0 times to Tanzania (it means the same level) and power consumption per capita of Ghana is 2.9 times to Tanzania. By considering the above comparison, it can be said that energy consumption of Tanzania is lower position. As one of the reasons, it is pointed out that Tanzania has a comfortable climate and not cold weather over a year.

It is predicted that the future primary energy consumption per capita will be increased inside area bounded by the yellow lines in the Figure 4.4-1 in company with increasing GDP per capita. And the future power consumption per capita also will be increased inside area bounded by the green lines in the Figure 4.4-2 in company with increasing GDP per capita.

Chapter 5 Energy Resources for Power Generation

5.1 Overview of Energy Supply

In the east African region, no significant activities have been observed in fossil energy development until recently. The situation is same for Tanzania, where small amounts of coal, 100,000 tons per year, and natural gas, 33 billion cubic feet (Bcf) or 820,000 tons in oil equivalent (toe), are produced locally and mostly used for power generation.[1] Crude oil is not produced locally. After the Tiper Refinery, a small refinery of 875 kt per year or 18 kbpd located in Dar es Salaam, was shut down in 1999, all petroleum products are imported for domestic supply.

In recent years, however, brighter prospects are emerging on development of coal and natural gas resources as shown in Table 5.1-1 and Figure 5.1-1.

Table 5.1-1 Energy Production/Consumption and Power Generation

		1980	1990	2000	2010	2012	2014
		ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Coal	Production	1	2	49	0	49	152
Natural Gas	Production	0	0	0	643	812	761
Oil	Import	718	668	765	1,549	2,594	2,659
Biomass	Production	7,237	8,928	12,458	18,232	19,567	21,033
Hydro	Production	59	133	184	232	152	223
Total		8,015	9,733	13,462	20,662	23,181	24,834
Non-Biomass		778	803	998	2,424	3,607	3,795
(Import)		718	668	765	1,549	2,594	2,659
(Import Ratio)		92.3%	83.2%	76.7%	63.9%	71.9%	70.1%
Biomass Ratio		90.3%	91.7%	92.5%	88.2%	84.4%	84.7%
Power Generation	TWh	0.79	1.63	2.47	5.27	5.59	6.22

Source: IEA "World Energy Balances of Non-OECD Countries - 2016"

Note: Natural gas production started to increase in the summer of 2015 when the new pipeline was put in operation.

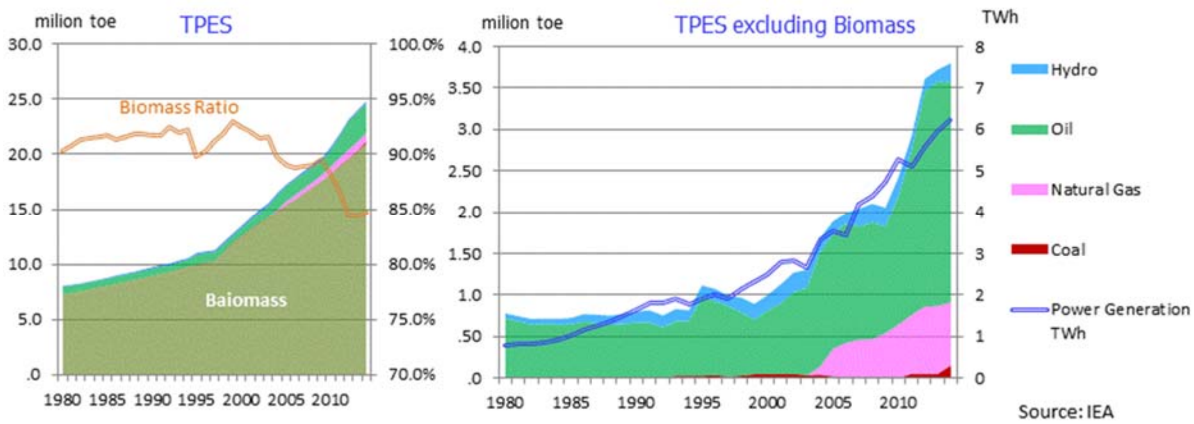


Figure 5.1-1 Energy Production/Consumption and Power Generation

The Songo Songo gas field located 200km south of Dar es Salaam was discovered in 1974, which extends onshore and shallow offshore of the Songo Song Island. Because of the tiny size, its development had been withheld for decades. Only in 2001, the World Bank decided to support

[1] These are actuals according to statistics of the IEA, USEIA, etc. Consumption of natural gas and coal is increasing recently. However, Tanzania's energy consumption still remains at a very low level similarly with other sub-Saharan countries.

development of the Songo Songo gas field and related gas utilization facilities. In 2004, the gas field and the gas system were completed to supply fuel for power generation and industrial use in the Dar es Salaam district. Following this, the Mnazi Bay gas field, located further south, was also developed and started gas supply in 2007 for a local small power station with a generation capacity of 18MW in Mtwara city.

Then, construction of a new gas pipeline, 36" x 534km from the Mnazi Bay gas field to Dar es Salaam with a transport capacity of 784 MMcfd, was commenced in summer of 2012 and completed in July 2015 to increase the country's natural gas supply capacity significantly from these onshore and shallow water gas fields. A new branch line from the Songo Songo gas field was also constructed for connection to the new trunk line. In order to fill up the new pipeline, oil companies are conducting well workover and drilling new production wells; the Songo Songo targets to increase production to 190MMcfd, North Kilwa 20 MMcfd and the Mnazi Bay to 210MMcfd. In line with this project, the new gas thermal power plants Kinyerezi-1 (150MW) started test operation in July 2015 and commercial operation by fall. In addition, construction of the Kinyerezi-2 (240MW) gas to power plant by a Japanese party has also started in the first quarter of 2016.

In addition to the above near shore gas fields, the Ministry of Energy and Minerals disclosed a news in February 2016 that a discovery of about 2.17 Tcf natural gas has been made in the Ruvu Basin block in Coastal Region. The gas field is located about 50km west of Dar es Salaam. Being an onshore gas field relatively easy to develop and because of its proximity to the demand center, the Ruvu basin discovery will join the natural gas supply line-up within a short period of time.

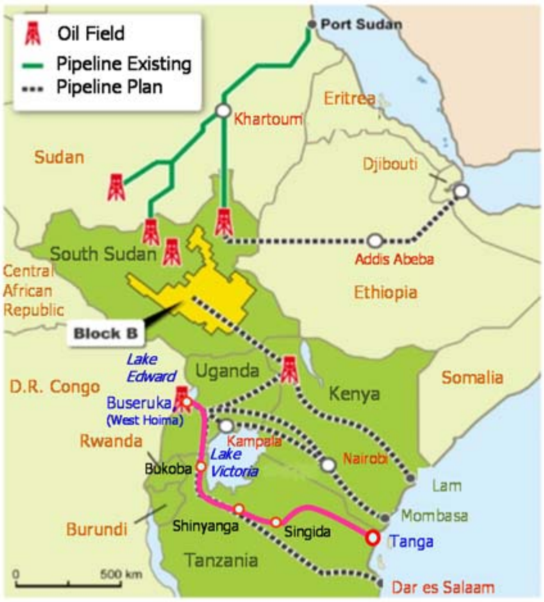
In addition, huge gas fields have been discovered in 2010 and onward in the offshore deepwater blocks (water depth ranges 1,150-2,500m) and are expected to become important future supply sources. They are located in the north of the gigantic discoveries made in series in the deepwater of Mozambique (their recoverable reserves are said to far exceed 100 Tcf). Significant discoveries followed in 2012 and 2013 in Tanzania and the gas-in-place at 50% probability (P90+P50) for the deepwater discoveries is estimated to be 47 Tcf at the end of December 2016. Gas recovery ratio from the sandstone reservoirs is estimated to be around 75-80%. Active exploration and appraisal programs are in progress and the reserves are expected to further increase.

These are by far the largest gas fields compared with the existing shallow water ones. However, as they are located in the extremely deepwater, many serious tasks have to be sorted out to clear high technical and economic hurdles to develop them. The development cost of these deepwater gas fields is estimated to amount to US$ 20–50 billion. In order to secure the sufficient revenue to justify such huge investment, materialization of an LNG project will be the key that could provide a large anchor demand backed by the global market. In the past examples in developing countries where domestic gas markets were yet in incubation stage, it was not possible to develop a large size gas field with small size domestic demands such as gas industries like fertilizer production, gas thermal power, nor industrial/commercial utilization. Once such deepwater gas fields were developed, maybe around 2025-2030, a significant quantity of gas-thermal power generation will become possible, for example, 10,000MW as a preliminary indicative capacity. Materializing such plans, however, it is necessary to 1) assure lifting of sufficient quantity of natural gas at an appropriate gas price that would allow development of gas field and construction of gas pipeline, 2) secure sufficient funds, technology and workforce in the backdrop, and 3) implement systematic development of the national power system and gas industries.

A small quantity of coal, annual 100,000 tons, used to be produced in far interior regions in southwestern Tanzania near Lake Nyasa (Lake Malawi), and is consumed locally or exported to Malawi. Since 2011 coal production at the Ngaka coal mine in the region has been developing and delivered to nationwide industrial users like cement producers. In 2015, coal production in Tanzania exceeded 250,000 tons and is further increasing. In this region several plans are also underway to develop interior coal mines for mine mouth power generation. In addition, several exploration licenses have been awarded for new ventures following the fast developing projects but they are still in the stage of studying exploration plans. The aggregate power generation capacity in the immediate development plans is 1,200MW, scheduled to start around 2019. However, several hurdles must be cleared before the final investment decision, such as construction of transmission lines extending for 250kms (between Ngaka and Makambako) or even finding financial and technical partners to develop projects. They are yet to announce the Final Investment Decision and some of them may need a longer lead time.

Presently, the proved recoverable reserves of coal in Tanzania is estimated to be above 800 million tons, with 700 million tons for the National Development Corporation (NDC), 85 million tons for the State Mining Corporation (STAMICO) and other miscellaneous deposits; some are suitable for open-cut mining. NDC says their estimated coal resources amount to 1,200 million tons recoverable. Both companies are optimistic about the resource explaining that coal reserves may be increased further if additional exploration were conducted. In the long run, therefore, a significant quantity of coal-thermal power generation may become possible. It should be noted that coal is of low quality with heat value of around 4,000kcal/kg and this would become constraints to efficient coal power development.

In addition, to materialize a large scale coal development exceeding the existing plans, a comprehensive coal development plan needs to be established including simultaneous construction of high voltage transmission lines or new railways extending over 600kms to the demand center located in coastal areas, new coal export/import port(s) and related infrastructure. Then, if domestic coal reserves are worrisome for developing large coal thermal power plants, import of coal may be considered. However, compared with the benefit of developing mine mouth power generation combined with local coal mines, construction of power stations in the coastal region requires clearing several problems. They include heavier environmental burden at the densely populated sites in the coastal



Source: JOGMEC, IEEJ

Figure 5.1-2 Crude Oil Pipeline Plan

region, construction of transport infrastructure, and, in addition, severe competition with indigenous natural gas, and/or outflow of foreign currencies to import coal. Thus, these new coal power stations in the Coastal Region may be developed as back-up capacity, if needed, but would not come up earlier than 2020-2025 while their construction lead time is significantly longer than gas power stations. From these analyses, we assume 10,000MW as a preliminary indicative ceiling capacity for coal thermal including 5,000MW as mine mouth generation using domestic coal and, after 2025, additional 5,000MW as backup capacity by imported coal, both on generation capacity basis.

Oil is not found in Tanzania, while a series of oil discoveries have been made in recent years in the Great Rift Valley, in the west in Uganda and in the east in Kenya. Following this, oil exploration activities have been accelerated in interior Kenya. Construction of an international oil pipeline to export these oils is being studied including two routes through Kenya to Lamu or Mombasa, and one through Tanzania to Dar es Salaam. This pipeline is also considered for export of crude oil from South Sudan, which is presently suspended due to the regional conflict.

In April 2016, governments of Uganda and Tanzania announced that the oil pipeline would be constructed to Tanga in northern Tanzania along a route bypassing through the southern corridor of the Lake Victoria. This is reportedly due to the worsening security in the Great Rift-valley province in western Kenya that would threaten safe operation. The pipeline will extend for 1,410km with a capacity of 200,000 bpd and its construction cost is estimated at $4 billion. A French oil company Total, operator, will start construction in early 2017 for completion in 2020. Such development of interior oil fields and construction of pipelines may bring various favorable effects on the economy of Tanzania.

Other primary energies such as hydro, geothermal and renewable energies are mostly to be used for power generation. Therefore, these are being studied in the survey on new power sources.

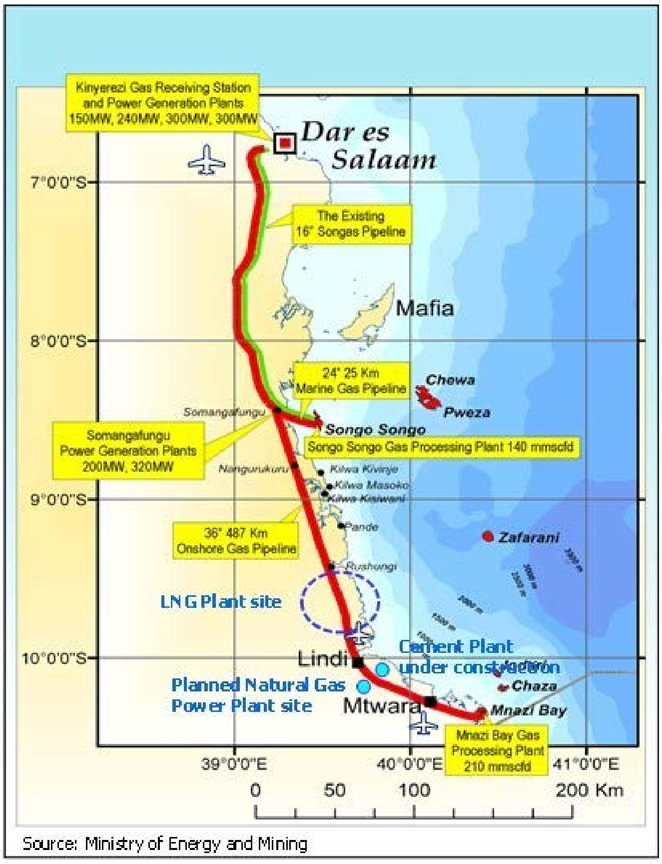


Figure 5.2-1 Pipeline and shallow Water Gas fields

5.2 Natural Gas

In view of the readiness of supply, gas fields in Tanzania may be divided into two groups, that is, shallow water gas fields already in production and the onshore discovery in Ruvu Basin made in 2015, and deepwater gas fields in the exploration and appraisal stage. Only shallow water and onshore fields can be considered for gas supply before 2025. In order to establish a development and utilization plan of the country's robust gas reserves, the government of Tanzania has undertaken compilation of the Natural Gas Utilization Master Plan (NGUMP: Natural Gas Utilization Master Plan). Its Draft-2 under review in early 2014 covers wide range of gas use possibilities mobilizing the consultant's rich knowledge and experience. However, it does not propose any practicable strategy or policy to utilize natural gas.

Thus, according to the request of the government of Tanzania, JICA implemented a study for the Natural Gas Utilization Master Plan (NGUMP) since December 2014. Its draft was finalized by September 2015, but the announcement was delayed to wait for the review by the new administration elected in 2015. The outline of the final draft of NGUMP was explained to stakeholders in October 2016, and the final full draft was uploaded at the website of the Ministry of Energy and Minerals (MEM) in February 2017, which strongly reflects political aspiration of the country.

At the same time, negotiation was started in September 2016 on the Host Government Agreement (HGA) to set out the framework of the LNG project between the Government and international oil companies (IOCs) engaged in the deepwater gas field development chaired by Professor Ntalikwa, Permanent Secretary of MEM. In addition to the PSAs that define conditions on exploration and production in the upstream, HGA will be a comprehensive agreement including the upstream and downstream which covers construction, operation and marketing of LNG. If necessary, amendment of the PSCs would also be discussed. According to participants, it may take one and a half year to be finalized.

Outlook of natural gas supply in Tanzania is explained below in accordance with the above NGUMP report by the JICA study team and observation on the recent development of gas exploration and development activities.

5.2.1 Shallow Water and Onshore Gas fields

The shallow water gas fields are mainly Songo Songo and Mnazi Bay. The discovery of an onshore gas field in the Ruvu basin made in 2015 may also be considered for early development. Other minor discoveries located along or near the gas pipeline may be put in production but they are not significant at present.

Source: Ministry of Energy and Mining

Figure 5.2.1-1 Songo Songo Gas Field

The Songo Songo gas field was discovered in 1974 by Agip (Africa) Ltd (presently ENI), but the Italian company gave up the gas field as not being commercially feasible. In 1995, the Tanzanian government opted for implementation of the Songo Songo gas-to-power project with the principal goal to provide reliable source of low cost electricity. The World Bank made the final decision to support the project in 2001, and the project was started by a consortium of various foreign/local joint ventures ranging from upstream through gas utilization. The gas field became on stream in June 2004. Production in 2013 was about 35 billion cubic feet (Bcf) or 96 million cubic feet per day (MMcfd).

The present reserve of gas initial in place (GIP) is 2.5 Tcf, of which recoverable reserve at a probability of 50% (P50) is estimated to be about 880Bcf including Songo Songo Main and Songo Songo North (SSN) at December 2016 according to TPDC. The main producer is upper cretaceous sand stone, and the average recovery factor is about 75-80%.

In line with the construction of the new gas pipeline from Mtwara to Dar es Salaam, a new branch line from Songo Songo was also constructed. There are 11 production wells at the Songo Songo main structure. The operator PanAfrican plans to workover corroded wells and add the 12th producing well to increase the gas production from the present 92MMcfd (early 2015) to 190MMcfd simultaneously with the start-up of the new pipeline. In addition, a new production capacity of 20MMcfd was constructed in the Kilwa North gas field located in the east of the Songo Songo Island operated by Ndovu Resources. It has started production at 15MMcfd upon completion of the new pipeline. As a production capacity of 190MMcfd is presently established at the Songo Songo field, this production rate is anticipated to start declining in 2020. With this anxiety, PanAfrican is planning to carry out evaluation of the Songo Songo North where gas has been confirmed already; running seismic survey and drilling an appraisal well. If SSN is put in production, gas production could be raised by 70MMcfd additionally. However, the production will again start to decline in 2026. Thus the operator wishes to appraise another nearby prospect[2] Songo Songo West (SSW). The recoverable reserve of SSW is estimated to be 0.45 Tcf.

The recoverable reserves of the Songo Songo cluster will double once the reserve of the SSW is confirmed, but PanAfrican warns a risk relating to a fault defining the prospect. An officer of the Tanzanian Petroleum Development Company Ltd (TPDC) explained that the combined gas reserve initial in place will increase to 3 Tcf, then. These numbers are yet to be checked further.

Table 5.2.1-1 Gas Reserves in Tanzania

Category	Gas fields	Proven Reserve	Provable Reserve
		P90	P50
		P1	P1+P2
Land/Shallow Water		Tcf	Tcf
	Songo Songo	0.88	2.5
	Mnazi-Bay	0.262	5
	Mkuranga		0.2
	Nyuni	0.045	0.07
	Ruvuma		0.178
	Ruvuma		2.17
	Sub-total		10.118
Deep Water	Block-2		25.4
	Block1,3&4		21.73
	Sub-total		47.13
Total			57.25

Source: TPDC

[2] In the oil and gas exploration a geological event identified via geological and geophysical study to have potential to yield oil and/or gas is called "lead", and a lead verified by further technical and economic study to be drillable are called a "prospect."

As above, the GIP of the Songo Songo cluster is estimated to be 3 Tcf, hopefully, and this will become more certain as appraisal of SSN and SSW progresses. Suppose that the recoverable reserve is its 80% or 2.4 Tcf, the Songo Songo cluster may be able to supply natural gas at an average rate of 120 Bcf per year for 20 years or for a 2,400 MW power generation.[3] PanAfrican expects that, by developing SSN, the gas production will be raised from the presently planned 190MMcfd, or 63 Bcf per year, by 70MMcfd. The total 260MMcfd (86 Bcf/year) production can run gas thermal plants at a rate of 1,700MW. Once adjacent prospects like SSW were confirmed, and a recoverable reserve of 2 Tcf is established, this production rate will be maintained for a longer period. Thus, we may assume that gas for power generation will be available at a rate maximum for 2,000 MW and, assuming that gas will be supplied to industrial and other users, on average at 1,000MW for the projection period of this Study.

The Mnazi Bay gas field was discovered in 1982 by Agip, and likewise with Songo Songo, it was relinquished as being not commercially viable. In 2002, Calgary-based Artumas Group proposed the Mtwara Gas-to-Power Project to the Tanzanian government. According to the proposed plan, the well Mnazi Bay 1 was re-entered[4] by Artumas in 2005 and flow tested. The consortium of Maurel & Prom Exploration Production Tanzania Ltd (M&P, operator, owned by Altus Group of France), Wentworth Resources Ltd (ex Artumas) and TPDC commissioned the project in 2007. Mnazi Bay used to supply a small quantity of natural gas (687 million cubic feet in 2013) for a tiny 18MW local power plant. As shown in figure 5.2.1-1, a new natural gas pipeline to transport the gas from Mnazi Bay to Dar es Salaam was completed in July 2015. Gas supply via the new pipeline started in August and presently running at 40MMcfd. Production from Mnazi Bay will eventually be increased to 210MMcfd (70Bcf per year).

[3] Here we apply a ballpark calculation that, from 1 Tcf of natural gas, one million tons of LNG will be produced annually for 20years. One million tons of LNG compares to an amount of LNG consumed for a year at a gas thermal power station with a capacity of 1,000MW (with generation efficiency of 50% and a capacity factor of 50%). At a most modern gas power station with a 60% generation efficiency, 800 kt of LNG will be sufficient to run a 1,000MW plant for a year.

[4] “Re-entry” means work on an old well to reuse it for testing, production or other purposes.

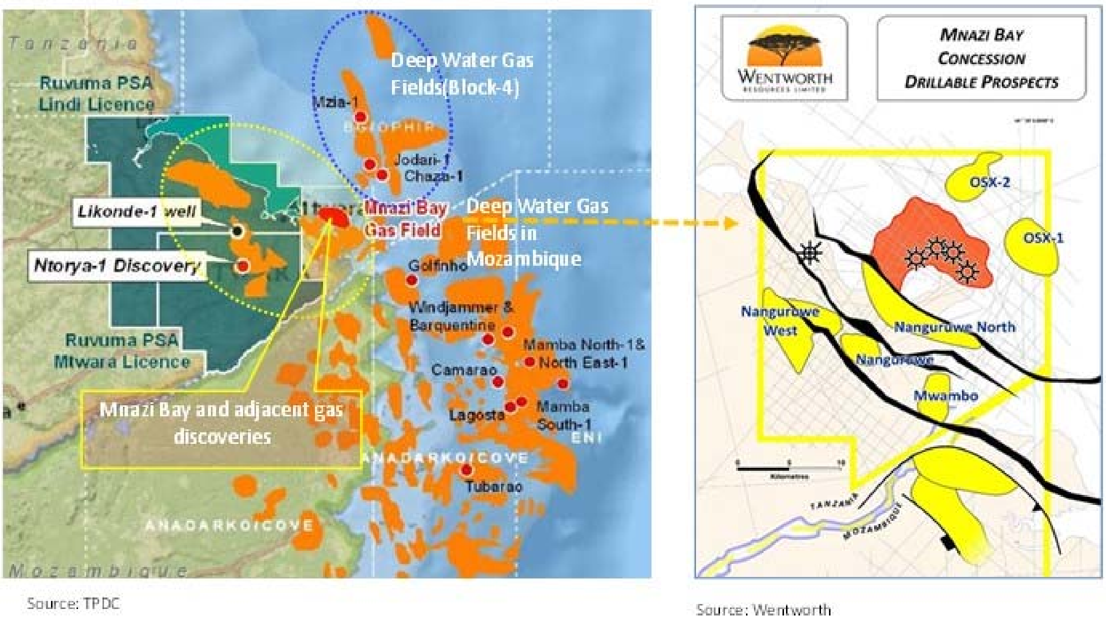


Figure 5.2.1-1 Mnazi Bay and adjacent gas fields

According to TPDC, the gas recoverable reserve of the Mnazi Bay at P50 is 820 Bcf. M&P explains that this number is for the structures under development to accommodate the requirement for the new pipeline completed in 2015. The company has conducted full seismic on four adjacent offshore and onshore prospects and has already decided drilling locations. M&P wishes to drill exploratory wells on these prospects once gas sale agreement is confirmed and assurance of price is established for the future additional production.

A bold estimation by TPDC indicates that the GIP of the Mnazi Bay cluster is 5Tcf at P10. Assuming a 75-80% recovery, this amounts to a 3.75- 4.0 Tcf recoverable reserve. Suppose a half of this quantity (2.0Tcf) is allocated for power, it will be able to run 2,000MW of gas-fired power generation for 20 years on fuel consumption basis or on capacity basis almost 3,000MW at a 65% load factor. Since big industrial gas users are yet to emerge in Tanzania, more natural gas can be made available for power generation in an early stage of the NGUMP before 2025.

In addition to the above shallow water gas fields, an onshore gas field was discovered in 2015 at the Mambokofi-1 well drilled in the Ruvu Basin block, about 50km west of Dar es Salaam, by UAE based Dodsal Hydrocarbons and Power. The discovered resource is reported to be 2.17Tcf. So far Dodsal has drilled three wells at Mambokofi, Mtini and Mbuyu in the block. While the Mtini-1 drilled near Bagamoyo was dry, Mbuyu-1 drilled near Kilosa 250km west of Dar es Salaam is reported as gas discovery: size of the resource is yet to be announced. The company is preparing for appraisal drilling on these discoveries. It said that “Exploration is still ongoing and we are optimistic of striking more natural gas reserves in the Ruvu Block”[5]

From the above observation, during the period up to 2025, natural gas from the shallow water fields will be available to run gas thermal power plants at least 3,000MW (or 150 Bcf per year or 450MMcfd

[5] http://www.naturalgasasia.com/more-natural-gas-discovered-in-tanzania-17794

of natural gas) on fuel consumption basis, and, if necessary and pending on the timing of the commissioning of the huge deepwater gas fields as explained below, even 5,000MW (250 Bcf per year or 750MMcfd of natural gas) may be possible. In addition, the Ruvu Basin discovery will possibly bring about natural gas at maximum 100 Bcf a year which can fuel 2,000MW gas power generation. Furthermore, emerging real demand for natural gas may stimulate gas exploration in adjacent prospects and leads, bringing more natural gas for quick development.

5.2.2 Deepwater Gas fields

Substantial gas discoveries made in the Ruvuma basin deepwater blocks of Mozambique has stimulated exploration in the Tanzanian deepwater. In 2010, BG/Ophir group made a significant gas discovery at the Pweza-1 well drilled in Block-4 in 1,400m deepwater. Following this, 5 wells have been drilled by the end of 2013. Out of 27 wildcat wells drilled in the deepwater to date, 20 wells were gas discoveries.

According to Tanzanian Petroleum Development Company (TPDC), the estimated gas initial in-place at "P90+P50" at December 2016 was 47Tcf. This number has significantly increased from 37.5 Tcf at June 2013 with active exploration and delineation, and expected to grow further. The Natural Gas Utilization Master Plan (NGUMP) Draft-2 stipulates that the ultimate gas resources in the Tanzanian deepwater may far exceed 100Tcf. The present estimate may compare to that of an LNG giant Malaysia; 41.3 Tcf proven recoverable reserve at the end of 2015 according to the BP statistics.[6] With these huge discoveries, it will be possible to implement gigantic gas projects; thus the government of Tanzania has drafted the NGUMP and announced it in February 2017.

Table 5.2.2-1 Deepwater Wells since 2010

	Well	Block	Company	Drilled	TD(m)	WD	Result
1	Pweza-1	4	Ophir	2010	4,082	1,400	Gas
2	Chewa-1	4	Ophir	2010	3,076	1,315	Gas
3	Chaza-1	1	Ophir	2011	4,600		Gas
4	Zeta-1	5	Petrobras	2011	4,832		Dry
5	Zafarani-1	2	Statoil/ExM	2012	5,150	2,500	Gas
6	Jodari-1	1	BG/Ophir	2012	4,490	1,153	Gas
7	Mzia-1	1	BG/Ophir	2012	4,860	1,639	Gas
8	Lavani-1	2	Statoil/ExM	2012	3,850	2,360	Gas
9	Papa-1	3	BG/Ophir	2012	5,575	2,186	Gas
10	Lavani-2	2	Statoil/ExM	2012	5,270		Gas
11	Zafarani-2	2	Statoil/ExM	2012	3,039		Gas
12	Jodari-S	1	BG/Ophir	2012	3,441		Gas
13	Jodari-N	1	BG/Ophir	2012	3,389		Gas
14	Pweza-2	4	Ophir	2013	3,159		Gas
15	Pweza-3	4	Ophir	2013	3,153		Gas
16	Mzia-2	2	Statoil/ExM	2013	4,341		Gas
17	Tangawini	2	Statoil/ExM	2013	3,030	2,300	Gas
18	Mzia-3	2	Statoil/ExM	2013	4,803		Gas
19	Ngishi-1	4	BG/Ophir	2013	4,640	1,301	Gas
20	Mkizi-1	1	BG/Ophir	2013	3,860	1,300	Gas
21	Mronge-1	2	Statoil/ExM	2013	6,110	2,511	Gas
22	Mlinzi	7	Dominion	2013	5,782		Dry
23	Zafarani-3	2	Statoil/ExM	2014	4,695		Gas
24	Taacui-1 ST1	1	BG/Ophir	2014	4,215		Gas
25	Piri-1	2	Statoil/ExM	2014	5,695		Gas
26	Kamba-1	4	BG/Ophir	2014	3,971	1,379	Gas
27	Binzari-1	2	Statoil/ExM	2014	5,580		Gas
28	Giligillani-U1	2	Statoil/ExM	2014	3,300		Gas
29	Tende-1	2	Ophir/E Pande	2014	4,153		Dry
30	Mkuki-1	7	Dominion	2014	3,229		Dry
31	Kungumanga-1	2	Statoil/ExM	2014	5,653		Dry
32	Piri-2	2	Statoil/ExM	2014	5,196		Gas
33	Mdalasini-1	2	Statoil/ExM	2015	5,556	2,296	Gas
34	Tangawizi-2	2	Statoil/ExM	2015	na		na
35	Kitange-1	1	Shell/Ophir	2016			Dry
36	Bunju-1	4	Shell/Ophir	2016			Dry

Source: TPDC, oil compnanies press release, etc.
Note: Blue colored wells are dry wells and yellow colored wells are appraisal wells.

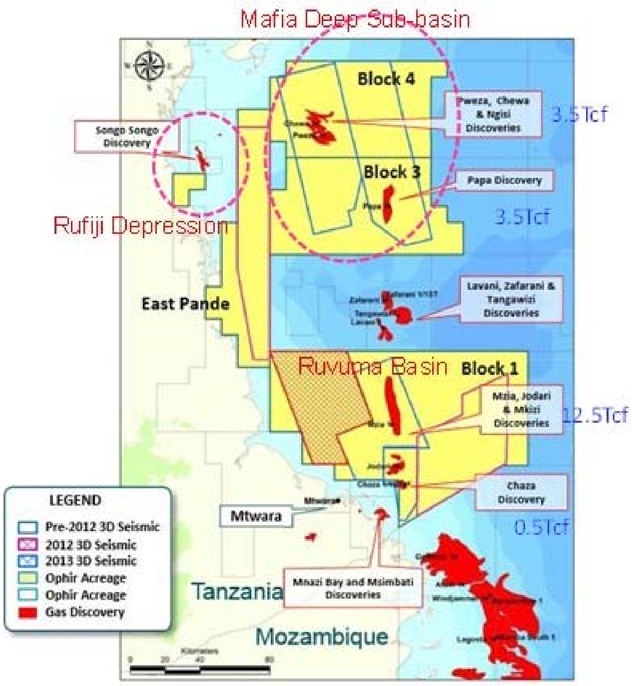


Figure 5.2.2-1 Deepwater Gas Discoveries

6 BP Statistical Review of World Energy 2015, June 2016

The NGUMP develops a plan to start full utilization of the deepwater gas discoveries, establishing an LNG project, several fertilizer and petrochemical projects and others. It proposes to start smaller sized projects such as fertilizer around 2020 as front runner projects with gases from shallow water gas fields which are easier to develop. Bigger projects such as LNG utilizing the deepwater fields are planned to start around 2025.

The key issue is that the deepwater gas development would be considerably expensive compared with shallow water gas fields.[7] Because of the gigantic volume of production, their unit production cost of natural gas may be comparable with that of the shallow water gases. However, a huge amount of capital must be mobilized for the initial investment to construct and commission such gas fields. This will in turn requires securing a huge amount of stable anchor demand for natural gas that brings firm revenue. At the same time, to implement domestic projects to use natural gas in a significant quantity, it is also necessary to secure funds for investment and foreign currency revenue to finance import of plants and related materials; on top of market for their products, necessary technology, site for plant, work force, supporting services, etc.

Justifying the huge upfront investment for deepwater field development, a sizable gas demand must be secured. This would be possible only with an LNG project, while it would be difficult to secure the required cash flow with smaller projects. If a stable flow of sufficiently large revenue is not foreseen, investment decision on a huge amount would be difficult. Consequently, development of the deepwater gas fields hinges on how and when an LNG project could be materialized.

The Government of Tanzania started negotiation on the Host Government Agreement (HGA) for developing LNG with two groups of IOCs, namely, Shell (former BG)/Ophir consortium and Statoil/ExxonMobil consortium. They intend to complete the HGA negotiation in one and a half year and to proceed with pre-FEED and FEED, which require 2-3 years, toward the Final Investment Decision (FID). However, the present world economy looks not very optimistic. In the global market, the LNG supply/demand balance is getting looser as Japan is recovering from the Fukushima Daiichi nuclear accident. Additional LNG supply is emerging with new LNG projects in the US based on shale gas. To materialize the project as envisaged in 2025, stakeholders are required to undertake full-powered efforts through close collaboration. In 2015 autumn, the Tanzanian government decided the site for gas plants including LNG near Lindi in a southern province of the country.

5.2.3 Outlook of Natural Gas Supply

The question how and when Tanzania would be able to use natural gas in a large scale in the long run hinges on feasibility of deepwater gas fields where huge amount of reserves have been discovered. However, present gas consumption level is low and the gas reserves identified at shallow water and onshore gas fields will be sufficient to supply demand for the time being even if there would occur strong demand surge. Based on such analysis, the NGUMP projects a scope of gas consumption as shown in Figure 5.2.3-1, where smaller sized project such as fertilizer will be implemented earlier as front runner projects using gases from shallow water gas fields and bigger projects such as LNG using

[7] Statoil estimates that development of the Block-2 gas fields may require $20-30billion.

deepwater gas fields will start around 2025.

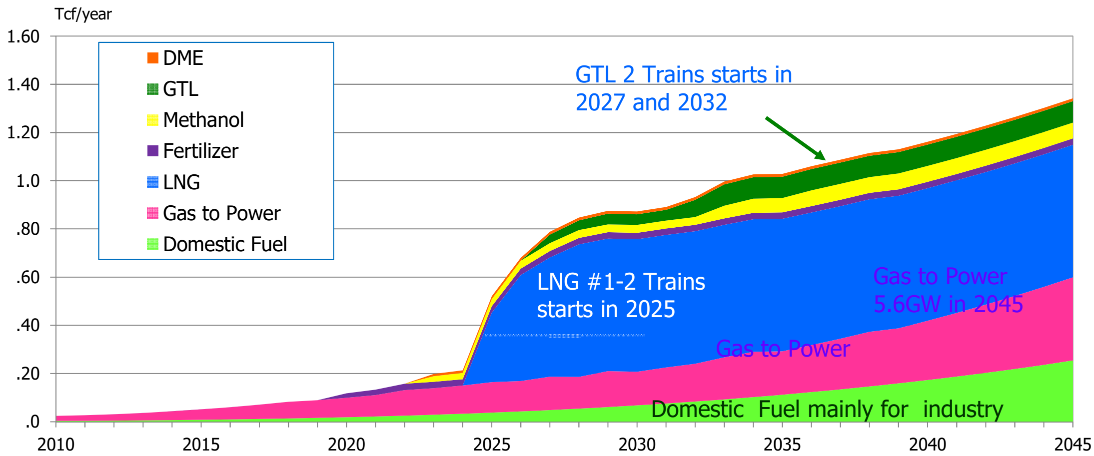


Figure 5.2.3-1 Prospect of Natural Gas Consumption: NGUMP

According to the above projection, the cumulative gas consumption prior to 2025 will be 1.2Tcf, as shown in Table 5.2.3-1, by the time the LNG project and hence deepwater gas fields come on stream. Major consumer will be gas thermal power generation. Even if the consumption by gas power plants triples, supply from the 10 Tcf gas discoveries reported to date will be sufficient.

Table 5.2.3-1 Prospect of Natural Gas Consumption: NGUMP

	Dom. Fuel	Gas to Power	LNG	Fertilizer	Methanol	GTL	DME	MTG	Total
	Bcf	Bcf	Bcf	Bcf	Bcf	Bcf	Bcf	Bcf	Bcf
2010	4	21	0	0	0	0	0	0	25
2020	18	81	0	18	0	0	0	0	118
2030	68	140	550	26	33	44	12	20	893
2040	172	247	550	26	66	88	12	20	1,182
Cummulative Consumption									
2015->24	185	800	0	120	50	0	20	35	1,209
2015->35	963	2,460	5,622	411	482	544	151	259	10,891
2015->45	2,795	5,088	11,120	675	1,142	1,428	270	463	22,981
	%	%	%	%	%	%	%	%	%
2015->24	15.3	66.2	0.0	9.9	4.1	0.0	1.7	2.9	100.0
2015->35	8.8	22.6	51.6	3.8	4.4	5.0	1.4	2.4	100.0
2015->45	12.2	22.1	48.4	2.9	5.0	6.2	1.2	2.0	100.0

Thus, the JICA report on the NGUMP study has recommended following strategies:

1) The NGUMP should be formulated considering the LNG project as its central pillar, which will justify a huge amount of investment for deepwater gas field development.
2) Smaller gas projects such as fertilizer and methanol may be developed as front runner utilizing the natural gas from the shallow water fields.
3) Sophisticated projects with higher technical and financial requirement such as Gas-to-Liquid may be decided once the prospect of the LNG project is well established.

The two LNG train case is illustrated above, the Study also recommends to consider expansion of LNG plants to four trains since the gas resources discovered to date significantly exceed the above projected requirement.

On the supply side, it assumes the gas field development and supply profile as shown in Figure 5.2.3-2. Firstly, with regard to shallow water gas field production, under the scenario set out as above that the deepwater gas fields will be developed upon confirmation of an LNG project, it will be possible to expect additional gas supply from them for domestic market. Then, it would also allow moving forward use of the shallow water gas. As the reserves of shallow water fields are increasing recently, natural gas from them looks to be sufficient to supply for at least 3,000MW or 150 Bcf per year or 450MMcfd for the immediate period up to 2025. Since gas thermal plants will be built step by step, gas consumption in the first half of the next decade would be slower, perhaps a half of this. In turn, the gas supply level in the second half may be increased, if necessary, even to 5,000MW or 250 Bcf per year or 750MMcfd with shallow water gas fields.

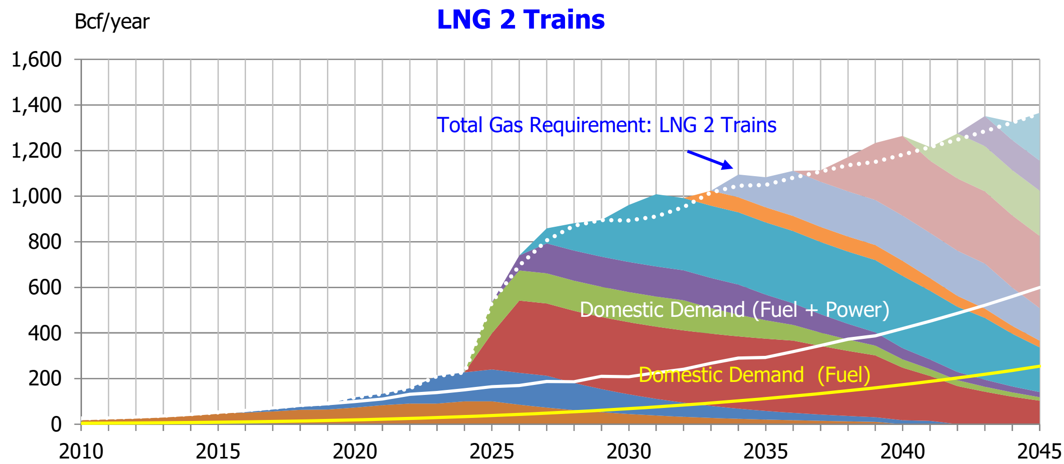


Figure 5.2.3-2 Natural Gas Production Profile for LNG 2 train Case

In addition, the Ruvu Basin discovery may bring about additional gas as much as 50-100 Bcf per year or 130-260MMcfd, which can fuel 1,000-2,000MW gas power generation. Present capacities of natural gas processing plants and pipelines are as shown in Table 5.2.3-2. To supply natural gas for incremental power generation, these capacities may need to be further expanded in a timely manner.

Table 5.2.3-2 Natural Gas Processing Facility and Pipeline (2016)

Gas Processing Plant		Capacity
		MMcfd
Old	Songo Songo	110
	Mnazi Bay	10
New	Songo Songo	140
	Madimba (Mtwara)	210
Total		470

Gas Pipeline	Distance	Capacity
	km	MMcfd
Songo Songo to Dar es Salaam	232	105
Mnazi Bay to Mtwara	27	70
NNIGP (Madimba to Dar es Salaam)*	534	784

(Note) National Natural Gas Infrastructure Project

(Source) TPDC

On the other hand, deepwater gas could not be expected before 2025 even if investment decision is made soonest possible. General expectation may be as follows. Appraisal of reserves may take several years before that will provide the third party certificate of gas reserves essential for a huge capital loan and/or long term sale of LNG; only then, the final investment decision can be made. Two years may be necessary to complete the FEED and EPC tender for development of gas fields and construction of an LNG plant, and construction to follow may need 4-5 years. Other anticipated issues would include preparation of infrastructure necessary for conduct of large scale construction, supply of industrial water, etc.

In this context, a realistic scenario conceivable at this moment may be as follows;

1) Natural gas in the next decade may be supplied only from the shallow water and onshore gas fields. The available quantity for power generation will be at a rate sufficient for 3,000MW power generation (consumption basis) or 150Bcf per year or 450MMcfd, and it could be increased up to a rate for 6,000MW or 300 Bcf per year or 900MMcfd assuming that deepwater gas will become available around 2025-2030 offsetting depletion of shallow water gas after peaking.

2) Once the deepwater gas fields are commissioned, natural gas supply for power generation will be increased, if necessary, to the amount to accommodate 10,000 MW or more power production, which compares to 500Bcf per year or 1,500MMcfd of natural gas.

It should be noted, however, that several conditions must be fulfilled such as listed below for materialization of this scenario;

1) In order to secure a stable anchor demand to justify huge investment for gas field development, an LNG project must be confirmed as soon as possible. To this end, the Framework Agreement should be first concluded with oil companies holding the mining right, which sets out the structure and formation to implement the LNG project. To this end, the HGA negotiation has been kicked-off in September 2016. The hardest threshold for such decision is to secure customers, which in turn

requires to set out lifting structure of LNG and/or making serious determination to offer competitive price in the present soft international market.

2) With regard to natural gas sales in the domestic market, an appropriate gas price must be offered that will provide sufficient incentive for upstream investment. While the portion of produced natural gas classified as TPDC's take and domestic supply obligation of IOCs will be allocated for the domestic market, it is necessary to set out fair and appropriate trading and pricing rules for such natural gas. Demonstration of healthy financial status of the domestic demand would also support investment decision making, in view of concerns on arrears incurred by TANESCO in its payment for fuel gas.

3) Performance should be guaranteed that domestic gas projects are bankable and will be definitely implemented as scheduled. To demonstrate this, selection and finalization of investors, site acquisition, preparation of infrastructure, and so on should be progressed in due course.

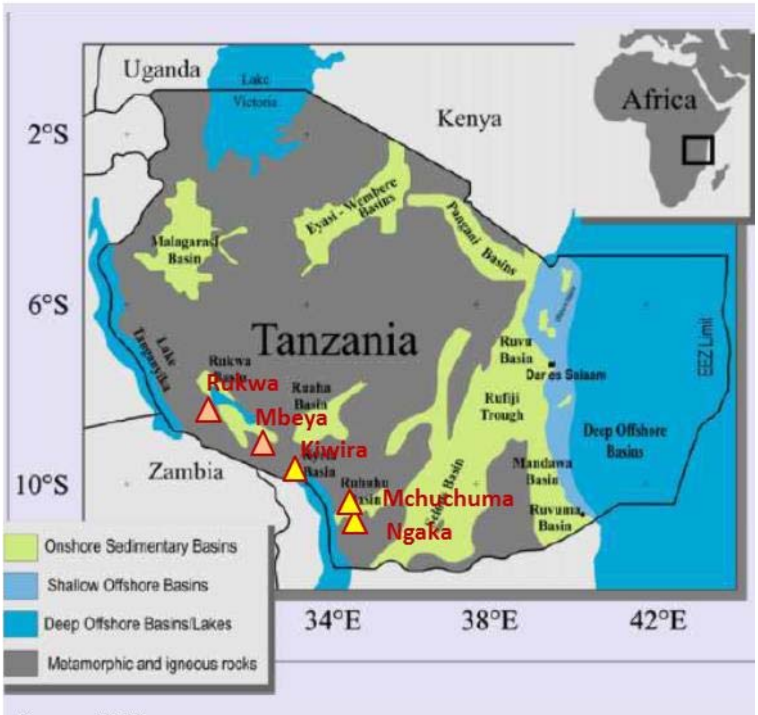
4) Laws and institutions, organizations and adequate staff at relevant offices must be prepared to accommodate administrative procedure to implement these projects.

It is particularly important that various projects from upstream through downstream should be implemented coherently in good harmony. To this end, it is necessary to formulate the natural gas utilization plan as an integrated plan, with time axis and confirmation on individual projects, and implement it as set out under the roadmap.

5.3 Coal

Coal production in Tanzania used to be quite tiny; 105,800 tons of coal was produced in 2012[8] and delivered to local market, such as cement plants, mini steel mills and coal pellets[9] producers, or exported to Malawi. However, the Ngaka coal mine project started in 2011 has increased production steadily to reach a production capacity of around 30,000 tons per month in 2016; coal is delivered to nationwide destinations by truck. Main coal deposits are located in the interior area where no substantial infrastructure such as railway or power transmission lines is presently available. The coal resources in Tanzania identified to date is about one billion tons as shown in Table 5.2.3-2, which could be increased further once demand growth becomes firm. Coal is of low quality with a heat value of around 4,000kcal/kg.

In the Power System Master Plan (PSMP) 2012 Update, construction of 3,800MW coal-thermal plants using domestic coal is scheduled for completion by 2020; some of them are mine mouth plants and other unidentified plants may be supplied coal via railway or trucks, or run with imported coal. At present, however, a realistic construction plans are much smaller. National Development Corporation (NDC) is planning development of three coal mines, while State Mining Corporation (STAMICO) plans to develop Kiwira coal mine as explained below. Some more coal mining licenses have been issued to develop other coal deposits in the interior regions. Among them, Kibo Mining Plc (registered in Dublin) announced a plan to implement mine-mouth coal to power project at Mbeya in the interior province.[10] Edenville Energy Plc (registered in London) has also disclosed on its website a coal to power plan at Rukwa coal mine located west of Lake Rukwa.[11] Both companies are reportedly conducting feasibility study, but they are yet to make material progress on the PPA (Power Purchase Agreement) negotiations. No obvious development is seen on these mine-mouth power generation projects by the end of December 2016. About three years are necessary for construction of power plants and transmission lines; they may start production at earliest in 2019.



Source: MEM

Figure 5.3-1 Coal Deposits in Tanzania

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[8] USEIA, International Energy Statistics, drawn down from the website in February 2016.

[9] Coal pellets are used by households and other minor users for cooking and heating.

[10] http://kibomining.com/projects/mbeya-coal/

[11] http://www.edenville-energy.com/

Table 5.3-1 Coal Reserves in Tanzania and Production/Consumption Plan

		National Development Corporation(NDC)			STAMICO	Others
Coal Mine	Unit	Mchuchuma	Katewaka	Ngaka	Kiwira - Ngoro - Kabulo - Maturi	- Mbeya - Rukwa
Reserves	Million Tons	370	81.65	251	85	M:109 R:58
Production plan	Million Tons / Year	3	0.34	3	1.5	N/A
(for Generation)	Million Tons / Year	1.5	(For iron making)	-1.0	-1.0	N/A
(for Industry)	Million Tons / Year	1.5		-2.0	-0.5	N/A
Power development	Megawatt	600(150×4)	-	400(200×2)	400	*1:300 *2:600

Source:NDC, STAMICO and various web information.

NDC plans to develop Ngaka, Ketewaka and Mchuchuma deposits located near the Lake Nyasa, about 1,000km southwest of Dar es Salaam. Ngaka under a joint venture with an Australian company[12] has developed its production capacity to 300,000 a year. It has a plan to expand production to 3 million tons a year for mine mouth coal thermal plants of 200MW x 2 after startup of the Mchuchuma project as explained below.

Mchuchuma under a joint venture with Chinese Sichuan Hongda is scheduled to start production in June 2019, produce 3.0 million tons a year, and allocate a half of the production for mine mouth coal thermal plants of 150MW x 4.[13] Ketewaka is planned to start at similar timing but is to be dedicated to supply only for a local steel mill to produce 340,000 tons of sponge iron. As NDC had been negotiating with TANESCO on electricity sale and construction of the transmission line, it has changed its policy in early 2015 that the Mchuchuma project will construct the 400kV x 200km transmission line to Makambako, and has conducted a feasibility study in 2015 together with its Chinese project partner. Another 50km transmission line is necessary from Ngaka to vitalize the Ngaka project. NDC has also adopted a plan to divert 240MW of the Mchuchuma power production to process the sponge iron produced under their Ketewaka project and sell the rest of the produced power to TANESCO. Exploration of these coal deposits has been completed and NDC has been given approval of the mining plans from the government authority.

As above, NDC changed its policy in the summer of 2015 to construct a 200km transmission line since no confirmation is readily available from TANESCO. However, through the follow-up negotiation, it has been agreed that the government will construct the transmission line connecting the power station and Makambako and TANESCO will operate it. Though TANESCO is locked-in due to the arrear issue and could not move proactively for investment, the mine mouth power plant project started to move toward materialization; the joint venture agreement was signed in September 2015. However, the Government of Tanzania suspended the project claiming that too much incentives are given to the project; it stands still in early 2017.

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[12] Tancoal Energy Limited (Tancoal), 70% owned by Australian Intra Energy Corporation and 30% by the National Development Corporation (NDC) of Tanzania.

[13] Sichuan Hongda Group holds an 80% while NDC holds 20%. Sichuan Hongda also invest in an integrated iron ore mine and steel mill project. The total investment by the company will be up to $ 3 billion.

These coal deposits are distant from the existing railway and located in a harsh terrain. Trucking coal to nearby railway would be difficult; rather, NDC prefers a plan to construct a branch rail line once a certain demand is confirmed. It is reported that NDC is in negotiation with TANESCO for PPA, while the final agreement is being delayed in particular relating to the electricity lifting price. NDC is simultaneously progressing negotiation on relocation of local residents. NDC plans to begin site construction as soon as payment of compensation is completed.

Figure 5.3-2 Mine-mouth Power Plant and Power Transmission Plans

Present proven reserve of coal is 370 million tons for Mchuchuma, 251 million tons for Ngaka and 81.65 million tons for Ketewaka. NDC also estimates that a possible amount of coal resources in the licensed area will be 1,200 million tons. Suppose that the proven reserves of Mchuchuma and Ngaka, in total 621 million tons, will be produced for 40 years, an average annual production will be 15 million tons. If a half of this amount, or 7.5 million tons, is allocated for power generation, coal thermal power generation may reach 2,200MW, which may correspond to 2,930MW of generation capacity assuming a 75% load factor. NDC says that, if more coal is required, the company is able to divert coal from Ketewaka and further increase production out of its estimated coal resources of 1,200 million tons identified in adjacent areas. Thus, if we assume an annual 20 million tons coal production in the NDC permits in the long run, it would enable a maximum 4,000MW (or 6,000MW on capacity basis) mine-mouth power generation.

STAMICO plans to develop Kiwira coal deposit located near the north shore of the Lake Nyasa for mine mouth coal thermal plants. The company plans to commission 200MW x 1 plant in 2019 and, if sufficient demand is foreseen, will construct another 200MW plant later. STAMICO also plans to expand its generation capacity to 800MW in future.

The company was in the process of selecting its project partner and evaluating tenders closed at the end of February 2015. However, there was no qualified bidder. STAMICO cancelled the tender and solicited rebidding in July 2016. Finalizing the partner, STAMICO plans to revise FS and EIA and begin construction of the coal mine, power plant and transmission line in the second quarter of 2017, and start power production in 2020. However, no material progress is seen in this project yet.

STAMICO has two coal mines in its license area, namely Kiwira and Kabulo, and their proven reserve is 35 million tons and 50 million tons, respectively. The company estimates that 100 million tons of coal may be found additionally in the adjacent area. It plans to produce 1.5 million tons a year on raw coal basis, and allocate 1.0 million tons for power generation and 0.5 million tons for other local use. The coal quality is problematic, and should be water washed; after washing, 1.0 million tons of raw coal will be reduced to 320,000 tons, which will just suffice the requirement for a 200MW power plant, according to the company. The Kiwira coal mine is located about 100km from the existing railway and just 4km from the trunk road connecting Tanzania and Malawi. There is a 33kV transmission line connecting to the national grid, and STAMICO wishes to upgrade it to 400kV for the new power plant (the company has revised the original proposal of a 220kV line). Most of the power produced will be consumed in the local market. Although present infrastructure is not sufficient, transmission system and truck transport[14] may be upgraded relatively fast. However, the 200MW x 2 plant plan may be the maximum capacity expected from the STAMICO's license area. STAMICO conceives that, once the immediate model project is verified to be successful, the company will purchase adjacent coal resources and roll out similar projects.

In addition to the above parastatal projects, there are two more projects being promoted by private capitals.

Kibo Mining Plc (registered in Dublin) has announced a plan to implement Mbeya Coal to Power Project to utilize the coal mine located near the southern shore of Lake Rukwa about 70km northwest od Mbeya. According to its website[15], coal reserves in said block is 109 million tons (including 71.33 million tons indicated and 38.05 million tons of inferred reserves), and coal is of low quality with heat value of 13.66 MJ (3,263kcal)/kg. Kibo Mining plans presently examining the outcome of feasibility study with a plan to start construction of 300MW (150MW x 2) coal thermal power station in the 1st quarter of 2017 and complete in 2019. Produced electricity will be sent to the Mwakibete substation at Mbeya via a newly constructed 65km transmission line. SEPCO III of China is a joint venture partner. Project construction costs are $31 million for coal mine and $699 million for power plant. It is reported that Kibo has commenced negotiation on PPA with TANESCO.[16]

Edenville Energy Plc (registered in London) disclosed a plan on its website in May 2016 to implement a mine-mouth coal to power project utilizing coal reserves at its Mkomolo, Namwele, Muze blocks.[17]

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14 The power plant site is in a short distance from the coal mine and the construction of the access road would not be a problem.

15 http://kibomining.com/projects/mbeya-coal/

16 http://www.proactiveinvestors.co.uk/companies/news/128951/kibo-mining-happy-with-mbeya-progress-but-flags-up-policy-issues-128951.html

17 http://www.edenville-energy.com/

The total coal reserves of three blocks are 57.5 million tons. The heat value is low at 17.42 MJ (4,162 kcal)/kg. It plans to construct 100MW++ coal thermal power plant in Phase-1 and 600MW in Phase-2, and the produced electricity will be sent to nearby Sumbawanga via a 25 km transmission line and connected to the national grid there. Edenville Energy says that it is conducting feasibility study presently while already commenced construction of access road.[18]

While projects of Kibo Mining and Edenville Energy are presently in the feasibility study stage, these projects may progress steadily as players and funds are already confirmed. From the above information and hearings from NDC and STAMICO, the aggregate generation capacity of mine mouth coal thermal plants scheduled to start before 2020 is 1,600MW. The Mchuchuma development plan is much smaller than the original one in its plant size and capacity; the PSMP 2012 Update slates 300MW x 2 + 400MW x 1. As 240MW is allocated to the electric furnace to process the sponge iron, the amount of electricity for sale to TANESCO has been reduced. Kiwira withholds second plant presently. No activities are heard about the Coastal Coal plant (500MW) and Local Coal Plants (5 units amounting to 1,500MW) scheduled in the PSMP.

All in all, the immediate coal consumption during the next decade may not significantly exceed the present development plan of 1,600MW. But, once such business model is successfully implemented, additional construction of mine mouth power plants will be accelerated. At the same time, we should note that several problems need to be solved. The planned mine mouth plants are located in a significant distance (100 -250km) from the existing national grid and therefore construction of long distance transmission lines is required. In particular, construction of the western grid in the interior regions (400kV) is the key issue. Location of such plants would be confined to the mine mouth or adjacent areas, since infrastructure to transport coal for long distance needs to be constructed from the greenfield while there is no such material plan yet. Thus, up to 2025, coal thermal capacity in Tanzania may remain most likely 2,000MW at maximum assuming that additional plants would be constructed utilizing the NDC's coal resources, while transmission remains a serious threshold.

In the long run, there is a dream plan to construct a new railway along the southern border of the country and transport coal and other mineral resources to coastal ports for export. At the same time, there prevails thinking that coal should be allocated 50:50 for power generation and other use, likewise natural gas. Such dogmatism without economic consideration would hinder development of coal mines. However, as the above projection developed in this Study schedules use of only a half of the slated production, the suggested mine mouth coal thermal of 5,000MW on capacity basis, could be sufficiently supplied in the long run even if coal production would be lower than the present plans. Nevertheless, it is highly important to select high efficiency, greater capacity plants in order to conserve the domestic resources as well as to confine GHG emissions. The thermal efficiency of a 150MW of sub-critical coal plant is about 37%, while that of a 600MW of USC is around 43-45%.[19] Low efficiency plants will consume15-20% more coal for power generation.

It should be a long term study issue whether it would be possible or necessary to implement coal

[18] Edenville Energy Plc,, "Project Update", 2016/5/18.

[19] At the Neurath Power Station in Germany, a 43% generation efficiency is achieved despite the use of lignite. (IEA, "Coal Medium Term Market Report 2015")

thermal generation beyond 5,000MW using domestic coal. It will also be possible to do so importing necessary quantity of coal from nearby countries. From the view point of electricity demand distribution, more demand is expected in the coastal area where industrialization will progress fast. Then, more new power plants would be needed there, while coal may face with severe competition with domestic natural gas as another optional power source. Thus, as an indicative maximum condition, we may consider an option of constructing coal thermal plants in the coastal region up to 5,000MW or more, as back-up, in the long run, if it is necessary. Imported coal may be assumed as the fuel, while it could be replaced with domestic coal once more resources were confirmed inland and the southern cross-country railway were constructed.

From the above observation, we assume in this Study as indicative conditions for the long run through 2030/2040 that maximum 5,000MW will be considered as domestic mine-mouth coal thermal generation while 5,000MW or more could be considered at coastal locations as back-up coal plants using imported coal, both on generation capacity basis.

5.4 Renewable energy

5.4.1 National Development

In Tanzania, the three top priority choices that emerged to support national development priorities were geothermal power development, renewable energy for rural electrification (RERE), and alternative biomass supply options.

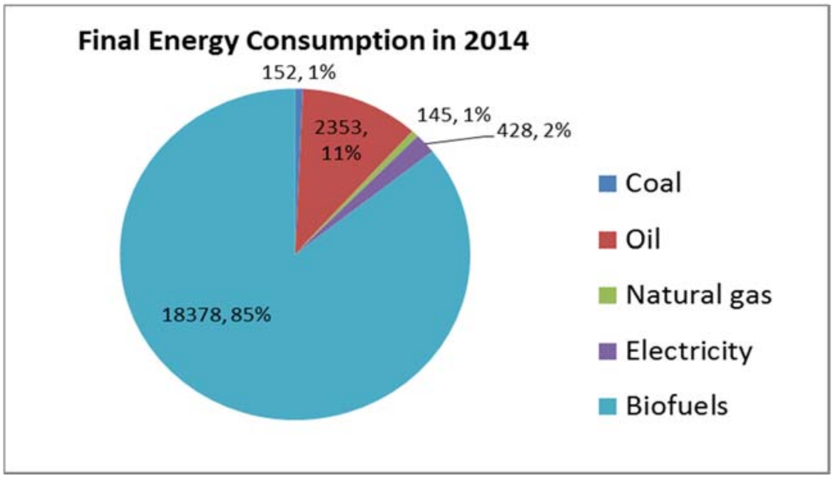
Tanzania is one of the pilot countries of the Scaling-Up Renewable Energy Program (SREP) under the Strategic Climate Fund of Climate Investment Funds (CIF).

The SREP-Tanzania Investment Program will consist of two distinct and complementary investment projects with a combined generation potential of about 147 MW.

Project 1: Geothermal Power Development Project. The expected project outcome is a PPP project that has successfully developed, constructed, and commissioned the operation and maintenance of about 100 MW of geothermal power supplying about 700 GWh per year to the national grid.

Project 2: Renewable Energy for Rural Electrification (RERE) Project. The project expects to generate a renewable energy potential of 47 MW directly co-funded with SREP resources and directly benefitting about half a million people and to create a pipeline of RERE projects that will eventually help 2.2 million people.

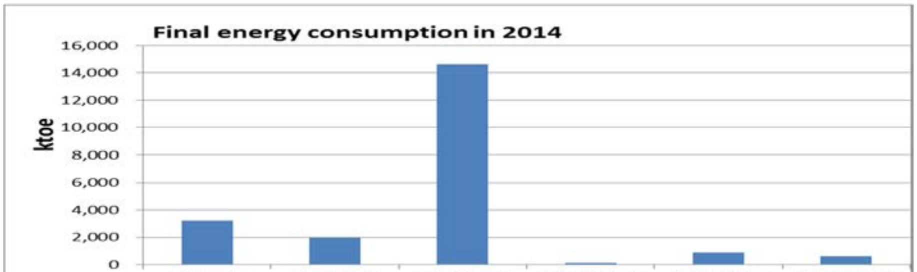
In 2014, biomass represented 85% of total energy consumption. Charcoal made from wood was the single largest source of household energy in urban areas, with about half the annual consumption occurring in Dar es Salaam. Petroleum products comprised 11% of the total energy consumed, whilst electricity accounted for just 2% (Fig. 5.4.1-1). Other energy sources, including solar, represented a small share.



Source: IEA: Energy Balance for Tanzania (2014)

Figure 5.4.1-1 Energy Balance for Tanzania (Total Final Consumption)

The residential sector accounts for most of the energy used, the vast majority of which consists of biofuels and agricultural waste; 78% of the biomass used in the residential sector is for household cooking (Fig. 5.4.1-2).



	Industry	Transport	Residential	Commercial	Agriculture	Non-energy
Total	3,223	1,973	14,632	98	890	597
Electricity	109	0	192	98	15	14
Bio fuel & Waste	2,612	0	14,330	0	854	583
Natural gas	145	0	0	0	0	0
Oil products	205	1,973	110	0	21	0
Coal and peat	152	0	0	0	0	0

Source: IEA: Energy Balance for Tanzania (2014)

Figure 5.4.1-2 Energy Balance for Tanzania (TFC for Sectorial Energy Use)

5.4.2 Renewable energy potential and development status

Currently, the country's total generation capacity from renewable energy, excluding large hydro, is about 4.9%; this includes captive generation in sugar, tannin and sisal factories, solar, and small hydro plants. By 2015, the government expects this share of the electricity mix to increase to 14%, meaning that total generation capacity from renewable energy, including large hydro, would total about 40%, however development has not progressed.

5.4.2.1 Hydropower

Historically, hydropower has been the mainstay of Tanzania's national electricity system. Hydro sources consist mainly of a few large dams and smaller plants. Total installed capacity is 562 MW[20]. But in recent years, intermittent river flows resulting from droughts have decreased hydro's reliability as a power source. In detail, it will be described at the power development plan for hydropower.

5.4.2.2 Small hydropower

According to the SREP, the assessed potential of small hydropower resources up to 10 MW is 480 MW. The installed grid-connected, small-hydro projects contribute only about 12 MW. Most of the developed small-hydro projects are owned by private entities and are not connected to the national electricity grid. Five sites in the 300-8,000 kW range are owned by TANESCO. More than 16 are owned by faith-based groups, with a 15-800 kW range in capacity and an aggregate capacity of 2 MW.

Table 5.4.2-1 Existing Hydro Power Plants in Tanzania

Location	Turbine type/manufacturer	Installed capacity (kW)
Ownership: TANESCO		
Tosamaganga (Iringa)	Gilkes & Gordon/Francis	1220
Kikuletwa (Moshi)	Boving & Voith Reaction	1160
Mbalizi	Gilkes & Gordon/Francis	340
Ownership: MISSIONS		
Kitai (Songea)	Cross Flow/Ossberger	45
Nyagao (Lindi)	N/A	15.8
Isoko (Tukuyu)	N/A	15.5
Uwemba (Njombe)	N/A	800
Bulongwa (Njombe)	N/A	180
Kaengesa (S'wanga)	N/A	44
Rungwe (Tukuyu)	N/A	21.2
Nyangao (Lindi)	N/A	38.8
Peramiho (Songea)	N/A	34.6
Isoko (Tukuyu)	N/A	7.3
Ndanda (Lindi)	N/A	14.4
Ngaresero (Arusha)	Gilbsk	15
Sakare (Soni)	Geiselbrecht	6.3
Mabarari (Mbeya)	Chinese	700
Ndolage (Bukoba)	B. Maler	55
Ikonda (Njombe)	CMTIP	40

Source: Target Market Analysis: 'Tanzania's Small-Hydro Energy Market' (December 2009)

5.4.2.3 Geothermal

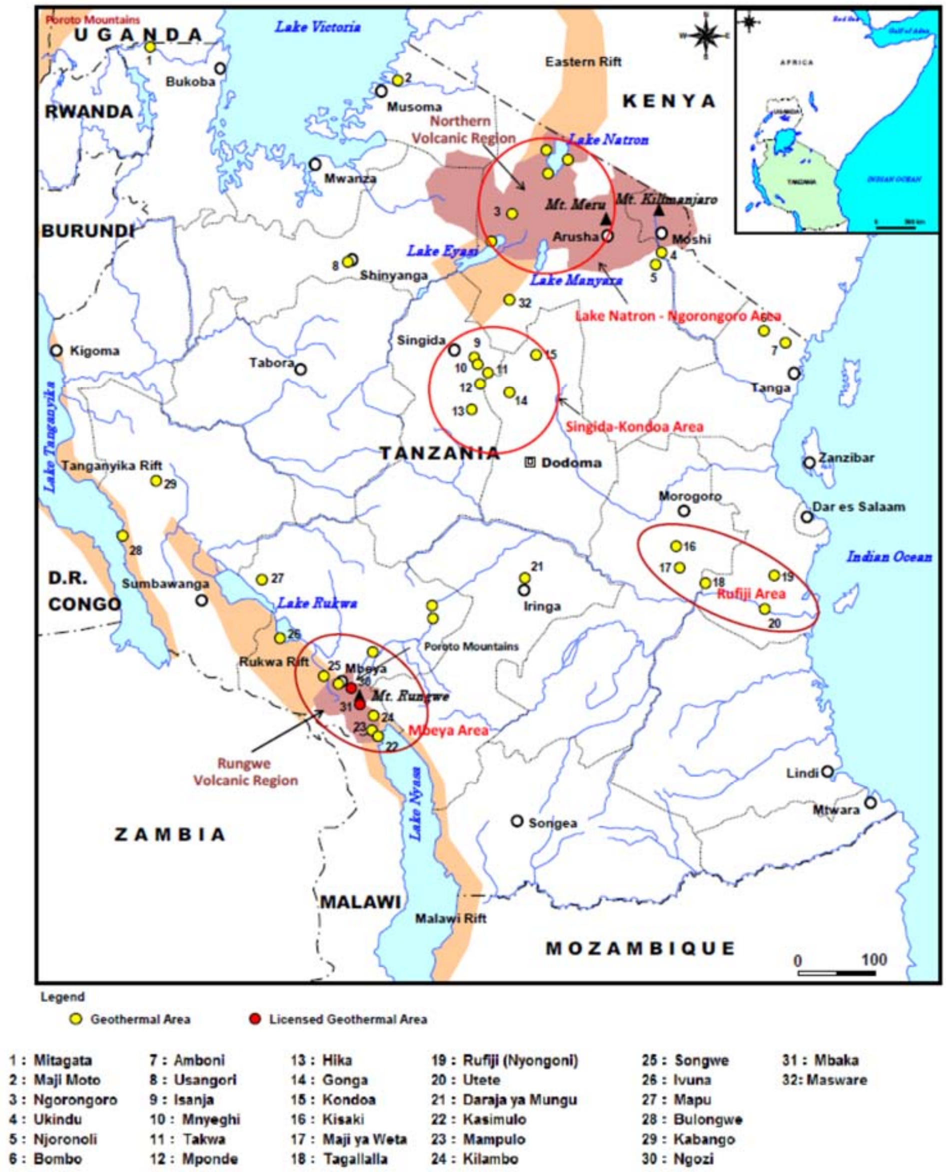
Rift Valley is potential area for geothermal exploitation. Such areas include the northern volcanic province of Kilimanjaro, Meru and Ngorongoro and the Rungwe Volcanic province in southwest Tanzania. At least 15 thermal areas with hot spring activity occur in Tanzania. In addition, some

[20] MEM: 'SCALING-UP RENEWABLE ENERGY PROGRAMME (SREP) INVESTMENT PLAN FOR TANZANIA' (May, 2013)

coastal areas show geothermal surface manifestations. Hot springs have been mapped in the Rufiji basin, south of Dar es Salaam and to the north in the Tanga region[21]. The hot springs in the coastal sedimentary basin are attributed to rifting and intrusions.

Potential geothermal sites could contribute up to 650 MW to the country's energy mix. According to the JICA report, the total geothermal potential of the whole Tanzania is about 678 MW[22].

There are about 50 geothermal prospects in Tanzania grouped into three main prospect zone; the Northern Zone (Kilimanjaro, Arusha and Mara region), The Southern Zone (Rukwa and Mbeya region) and the eastern coastal belt which is associated with rifting and magmatic intrusion (Rufiji Basin)[23].



Source: JICA: 'DATA COLLECTION SURVEY ON GEOTHERMAL ENERGY DEVELOPMENT IN EAST AFRICA' (2014)

Figure 5.4.2-1 Geothermal Fields in Tanzania

21 Taramaeli T. Mnjokava: 'GEOTHERMAL EXPLORATION IN TANZANIA – STATUS REPORT' (2008)

22 JICA: 'DATA COLLECTION SURVEY ON GEOTHERMAL ENERGY DEVELOPMENT IN EAST AFRICA' (2014)

23 MEM: 'SCALING-UP RENEWABLE ENERGY PROGRAMME (SREP) INVESTMENT PLAN FOR TANZANIA' (May, 2013)

Geothermal Power Tanzania (GPT) initially obtained six geothermal exploration licenses which were held through Interstate Mining & Minerals limited around Mbeya and Rufiji areas. Three licenses were at Mbaka, two at Ngozi and one at Rufiji. However, due to lack of activities in many of these licenses as required by the law (Mining Act), the government cancelled all the other licenses except two at Ngozi and one at Mbaka licensed to GPT.

Source: GPT Web page

Figure 5.4.2-2 Prospecting Licenses of Geothermal Power Tanzania

As development risk (leading to an unfavorable result) is not negligible in steam field development, a phased process of steam field development is usually adopted. The development process is composed of the following four stages:[24]

1st Stage: Exploration Stage
2nd Stage: Feasibility Study Stage
3rd Stage: Project Implementation Stage
4th Stage: Operation and Maintenance Stage

The goal of the First Stage (Exploration Stage) is to confirm the presence of a geothermal resource, to identify the chemical and physical properties of the geothermal resource and to estimate the resource capacity (optimum output to maintain sustainable operation). The exploration stage is subdivided into the following three phases:

Phase 1: Regional Exploration Phase, to select a prospective area (or areas)
Phase 2: Detailed Exploration Phase, to clarify the presence of a geothermal resource, to identify the geothermal structure and to select drilling targets

[24] JICA: 'DATA COLLECTION SURVEY ON GEOTHERMAL ENERGY DEVELOPMENT IN EAST AFRICA' (2014)

Phase 3: Resource Evaluation Phase, to identify the chemical and physical properties of a targeted geothermal reservoir by well drilling and to evaluate resource capacity

In Tanzania, considering of the lack of experience in geothermal development, government-led surveys corresponding to Phase 1 and Phase 2 are very much desired to promote geothermal development in this country. By reducing development risk, these will facilitate the participation in geothermal development projects by the private sector, leading to an anticipated overall promotion of geothermal development in the country.

5.4.2.4 Wind

Several areas of Tanzania are known to have promising wind resources. In areas where assessments have been conducted to date, only Kititimo (Singida) and Makambako (Iringa) have been identified as having adequate wind speeds for grid-scale electricity generation. At Kititimo, wind speeds average 9.4 meter per second and 8.7 meter per second at Makambako, at a height of 30 meter[25].

The MEM, in collaboration with TANESCO, is conducting wind resource assessments in Mkumbara (Tanga), Karatu (Manyara), Gomvu (Dar es Salaam), Litembe (Mtwara), Makambako (Iringa), Mgagao (Kilimanjaro), and Kititimo (Singida). The REA is supporting wind measurements at Mafia Island (Coast region). MEM and TANESCO will be conducting wind resource assessments in Usevya (Mpanda).

Table 5.4.2-2 Sites Names and Coordinates for Wind Resource

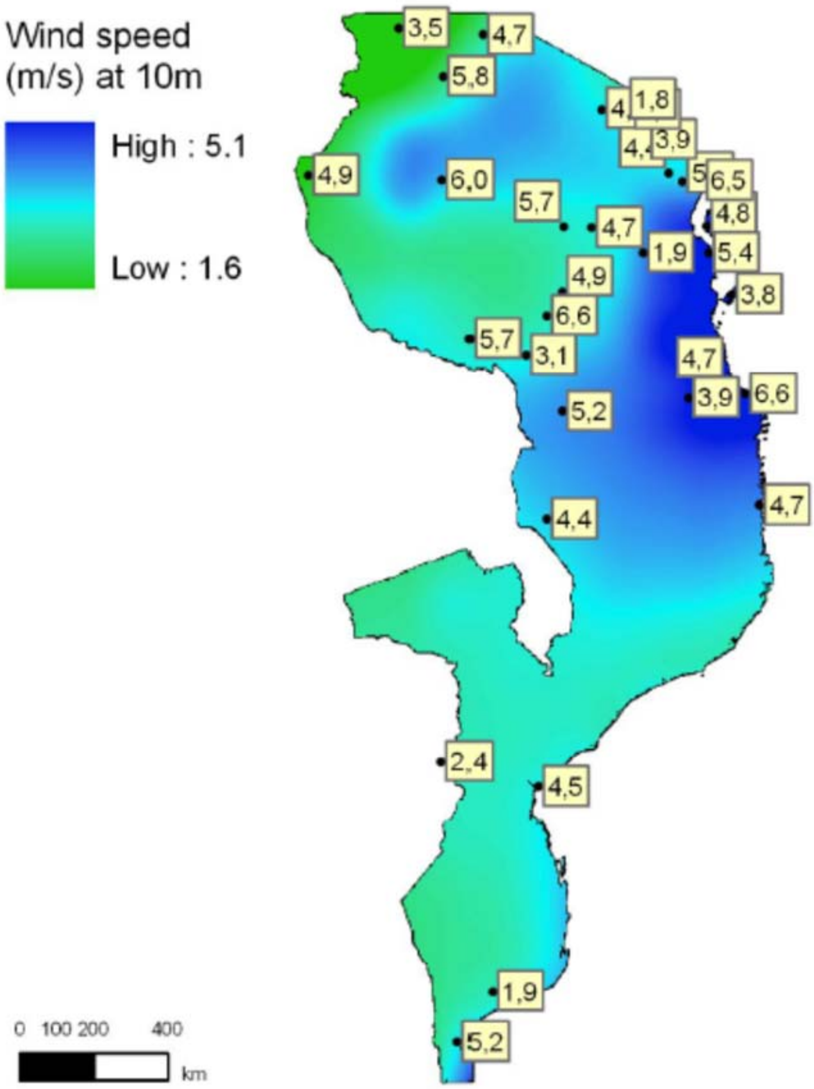
S/N	Region	District	GPS-Coordinates		Average Wind Speed at 10m (m/s)	Average Wind Speed at 30m (m/s)
1	Singida	Singida	4°51'01,69"S	34°50'18,93"E	8.2	9.4
2	Iringa	Makambako	8° 50' 49.62"S	34° 48' 37.74"E	7.6	8.7
3	Kilimanjaro	Mwanga	3° 53' 59.52"S	37° 39' 08.68"E	3.8	5
4	Tanga	Mkumbara	04° 43.938′ S	38° 08.956′ E	4.14	4.9
5	Arusha	Karatu	03° 20.386′ S	35° 36.761′ E	4.9	5.5
6	Dar es Salaam	Gomvu	06° 58.297′ S	39° 28.649′ E	3.56	4.28
7	Mtwara	Litembe	10° 26.49′ S	40° 19.14′ E	3.21	4.47
8	Coast	Mafia	07°46'34.8"	039° 50' 37.2"E	on progress	on progress
9	Mwanza	Ukere	9°79.4'178"	5°10.324"E	4	5.6

Source: TANESCO

The ground measurements of wind speed at 10 meter height show annual mean values between 1.8 meter per second in Lyamungo and 6.6 meter per second in Sao-Hill and Mtwara (Fig. 5.4.2-3). The variations in wind speed are high as some measurements are carried out at specifically windy locations; wind hotspots. The interpolated SSE estimations indicate somewhat lower annual mean wind speeds, ranging from 1.6 to 5.1 meter per second. According to SSE data, only coastal Tanzania and north eastern Mozambique have annual averages of wind speed reaching 5 meter per second. A larger caption of southern Tanzania and northern Mozambique, along with north western Tanzania and

25 TANESCO "SITES_NAMES_AND_COORDINATES"

southernmost Mozambique show indications of wind speeds from 4 meter per second. However, the ground measurements add several hot-spots of wind speed which are not reflected by the SSE data. In Tanzania 10 out of 26 ground measurement sites show annual wind speeds exceeding 5 meter per second. In Mozambique only the Maputo station reports wind speeds above 5 meter per second.



Labels show ground measurements and color gradient represent interpolation of SSE data.

Source: CHALMERS UNIVERSITY OF TECHNOLOGY (2011)

Figure 5.4.2-3 Annual averages of wind speed (m/s) in Tanzania and Mozambique.

To date, four companies have expressed interest in investing in wind energy, namely Geo-Wind Tanzania, Ltd. and Wind East Africa in Singida and Sino Tan Renewable Energy, Ltd. and Wind Energy Tanzania, Ltd. at Makambako in Iringa. These companies are considering investments in wind farms in the 50-100 MW range[26].

Singida Wind Power project consists of a 100 MW wind farm to be built, owned, and operated (BOO)

[26] World Bank: 'PROJECT INFORMATION DOCUMENT (PID) for Singida Wind Firm' (2011)

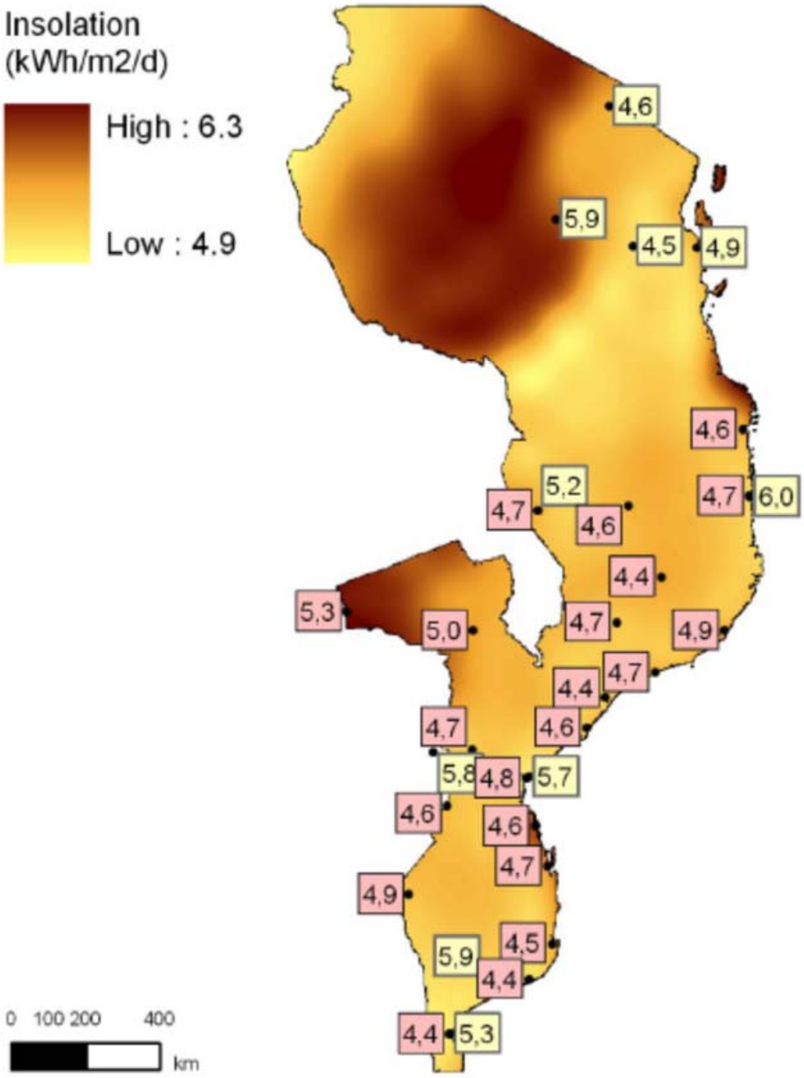
by a private-sector project company (Wind EA). The project cost is estimated to be between US$230-290 million and the project was confirmed by the PSMP 2009 as one of the next least cost short to medium term generation additions. It is envisaged that this privately financed project company will supply power into the Tanzanian national grid under a long term Power Purchase Agreement (PPA) with TANESCO. The wind farm will be constructed along the Rift Valley on a site located east of the town of Singida, in the district and region of Singida.

5.4.2.5 Solar

Tanzania has high levels of solar energy, ranging between 2,800 and 3,500 hours of sunshine per year, and a global radiation of 4-7 kWh per square meter per day[27]. Solar resources are especially good in the central region of the country. Thus, solar energy as a viable alternative to conventional energy sources is a natural fit for Tanzania if efficiently harnessed and utilized. Both solar PV and solar thermal technologies are under development in the country.

According to ground measurements the insolation varies from 4.5 kWh per square meter per day in Morogoro, Tanzania, and 6.0 kWh per square meter per day in Pemba, Mozambique (Fig. 5.4.2-4). According to the interpolation of SSE data the insolation ranges from 4.9 to 6.3 kWh per square meter per day. In both cases, the insolation corresponds to good solar energy potentials. In comparison, the insolation in the Sahara desert is approx. 6-7 kWh per square meter per day and the Mediterranean coast receive about 4.5 kWh per square meter per day.

[27] MEM: 'SCALING-UP RENEWABLE ENERGY PROGRAMME (SREP) INVESTMENT PLAN FOR TANZANIA' (May, 2013)



Yellow labels represent ground measurements values and red labels show simulation-based values from Nijegorodov et al. (2003). Color gradient represent interpolated values from SSE data.

Source: CHALMERS UNIVERSITY OF TECHNOLOGY (2011)

Figure 5.4.2-4 Annual averages of insolation kWh/(m^2·day) in Tanzania and Mozambique.

PSMP 2012 envisages 120 MWp of solar in the short-term power expansion plan by 2016/2017. Several private firms have expressed interest in investing in 50-100 MWp of solar PV. According to TANESCO, which is under negotiation PPA, but development has not progressed[28]. NextGen Solawazi has signed a SPPA (Small Power Producer Agreement) with TANESCO to supply electricity from 2 MWp of PV to an isolated grid. TANESCO has also signed a Letter of Intent for a 1 MWp isolated grid-tied PV project.

28 Hearing from TANESCO (2014)

5.4.2.6 Biomass

Biomass is Tanzania's single largest energy source. According to REA estimates, agricultural, livestock, and forestry residues amount to about 15 million tons per year (MTPY). A portion of that amount may be available for use in power generation. This includes sugar bagasse (1.5 million MTPY), sisal (0.2 MTPY), coffee husk (0.1 MTPY), rice husk (0.2 MTPY), municipal solid waste (4.7 MTPY), and forest residue (1.1 MTPY), with the balance from other crop waste and livestock. Further supplies can be obtained through sustainably harvested fuelwood from fast-growing tree plantations. For example, a 50 MW biomass power plant could obtain all its fuelwood needs from a 10,000 hectare plantation[29].

Wood waste is a renewable resource that can be used to generate electric power, steam or liquid biofuels such as ethanol. Wood waste refers to low-grade timber material with no other identifiable market or environmental value. This includes material that is left in the forest after the higher-value timber resources have been harvested, and the sawdust, shavings, off-cuts and other wastes associated with timber processing. Table 5.4.2-3 provides the East African wood charcoal production. As can be seen from the tables, production of charcoal is a large amount in Tanzania.

Table 5.4.2-3 East Africa Wood Charcoal Production, 2010

Country	Tonnes
Rwanda	264,503
Burundi	303,048
Kenya	902,486
Uganda	906,579
Tanzania	1,558,324
Total	3,934,940

Source: FAOSTAT (2011)

Agriculture still accounts for about 75% of the labor force in all these countries, underscoring the importance of the sector in job creation and poverty reduction across countries. The main crops grown in the region include maize, beans, sorghum and millet. Table 5.4.2-4 provide East African agricultural production. Biomass utilization of these wastes or residues generated from these crops is expected.

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29 MEM (May, 2013) "SCALING-UP RENEWABLE ENERGY PROGRAMME (SREP) INVESTMENT PLAN FOR TANZANIA

Table 5.4.2-4 East Africa Agriculture Production (tonnes), 2009

Country	Commodity						
	Beans	Cassava	Coconut	Coffee	Groundnuts	Oil Palm	Rice Paddy
Burundi	202,934	235,369	0	25,130	7,967	15,500	78,432
Kenya	465,363	819,967	60,134	57,000	27,296	0	37,198
Tanzania	948,974	5,916,000	577,099	68,577	385,480	65,000	1,334,000
Uganda	452,000	5,179,000	0	195,871	185,000	0	181,000
Rwanda	326,532	980,000	0	28,000	10,414	0	111,076

Country	Commodity					
	Sisal	Sorghum	Sugarcane	Tea	Wheat	Maize
Burundi	0	81,176	132,769	6,729	8,583	120,379
Kenya	16,155	99,000	5,610,700	314,100	129,200	2,439,000
Tanzania	23,800	709,000	2,370,000	32,000	92,400	3,324,200
Uganda	0	497,000	2,350,000	48,663	20,000	1,272,000
Rwanda	0	174,499	63,000	20,000	72,430	285,505

Source: FAOSTAT (2011)

Table 5.4.2-5 is the municipal solid waste data for 21 municipalities and major cities in Tanzania. Major Cities like Dar es Salaam, Mwanza, Shinyanga, Kagera, Mbeya and Kigoma have relatively higher potential energy from the waste. However, all over Tanzania urban waste collection is marginal, at 32% of the total generated amount[30]. Therefore for this waste to be applied in energy generation there is a need to put in place organized waste collection and management procedures and infrastructure.

[30] Lugano et al.: 'Biomass Energy Systems and Resources in Tropical Tanzania' (2010)

Table 5.4.2-5 Waste generated (Tones) in Tanzania Cities

No.	City/Town	Amount Generated (Tones/Day)	Amount Open Dumped (Tones/Day)	Dumped/ Generated Ratio	Amount Generated In 2000 (Tones/Day)	Amount Generated In 2003 (Tones/Day)	Amount Generated In 2005 (Tones/Day)
1	Dar es Salaam	2,200			2,000	2,848	3,100
2	Mwanza	210	80	38	751	977	1,036
3	Shinyanga	100	25	25	564	898	991
4	Kagera	24	8	31	64	242	714
5	Mbeya	145	66	46	442	662	712
6	Kigoma	60	15	25	274	537	620
7	Tabora	120	12	10	405	550	612
8	Morogoro	260	54	21	391	563	608
9	Dodoma	156	42	27	395	544	585
10	Tanga	400	190	48	519	657	554
11	Iringa	36	11	31	382	479	500
12	Mara	30	7	23	303	438	472
13	Kilimanjaro	92	45	49	354	442	464
14	Arusha	200	125	63	413	414	440
15	Rukwa	45	16	36	240	390	407
16	Lindi				206	253	385
17	Ruvuma	56	21	38	249	358	385
18	Mtwara	50	15	30	222	361	380
19	Singida	65	17	26	253	349	374
20	Manyara				193	332	373
21	Pwani				203	284	305
	TOTAL	4,249	749	33	8,823	12,577	14,017

Source: Lugano et al.: 'Biomass Energy Systems and Resources in Tropical Tanzania' (2010)

Under the SPPA program, two biomass power projects are supplying power to TANESCO: TPC, a major sugar producer with an SPPA for 9 MW of power, and TANWATT, a tannin producer with an SPPA for 1.5 MW. In January 2013, a third SPPA for 1.5 MW, the Ngombeni project, is expected to be commissioned to supply power to TANESCO's isolated grid on Mafia Island. TANESCO has signed SPPAs for three additional biomass projects with a total capacity of 9.6 MW (Table 5.4.2-6).

Table 5.4.2-6 SPP Projects with signed SPPA or LOI

SPP name	Technology	Export capacity (MW)	Grid connection	SPP/LOI date	Commission date
SPPA signed					
TANWAT	Biomass	1.5	Main	17 Sept. 09	15 June 10
TPC, Moshi	Biomass	9.0	Main	6 Oct. 09	13 Sept. 10
Mwenga, Mufindi	Hydro	4.0	Main	19 Jan. 10	21 Sept. 12
Ngombeni, Mafia Island	Biomass	1.5	Isolated	19 Jan. 10	March 13
Sao Hill, Mufindi	Biomass	6.0	Main	26 Feb. 10	June 14
Symbion-KMRI, Tunduru	Biomass	0.3	Isolated	17 July 12	July 14
Symbion-Kigoma	Biomass	3.3	Isolated	31 Dec. 12	March 14
St.Agnes Chipole, Songea	Hydro	7.5	Isolated	11 Jan. 13	July 14
NextGen Solawazi, Kigoma	Solar	2.0	Isolated	16 Jan. 13	April 13
EA Power, Tukuyu	Hydro	10.0	Main	March 13	-
AHEPO, Mbinga	Hydro	1.0	Isolated	March 13	-
Total SPPA		46.1			
LOI signed					
Mapembasi, Njombe	Hydro	10.0	Main	25 June 10	-
Kikuletwa II, Kilimanjaro	Hydro	7.0	Main	28 Oct. 11	-
Darakuta, Manyara	Hydro	0.9	Main	10 Jan. 12	-
Mofajus, Mpanda	Hydro	1.2	Isolated	27 April 12	-
Tangulf, Natakuta	Hydro	10.0	Main	16 Nov. 12	-
Windpower, Mpanda	Solar	1.0	Isolated	21 Nov. 12	-
Go On Tosa, Iringa	Hydro	0.8	Main	Lease from TANESCO	-
Total LOI		30.9			

Source: MEM: 'SCALING-UP RENEWABLE ENERGY PROGRAMME (SREP) INVESTMENT PLAN FOR TANZANIA' (May, 2013)

Chapter 6 Challenges of PSMP2012

6.1 Power demand forecasts

6.1.1 Eligible impact factors to power demand

The eligible related impact factors to the power demand described and the future power demands as the results in PSMP 2012 are as the following Table 6.1.1-1.

Table 6.1.1-1 Preconditions of the factors on power demand

Factors	Current recognitions and future prospects in PSMP2012	Sources
Population	The average growth rate was 2.8 % per year from 2002 to 2010. The future population trends are 43 million in 2010, 50 million in 2015, 57 million in 2020, 65 million in 2025 and 75 million in 2030. The future average growth rates are 2.84 % per year from 2010 to 2020 and 2.78 % per year from 2020 to 2030. The two future average growth rates are almost equivalence to the past growth rate from 2002 to 2010.	Census in 1988 and 2002 and extended population to 2011
Household and family	Number of population, houses and households give the big impacts to the power demand. The number of family members per household is currently 8 persons in average and the number of households per house is 5 households in Tanzania. The number of households per house becomes gradually small year by year.	Original prediction in PSMP2012
Economy	The average growth rate of real GDP in Tanzania was around 7 % per year from 2001 to 2011. And the future growth rate by 2025 is expected with 8 ～9 % per year. As the reasons of the higher GDP growth in future than in the past, the increases of food self-sufficiency, the structural reforms aimed personal income increasing in Agriculture sector and introducing FDI by creating free trade zones are pointed out. When considering the above economic policies, it is predicted that power demand rapidly increases in Tanzania in future.	Tanzania Development Vision 2025
Power demand structure	The expansion of power consumption in Mining and Manufacturing sector is a main reason to increase the total power demand in current Tanzania. The Government has a plan to increase number of customers with 250,000 from 2013 to 2017. It means that the electrification rate reaches 30% as of 2015. In the plan, the increasing power supply facilities in rural area and promoting grid system connections with IPPs are included.	Energy Development and Access expansion program in Tanzania (TEDAP)
Power tariff	Power tariff elasticity to power demand is not measured in Tanzania, even though it is well known that power tariff has a big impact to power demand. Therefore, it is required that the Government should study the changes of power demand in company with power tariff increasing after referring other similarly policies.	Energy and Water Utilities Regulation Authority (EWURA)
T/D loss	The details of T/D loss in 2010 are 5.3 % in transmission lines and 19.7 % (including non-tech loss) in distribution lines The improvement of the losses has an effect to suppress the additional power generation capacities.	TANESCO

Source: Chapter 2 of Power System Master Plan 2012 Update

Comments: When looking at the data sources in the above table, the power demand forecasts in PSMP2012 are built up after referring the prospects and plans of the Government such as future GDP growth rate and future number of households. It can be recognized that suitable factors are selected for the power demand forecasting in PSMP 2012. If permitting to add an idea to the forecasting factors, the power demand should be forecasted as a part of the total energy demand, even though the power demand are classified to business sector and regional area. Especially, when the electrification rate is increased in country wide, fossil energies are converted to electricity. It makes power ratio increase. The phenomenon is happened in many developing countries in the past years. As the increase of the power ratio has big impacts to future power demand, the power ratio should be applied to power demand forecasting models.

6.1.2 Forecasting methodology

The period of the actual data in PSMP 2012 is 25 years from 1986 to 2010 and the forecasting years are from 2011 to 2035. The basic forecasting methodology is linear economic expressions (Regression expressions) using several explanatory variables. The methodology is frequently used in econometric model. The forecasted variables (explained variable) are power sales, load factor, Loss rate, peak demand, power generation, energy consumption and so on. The following Table 6.1.2-1 shows the explained variables and the explanatory variables in power demand model in PSMP 2012.

Table 6.1.2-1 Explained and Explanatory variables in PSMP2012 model

Explained	Explanatory
Power sales (Note)	GDP Number of customers Power consumption per customers Load shedding, DSM and power tariff
Load factor	Setting future expected load factor (Exogenous variable)
Loss	Transmission loss, non-technical loss and technical loss are set from the targets of the Government
Peak demand	Peak demand is forecasted by the factors such as power sales, load factor and loss rates
Power generation	Power generation is forecasted by power sales and power loss.
Energy consumption	Energy consumption by power generation facilities

Source: Chapter 2 of Power System Master Plan 2012 Update

Note: Forecasting expressions for power sales of Econometric approach

$\text{Power sales}_t = a + b^*(\text{Population trend})_t + c^*(\text{Economic indicator})_t$

a, b, c : Constant

Population trend: Number of population, household and houses

Economic growth: GDP, Production data and Import/Export data

Comment 2: Regarding power sales, the first (GDP) and second (Number of customers) explanatory variables in the above table are growth components. When national economy is developing, number of population and households, power customers of the country are increased together. As the explanatory variable for power demand, the two variables are duplicated. The phenomenon is called as “Multi-collinearity” (Usually it is called “Multico” shortly). The two variables have strong relation each other, as the results, one of them has sometimes non meaning co-efficient. In the model with multico, it is happened that some explained variables has divergence values. The demand and production econometric models generally use the following expressions, and the power and energy demand model built by the study team uses the following expressions.

First expression Power demand = p*（GDP）ᵃ＊（Power tariff /CPI）ᵇ

Second expression LN(Power demand)＝a*LN(GDP)+b*LN（Power tariff/CPI）+c

LN: Natural logarithm CPI* Consumer price index

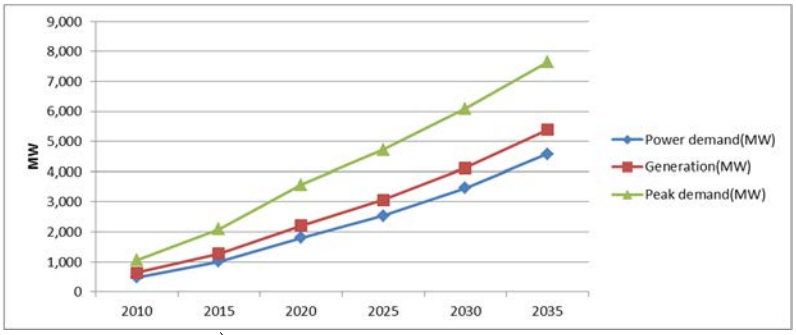
6.1.3 Results of power demand forecasts

The power demand in PSMP 2012 report is “Potential power demand” (Other words : Underlying power demand or Un-constrain power demand), it is not actual statistical power demand. The annual growth rate per year by 2020 is 14% over, and the elasticity to GDP is 1.68. When setting 4,175 GWh for the actual power demand in 2010, the growth rate from actual power demand 2010 to the potential power demand in 2020 is 14.3% per year, its elasticity to GDP is 1.7. In the developing country where the gap between potential power demand and actual power demand is so big, it is sometimes happened that the power demand elasticity to GDP reaches 2.0. There does not remain doubtful regarding the growth rate of power demand by 2020 in PSMP 2012.

Table 6.1.3-1 Forecast results of power demand and elasticity in PSMP2012

	GDP	Power demand	Generation	Peak demand
	%/year	GWh	GWh	MW
2010	7.0	4,175	5,591	1,061
2015	8%~9 %	8,800	11,122	2,088
2020	8%~9 %	15,821	19,391	3,573
2025	8%~9 %	22,200	26,840	4,724
2030	8%~9 %	30,324	36,141	6,085
2035	8%~9 %	40,083	47,198	7,644
20/10	8%~9 %	14.3 %(1.7)	12.7 %(1.5)	12.9 %(1.5)
30/20	8%~9 %	6.7 %(0.8)	6.4 %(0.8)	5.5 %(0.6)
30/10	8%~9 %	10.4 %(1.2)	9.5 %(1.1)	9.1 %(1.1)

Note: ( ) are elasticity to GDP, the growth rates of GDP are 8.5% during all terms



Power demand MW） = Power demand (GWh)/(24*365)*1000

Generation （MW） = Net generation (GWh)/(24*365)*1000

Figure 6.1.3-1 Power demand forecasts in PSMP 2012

Comment 3: When GDP growth rate in PSMP2012 are 8～9% from 2020 to 2030, the growth rates of the power demand are 6～7%. In the conditions, the elasticity between the power demand growth rate and GDP growth rate is around 0.75. Generally speaking, the elasticity of 0.7～0.8 between power demand and GDP are happened sometimes in middle developed countries with stabile GDP growth. In developing countries with higher GDP growth, there are many cases that the elasticity is bigger than 1.0. Therefore, it is required to analyze the elasticity between GDP growth rate and power demand growth rate of future Tanzania in this Study.

6.1.4 Principle for building Power system master plan of Tanzania

(1) Procedures of power demand forecasting

The procedures of the power demand forecasts are as follows;

Table 6.1.4-1 Procedures of power and energy demand forecasts

Step 1	Survey on social and economic strategies in Tanzania
Step 2	Predict international energy prices and power tariff strategy in Tanzania
Step 3	Forecast total energy consumption by sector
Step 4	Forecast power and fossil energy demand by sector
Step 5	Sum up power and energy demand in the whole country
Step 6	Estimate future import / export of power, T/D loss and Load factor
Step 7	Estimate power generation by facility and fuel consumption
Step 8	Estimate domestic energy consumption
Step 9	Estimate power and energy consumption per GDP and per capita

- The sector categories of the forecasts are depended on IEA category codes (Agriculture, Industry, Commercial & Services, Transportation and Residential). When C/P requests additional power demand categories such as government and street light categories, the categories are added in the model.
- The model forecasts the total energy demand by the sectors including power, fossil energies and wood & charcoal as shown in the above table. The variables and indicators such as sectoral GDP, energy price, energy efficiency & conservation policy and woods & charcoal are set for the forecasting equations as explanation variable.
- As the next step, the forecasted total energy demands are separated to fossil energies and power by using power ratio (It includes electrification ratio). The fossil energies consumed in the sectors usually are shared by LPG, Kerosene, Diesel, Fuel oil, Natural gas and Coal and so.
- When forecasting peak demand and power generation, the related factors (power efficiency, reserve margin, generation facility configuration, load factor and T/D loss) are used for explanation variable as well as referring the government and the related authority plans. And the results are discussed between C/P and JICA Study team.
- The demand and supply balance of primary energy a country becomes important information for establishing national energy master plan. As the details, it is the essential information to judge whether the primary energies such as oil, coal and gas can be procured or not. Therefore, fossil energy demand is forecasted not only for national energy plan but also power system plan.
- The forecasted power demand of Tanzania is evaluated by comparing to other countries. After the power consumption per capita and power consumption per GDP of the countries including

Tanzania are calculated, the indicators are compared each other. By doing so, the consistency between Tanzania and other counties is examined.

(2) Power demand forecasting unit

The following table shows the categories of power demand forecasts. As the categorized items, Sector, Potential power demand, Power tariff and Region are prepared.

Table 6.1.4-2 Power demand forecast unit

Items	Category	Consumer and power Supply
Sector	Agriculture Mining & Manufacturing Commercial & services Transportation Residential Energy conversion	Agro processing and products Mining of Metal and Diamond, Manufacturing Commercial, Public services & facilities and Offices Street lights, Rail way Port and Air port Lights, Air conditioner and Hot water supply Natural gas, LNG, Power, Water supply
Potential demand	Agriculture Mining & Manufacturing Commercial & services Residential	TANESCO supply＋Auto producers TANESCO supply＋Auto producers TANESCO supply * Potential demand ratio TANESCO supply * Potential demand ratio
Power tariff	T1（general use） T2 (Low Voltage) T3 (High Voltage)	Residential, small commercial, light industry, street light, Residential Commercial & Services Agriculture, Mining & Manufacturing
Region	The target is 20 regions. The total power demand of the country is distributed by the variables in right hand box.	Regional population Regional GDP Development plan (SEZ, Port, Airport, Road, Railway and Industrial facilities) Number of power registered customers Regional electrification rate

Region name: Arusha、Dar es Salaam、Dodoma、Iringa、Kagera、Kigoma、Kilimanjaro、Lindi、Manyara、Mara、Mbeya、Morogoro、Mirawa、Miwanza、Rukwa、Ruvuma、Shinyanga、Singida、Tabora、Tanga

SEZ: Special Economic Zone

(3) Basic forecasting equations

The forecasting equations are built by the following procedures.

Table 6.1.4-3 Power and energy demand forecasting equations by sector

Energy demand forecasts by sector	Growth factor：GDP, Sectoral GDP, Population, Households Price elasticity：Oil price, Domestic gas price, Coal price and Power tariff Inflation rate：Consumer price index, Industrial products price index Energy Demand = a*(Growth factor) ＋
Sectoral potential power demand	Power ratio：Power consumption / Total energy consumption, the future values are estimated by time trends method. Power demand = a*(Energy demand) *(Power ratio) + b*(Price/Inflation rate) + c
Sectoral power demand (Power demand = Visible power demand)	Effective power tariff ：Power tariff / Consumer price index Power supply achievement rate: Visible / Potential demand, the future is estimated by time trend method Power demand =a*(Potential demand) * (Achievement rate) + c

6.1.5 Principle for power system master plan for Dar es Salaam (DSM)

The principle of power system master plan for DSM is as follows;

- The total power consumption of the regions is forecasted in power and energy demand forecasts of the country wide.
- Regarding power demand by substation, the power demand growth rate of DSM is applied to each substation after studying current power consumption of the existing substations, future power demand of new substations and power transmission to other regions.
- As substation power demands are fluctuated by the development plan of DSM and neighboring regions, the growth rates of the substations are adjusted by such plans.

6.2 Power Development Planning

Power development plans of PSMP2012 will be updated according to the following directions.

Table 6.1.5-1 Challenges of PSMP 2012 and directions for update (Power Development Planning)

№	Challenges of PSMP 2012	Guidelines for PSMP update
(1)	As the load characteristics (load duration curve) of the power system included in the plan is not clearly indicated in PSMP 2012, the basis on which the power source configuration was decided is not clear.	Determine power plants configuration according to the minimum cost method using power source development planning software (WASP) by anticipating future load duration curve.
(2)	While the ratio of facility capacity for hydroelectric power plant and thermal power plant is fixed at 40:60 in PSMP 2012, this ratio should change in response to conditions such as power generation cost for each power source and timing of facility launch.	Select the combination of power plants that minimizes the total cost (sum of power generation facility construction cost, fuel cost and operation, maintenance and administration cost) during the planned period after assuming the candidate power source for hydroelectric and thermal power generation. Ratio of facility capacity for hydroelectric power plant and thermal power plant shall not be fixed.
(3)	The output of hydroelectric power plant under construction in Ethiopia is described as 2,970MW (Takese: 300MW, Gilgel-II: 420MW, Anablels: 460MW, Gilgel-III: 1,870MW) in PSMP 2012. However, according to the latest information from Ethiopian Electric Power Corporation (EEPCO), 7,549MW output including Ethiopian Grand Renaissance (6,000MW) is under construction and attainment of 10,000MW power generation capacity is anticipated in 2015. Therefore, power export potential of Ethiopia has been underestimated.	Amount of electric power that can be imported and amount of electric power import to be considered in power source development plan will be determined after collecting the latest information from East Africa Power Pool and South Africa Power Pool.
(4)	Evaluation of electric energy from hydroelectric power generation in PSMP 2012 directly reflects the content of analyses in PSMP2008 and 2009 UPDATE, conditions at the time of serious drought in 2011 are not reflected.	Decrease in power generation from hydro power plants is taken into consideration as a "drought case" scenario. Power generation from hydro power plants during drought years is to be calculated by obtaining data on river discharge up to the latest years.
(5)	Gas thermal is not included among the candidates of power source to be developed for the future while coal thermal is mentioned as power source candidate including those with undetermined location (e.g. Local Coal I and II). New power source using gas thermal should also be the candidate of development considering the potential of natural gas in Tanzania.	Candidates of power source to be developed for the future such as gas thermal and coal thermal shall be identified by anticipating standard plant model aside from planned power source.
(6)	While the order of power generation facility launch is decided in PSMP 2012 through comparison of power generation cost at certain point in time, the concept of opportunity cost depending on timing of launch has not been applied.	With the power source development planning software (WASP) used in this project, capital opportunity cost will be taken into consideration as total power generation cost during the planned period is calculated as net present value after inputting the discount rate.

6.3 System Planning

System Planning is planned based on Power Demand Forecast and Electric Power Development Plan, and the problem which the existing Power Demand Forecast and the Electric Power Development Plan have was being reflected as it was.

Moreover, in PSMP 2009, although fault analysis (short circuit capacity calculation) was carried out about the 400 / 220kV system of 2033 year system and it was checked that there was no problem in breaker capacity, this analysis was not carried out in PSMP 2012. Since it is an important check item that the fault current at the time of fault occurrence is below breaker capacity, in this project, it is due to carry out. Since it is an important check item that the fault current at the time of fault occurrence is below breaker capacity, in this project, it is due to carry out.

However, it is still unknown whether various required data for short circuit capacity calculation can be obtained from the result of the first field work, and the further survey will be required.

Chapter 7 Energy and Power Demand Forecasts

7.1 Methodologies for energy and power demand forecasts

7.1.1 Required functions of demand forecasts

For forecasting the future power demand of Tanzania, the trends of the past electric power and fuel energy consumptions and the current situation of the consumptions should be analyzed, and it is required that the structure factors should be found out. As the trends of the energy consumption are one of the results of social economic activities, it can be considered that the changes of the energy demands are reflected by the changes of social, economic and industrial activities. For analyzing the changes, the social economic activities and the demand structure of fuel energies and electric power should be studied, after that, the structures of fuel energy and electric energy demand model should be designed. The following functions are required for the demand model used in this project.

- Social economic changes be linked to the model
- Impact of energy price volatility and energy conversion trends be considered in the model
- Capability of analyzing final energy demands and electric power demands by sector be had in the model
- Functions of the regional power demand forecasts be had in the model
- Procedures of the international comparison of fuel energy and electric energy demand be had in the model

7.1.2 Structure of demand forecast model

At first, the model forecasts final energy and electric power demands by sector, and it calculates the country wide electric power consumption, fuel energy consumption and primary energy consumption. The outline of the model flow is as follows;

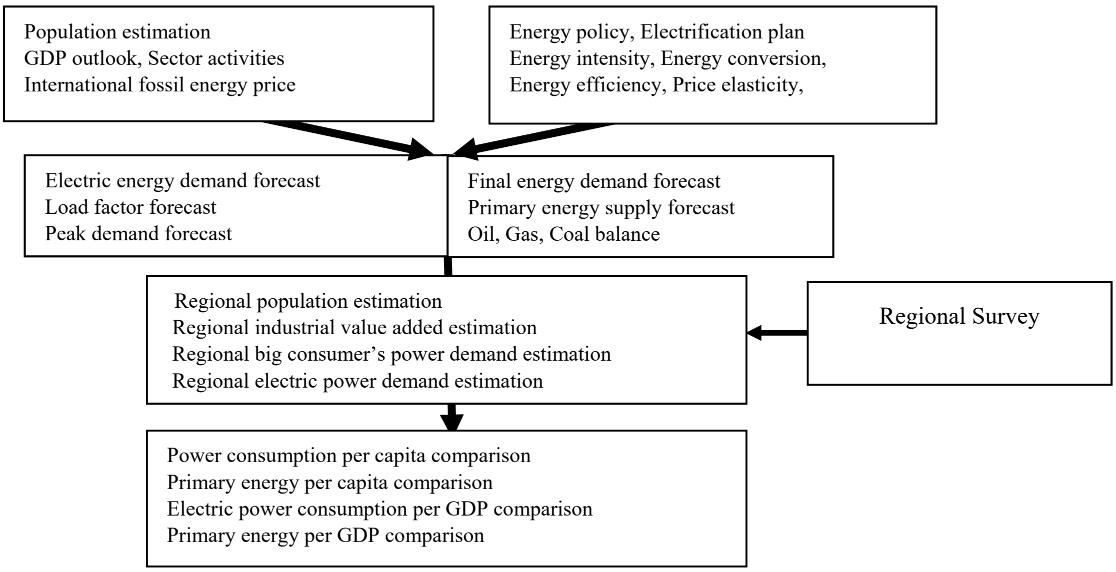
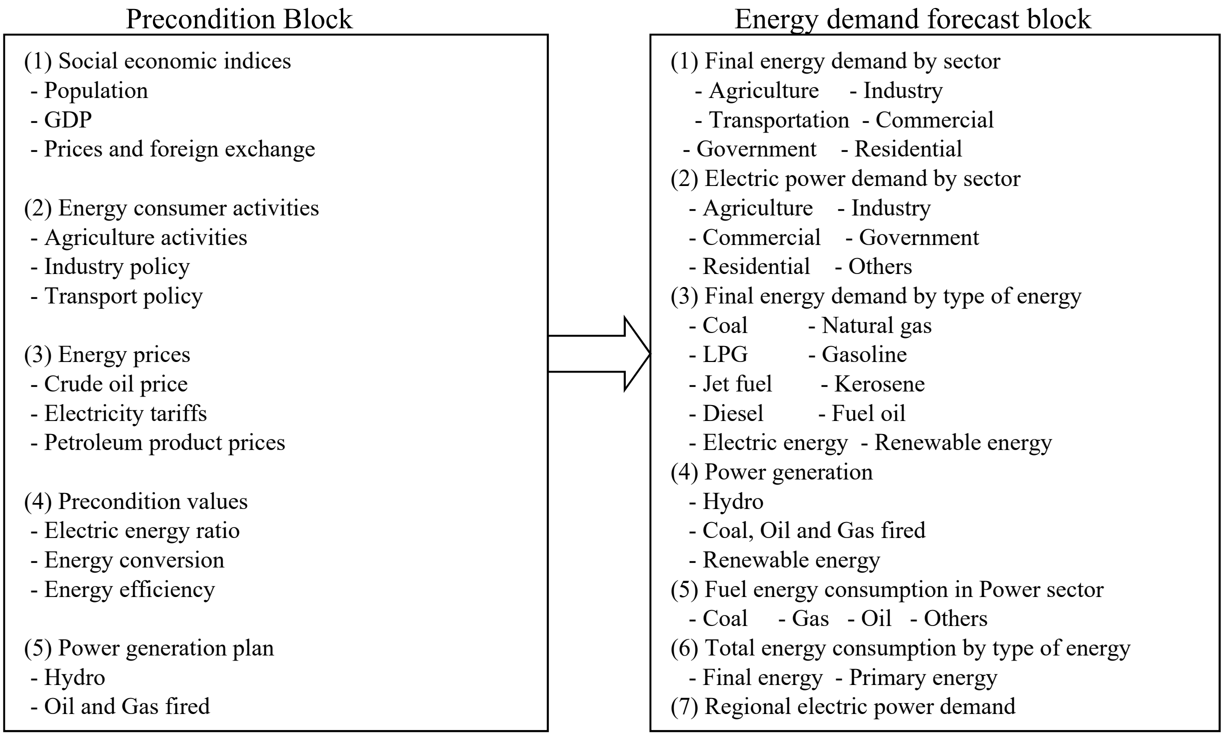


Figure 7.1.2-1 Outline of demand model flow

As the methodologies of the model building, energy demand / supply balance technology defined by International Energy Agency (IEA), econometric model building theory for expressing economic equations, “Simple.E” software to be MS-Excel add-in module as econometric model engine are used for building the model. The model outline is as follows;



Note: Electric energy ratio = Electric energy consumption / Final energy consumption * 100

Figure 7.1.2-2 Outline of model structure

7.1.3 Procedures of the demand model

The sectors of fuel energy and electric energy power consumptions are Agriculture, Industry, Commercial & Services, Public, Transport and Residential. The fuel energy and electric power demands to sum up the sectoral fuel energy and electric power demands become the country wide fuel energy and electric power demand. The procedures of the demand forecasts are as follows;

Table 7.1.3-1 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
(4) Sum up electric energy and fuel energy demand in the whole country
(5) Estimate future T/D loss and Load factor
(6) Estimate electric power generation and fuel consumption by facility
(7) Estimate domestic fuel energy consumption
(8) Estimate electric energy and fuel energy consumption per GDP, and per capita
(9) Forecast regional power demand

The establishing of the forecasting equations is as the following procedures. At first, the future energy consumption intensities to GDP (but energy consumption per capita in Residential sector) are estimated by the past trends. The next, the future demands are calculated by using the following steps and equations.

Step 1 Sectoral total energy consumption by sector (Ai)

＝ Sectoral total energy consumption intensity of sector(i)

× Sectoral GDP(i) （Population is used for Residential sector）

Definition of Sectoral total energy consumption by sector (Ai)

A1: Agriculture, A2: Industry, A3: Transportation, A4: Commercial & services, A5: Government,

A6: Residential

Definition of Sectoral total energy consumption intensity of sector (i)

Sectoral energy consumption / Sectoral GDP for business sectors（A1, A2, A3, A4, A5）

Residential sector energy consumption / population （A6）

Future intensity is estimated by auto correlation analysis

Step 2 Sectoral electric energy demand (Bi)

＝Sectoral total energy consumption(Ai) × Electric energy ratio(i)

× Power tariff elasticity(i) × Energy Efficiency & Conservation index (i)

Definition of Sectoral electric energy demand (Bi)

B1: Agriculture, B2: Industry, B3: Transportation, B4: Commercial & services, B5: Government,

B6: Residential

Definition of Electric energy ratio

Electric energy consumption (ktoe) / Sectoral total energy consumption (ktoe)

Future electric energy ratio is estimated by auto correlation analysis. The sectors have the upper limits. The limits are estimated by experience of developed countries.

The elasticity of power tariff and EE&C policy effectiveness are set in the expressions.

Step 3 Sectoral fuel energy demand (Ci)

＝(Sectoral total energy consumption(Ai) – Sectoral electric energy demand)

× Energy price elasticity(i) ×EE&C indicator(i)

Definition of Sectoral fuel energy demand (Ci)

Ci: Agriculture, C2: Industry, C3: Transportation, C4: Commercial & services, C5: Government,

C6: Residential

Definition of fuel energy demand

=’Sectoral total energy demand – electric energy demand’

The elasticity of energy costs and EE&C policy effectiveness are set in the expressions.

Step 4 Electric energy demand as final energy demand(Di)

＝ Sum sectoral electric energy demand of Agriculture (B1), Industry (B2), Transportation (B3), Commercial & service(B4), Government(B5) and Residential(B6)

The electric energy demand as final energy demand is not dispatched energy demand, T/D loss is required to be added for the dispatched energy demand.

Step 5 Fuel energy demand as final energy demand (Ei)

＝Sum Fuel energy demand of Agriculture(C1), Industry(C2), Transportation(C3), Commercial & service(C4), Government (C5) and Residential(C6)

Fuel energy demand as final energy demand is energies consumed in end users. Generally, Electric energy, Natural gas, Oil products, Coal, Coal products and Woods /charcoal are used.

Step 6 Dispatched electric energy demand(Fi)

＝Electric energy demand as final energy demand(D)＋T/D loss

T/D loss is calculated by T/D loss rate. The rate is set by the governmental target and/or Power sector targets.

Step 7 Forecast Peak demand (G)

＝Dispatched electric energy demand (F) / Load factor / 24hours / 365 days

Definition of Peak power demand （MW）

Dispatched electric energy demand / 24 hours/ 365days / Load factor

Definition of Load factor (%)

Average load a year (MW)/ Peak load (MW)in the year ×100

7.2 Preconditions and Scenario setting

7.2.1 Preconditions of social economic outlooks

The followings are the preconditions of population, GDP, foreign exchange, inflation rate and crude oil price.

(1) Growth rate of population

According to 2002 and 2012 census of Tanzania, the past trends of population in Tanzania are 2.9 % per year from 1988 to 2002 and 2.7 % per year from 2002 to 2012. It can be considered that the future growth rate of the population gradually will be going down in comparing to the past trends. Therefore, the population and the growth rate of Tanzania are set as follows;

Table 7.2.1-1 Population outlook of Tanzania

Unit: 1000 person

Items	2012~ 2015	2015~ 2020	2020~ 2025	2025~ 2030	2030~ 2035	2035~ 2040
Growth rate (%)	2.7	2.7	2.1	2.1	1.6	1.5
Total population	48,500	55,800	61,500	68,800	74,500	80,100
(Mainland)	47,100	54,200	59,700	66,700	72,300	77,800
(Zanzibar)	1,400	1,600	1,800	2,100	2,200	2,300

Note: Number of the population is at the end of the year in the blocks.

Source: The actual data are referred to the census 2002 and 2012, and the outlook is estimated by PSMP2016 UPDATE

By the above population growth rate, the future regional populations are estimated as the following table. For estimating the regional population growths, the elasticity between regional population growth rate and country population growth rate are calculated.

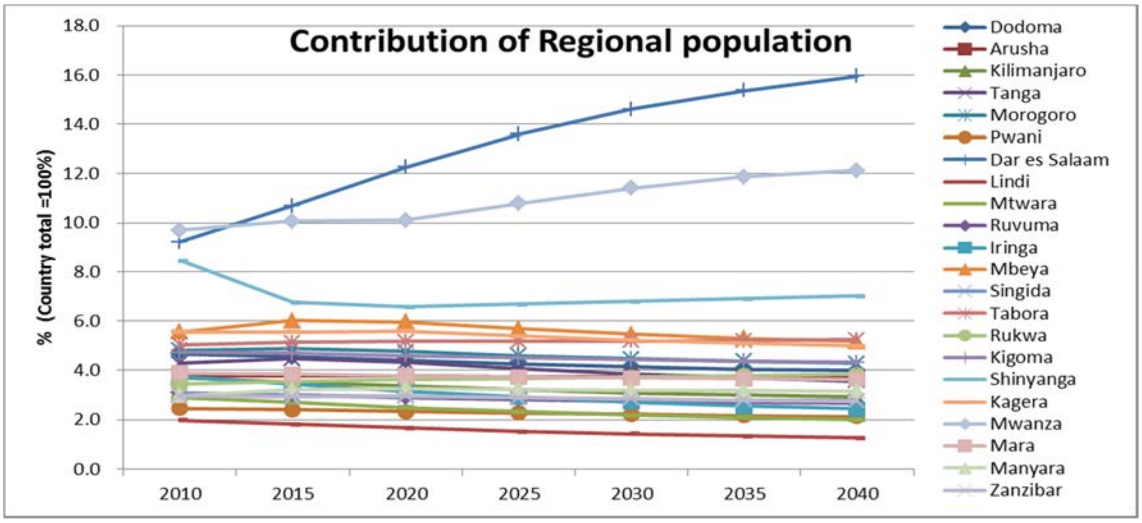
Basically, the elasticity are applied to the calculation of future regional population, however, the elasticity more than 2.0 (it means significantly higher growth rate than other regions) gradually go down to 1.0 (it means the future growth rate closes to the average of the country growth rate.) After that, the total population of the regional population is adjusted in order to meet the country population.

Table 7.2.1-2 Population prediction by Tanzanian state

Unit: Population 1000 person, Growth rate: %

	Region names	2012	2015	2020	2025	2030	2035	2040	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35
1	Dodoma	2,099	2,234	2,472	2,706	2,932	3,146	3,347	2.1	2.0	1.8	1.6	1.4	1.3
2	Arusha	1,711	1,857	2,121	2,386	2,647	2,902	3,146	2.8	2.7	2.4	2.1	1.9	1.6
3	Kilimanjaro	1,650	1,739	1,893	2,044	2,186	2,319	2,444	1.8	1.7	1.5	1.4	1.2	1.1
4	Tanga	1,898	2,204	2,438	2,594	2,740	2,875	2,993	3.6	2.0	1.2	1.1	1.0	0.8
5	Morogoro	2,162	2,400	2,683	2,930	3,167	3,392	3,591	3.0	2.2	1.8	1.6	1.4	1.1
6	Pwani	1,107	1,181	1,312	1,441	1,566	1,685	1,790	2.2	2.1	1.9	1.7	1.5	1.2
7	Dar es Salaam	4,451	5,269	6,913	8,649	10,346	11,940	13,387	5.8	5.6	4.6	3.6	2.9	2.3
8	Lindi	867	892	933	971	1,005	1,036	1,064	0.9	0.9	0.8	0.7	0.6	0.5
9	Mtwara	1,276	1,324	1,405	1,481	1,552	1,617	1,676	1.2	1.2	1.1	0.9	0.8	0.7
10	Ruvuma	1,387	1,478	1,639	1,798	1,952	2,098	2,236	2.2	2.1	1.9	1.7	1.5	1.3
11	Iringa +Njombe	1,646	1,699	1,782	1,857	1,925	1,988	2,045	1.0	1.0	0.8	0.7	0.6	0.6
12	Mbeya	2,478	2,965	3,354	3,623	3,878	4,117	4,328	4.4	2.5	1.6	1.4	1.2	1.0
13	Singida	1,382	1,481	1,658	1,835	2,007	2,172	2,328	2.4	2.3	2.0	1.8	1.6	1.4
14	Tabora	2,292	2,527	2,911	3,294	3,674	4,045	4,404	3.2	2.9	2.5	2.2	1.9	1.7
15	Rukwa +Katavi	1,573	1,747	2,042	2,343	2,644	2,943	3,222	3.4	3.2	2.8	2.5	2.2	1.8
16	Kigoma	2,128	2,306	2,589	2,866	3,135	3,393	3,624	2.6	2.3	2.1	1.8	1.6	1.3
17	Shinyanga+ Simiyu	3,880	3,329	3,703	4,256	4,812	5,362	5,879	-1.7	2.2	2.8	2.5	2.2	1.9
18	Kagera	2,485	2,733	3,151	3,434	3,704	3,960	4,186	2.7	2.9	1.7	1.5	1.3	1.1
19	Mwanza +Geita	4,556	4,962	5,690	6,865	8,096	9,221	10,179	3.5	2.8	3.8	3.4	2.6	2.0
20	Mara	1,759	1,894	2,134	2,376	2,613	2,841	3,058	2.5	2.4	2.2	1.9	1.7	1.5
21	Manyara	1,347	1,585	1,838	2,054	2,265	2,469	2,648	4.4	3.0	2.2	2.0	1.7	1.4
	Mainland total	44,134	47,807	54,660	61,802	68,846	75,520	81,575	2.8	2.7	2.5	2.2	1.9	1.6
22	Zanzibar total	1,359	1,439	1,679	1,836	2,024	2,172	2,315	2.5	3.1	1.8	2.0	1.4	1.3
	Total	45,493	49,246	56,339	63,639	70,869	77,692	83,891	2.7	2.7	2.5	2.2	1.9	1.5

Source: Actual data in 2012 from Census 2012, the outlook is estimated by PSMP2016 UPDATE

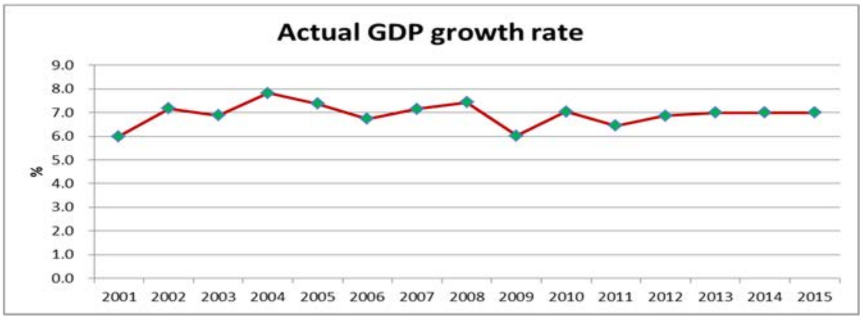


Source: PSMP2016 UPDATE

Figure 7.2.1-1 Future contribution of the state population

(2) GDP growth rate

According to the Governmental statistics, the GDP growth rates from 2002 to 2015 were around 7 % per year, and even though the growth rates were dropped to 6.0 % in 2009, it is recovered to 7 % after the year of 2010.



Source: NBS statistical Abstracts

Figure 7.2.1-2 The past growth rates of real GDP (from 2001 to 2015)

And it can be estimated that the real GDP growth rates of Tanzania are in the range from 6 % to 9 % in long term.

Table 7.2.1-3 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. It means that Tanzania becomes a middle income country.
FYDP	The economic growth rate from 2000 to 2010 was 7 % per year, therefore, more than 10 % of the growth rate after 2011 to 2025 is required.
FYDP Ⅱ	Economic renovation by industrialization policy increases GDP share of manufacturing sector from 8% to 19 % in Tanzanian GDP.
LTPP	During 2010 – 2015, Make construct infrastructure and energy supply During 2015 – 2020, Make grow natural gas industry and agroindustry During 2020 – 2025, Make grow Manufacturing, Services and Exports

Note: FYDP: Five year development plan 2011-2016 and FYDPⅡ is a plan for 2016/17 - 2020/21.
Note: LTPP: Long term perspective plan

For encouraging the economic growth, the action plans and projects described in VISION 2025, FYDP (Five-year development plan) and LTPP (Long term perspective plan) are in the following tables.

Table 7.2.1-4 Action plans and projects included in economic plans

	Future Social and Economic Plans & Stratigies
2015 - 2025	01. High population growth rate
	02. Increased urbanization
	03. Industrial park (tixitile industry) and Urban development
	04 Foreign trade to EAC and SADC will be increased over the future
	05. Inflow FDI will be increased (113 companies in EPZA located in 19 regions as of 2014)
	06. Exports will be shifted from the EU to China,South Africa and EAC.
	07.The economic reforms policies will reshape the corporate environment
	08. Tanzania has not of debt risk. it is 18.9% of GDP compared to the threshold of 50%.
	09. Developing agriculture, manufacturing, ICT and banking sectors
	10. Improve Power tariff and intorducing IPP
	11. Rural electrification promotion & Renewable energy development
	12. Developing transportation infrastructure
	13. Developing country (GDP $1000 per capita) in 2025
2025 - 2035	1. Developing Narural gas production
	2. Developing natural gas related industries
	3. Developing chemical, machinery and engineering industries
	4. Increase private income
	5. Use many electric appriances in housholds
	6. Developing international trading among neibouring countries
	7. Developing natural resources
	8. Constructing high sky buildings and high rising apartments
	9. Not middle developed counry, it is developing country (GDP $2000 per capita) in 2035
2035 - 2045	1. Stop high population growth
	2. High age socity and reducing working age population
	3. High cost for social security
	4. Use full cell engine and electric engine cars
	5. Midde developing country (GDP $3000 per capita) in 2045

Source：VISION2025、FYDP and LTPPs

When considering the above governmental economic strategies, the following scenarios are assumed.

HIGH scenario: After 2025, the high economic growth by developing natural gas and the related industries is achieved in company with developing the economic policies in Vision 2025.

BASE scenario: The current economy is grown by the main two factors with higher population growth and increasing labor productivity. After the year of 2025, it can be considered that the population growth rate is gradually going down and the economy is growing more stable than the current growth rate.

LOW scenario: Although the domestic economic conditions are the same to BASE scenario, however, due to busting the international political and economic conflicts, the international economy is not encouraged. The conflicts give negative impacts to Tanzanian economy.

When the above scenarios are shown by the GDP growth rates, the results are as follows;

Table 7.2.1-5 Real GDP by the scenario case

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 PSMP2016 UPDATE Study Team after discussion MOF, Planning commission and other relevant organizations.

Source: PSMP2016 UPDATE

And the sectoral GDP growths to realize the above GDP scenario cases are in the following table.

Table 7.2.1-6 Sectoral GDP growths by scenario case

HIGH	GDP growth	Elasticity				Sector Growth		
	Total	Agriculture	Industry	Commercial		Agriculture	Industry	Commercial
2014	7%	0.6	1.20	1.00	2014	4.2%	8.4%	7.0%
2015-2020	8%	0.7	1.20	1.00	2015-2020	5.6%	9.6%	8.0%
2021-2025	8%	0.7	1.30	0.90	2021-2025	5.6%	10.4%	7.2%
2026-2030	9%	0.6	1.30	0.90	2026-2030	5.4%	11.7%	8.1%
2031-2035	9%	0.6	1.30	0.90	2031-2035	5.4%	11.7%	8.1%
2036-2040	8%	0.6	1.30	0.90	2036-2040	4.8%	10.4%	7.2%
Base	GDP growth	Elasticity				Sector Growth		
	Total	Agriculture	Industry	Commercial		Agriculture	Industry	Commercial
2014	7%	0.6	1.20	1.00	2014	4.2%	8.4%	7.0%
2015-2020	7%	0.7	1.20	1.00	2015-2020	4.9%	8.4%	7.0%
2021-2025	7%	0.9	1.25	0.90	2021-2025	6.3%	8.8%	6.3%
2026-2030	6%	0.9	1.25	0.90	2026-2030	5.4%	7.5%	5.4%
2031-2035	6%	0.9	1.25	0.90	2031-2035	5.4%	7.5%	5.4%
2036-2040	5%	0.9	1.25	0.90	2036-2040	4.5%	6.3%	4.5%
LOW	GDP growth	Elasticity				Sector Growth		
	Total	Agriculture	Industry	Commercial		Agriculture	Industry	Commercial
2014	7%	0.6	1.10	1.00	2014	4.2%	7.7%	7.0%
2015-2020	6%	0.9	1.10	1.00	2015-2020	5.4%	6.6%	6.0%
2021-2025	6%	0.9	1.10	1.00	2021-2025	5.4%	6.6%	6.0%
2026-2030	5%	0.9	1.10	1.00	2026-2030	4.5%	5.5%	5.0%
2031-2035	5%	0.9	1.10	1.00	2031-2035	4.5%	5.5%	5.0%
2036-2040	4%	0.9	1.10	1.00	2036-2040	3.6%	4.4%	4.0%

Source: PSMP2016 UPDATE

(3) Foreign exchange rates

The volatility of foreign exchange rates effects coming Foreign Direct Investment (FDI) and inflation rate. When looking at the devaluation of US dollar and Euro currencies, it cannot be considered that Tanzanian currency (TZS) is devaluated drastically in short term. However, it is difficult to predict foreign exchange rate in long term, so it is assumed that the current exchange rate with 2,200 TZS per US dollar (as of June 2016) is devaluated a little bit in future. When considering exchange rate by 2025, inflation rates are around 2 % per year for USA and 5 % per year for Tanzania. Under the inflation rates of the two countries, Tanzanian currency devaluates with 3 % per year according to foreign exchange theory. In the Study, it is assumed that the foreign exchange rate after 2025 is kept with the same level by the reason why Tanzanian currency will be demanded due that some level of FDI will be expected to come in future.

(4) Inflation rate

Under the stable inflation economy (3 % ~5 %), increasing saving rate and active investments are expected, however, the normal economic growth is not expected under hyperinflation. Although the Tanzanian inflation rate from 2004 to 2008 was more than 10 % per year, but it became normal level in 2009 and 2010. During 2011 ~ 2015, as there are some domestic prices in the increasing aspects, it is predicted that the inflation rate during the term is 5 % per year. After that, it can be considered that Tanzanian inflation rate will become more stable.

Table 7.2.1-7 Inflation rate prediction

	2013-15	2015-20	2020-25	2025-30	2030-35	2035-40
Inflation rate（%）	7.0 %	5.0 %	5.0 %	4.0 %	3.0 %	3.0 %
GDP deflator	203.3	269.4	343.9	418.4	485.0	562.3

Note: Base year of GDP deflator is 2005 =100, and it is the value at the end of year.
Source: Actual data from Central bank

(5) Crude oil price

As of October 2016, WTI (West Texas intermediate) in New York market is kept in around $50/bbl. The crude oil exporting countries like Saudi Arabia expect that crude oil price should be increased for compensating benefits from US dollar devaluation (it equal to US inflation rate with 2%). However, according to some oil experts, when looking at recent energy market supplying shale oil & gas, it is predicted that the near future crude oil price is kept at current level by 2020, after the year, the crude oil price gradually increased again. By considering the international oil market, WTI price is assumed in the following table.

Table 7.2.1-8 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

Note: The price is at 2015 price. Note: Brent price is nearly same to WTI price.
Source: The Institute of Energy Economic, Japan

7.2.2 The preconditions on electric energy consumption

(1) Un-constrain demand

The Un-constrained demand is calculated with adding potential factors to constrained energy demand (Statistical data). The expression for calculating the un-constrained demand in the Study is defined as follows;

Un-constrained demand ＝ Constrained demand*(1＋Potential factor)

The Un-constrained demands also are applied to Industry, Commercial & Services, Agriculture and Residential sectors. It is not applied to Governmental (mainly for Zanzibar) and Gold mining power sectors. The un-constrained demands from 2002 to 2015 are as follows;

Table 7.2.2-1 Un-constrained electric energy demand from statistical electric energy consumption

Unit: GWh

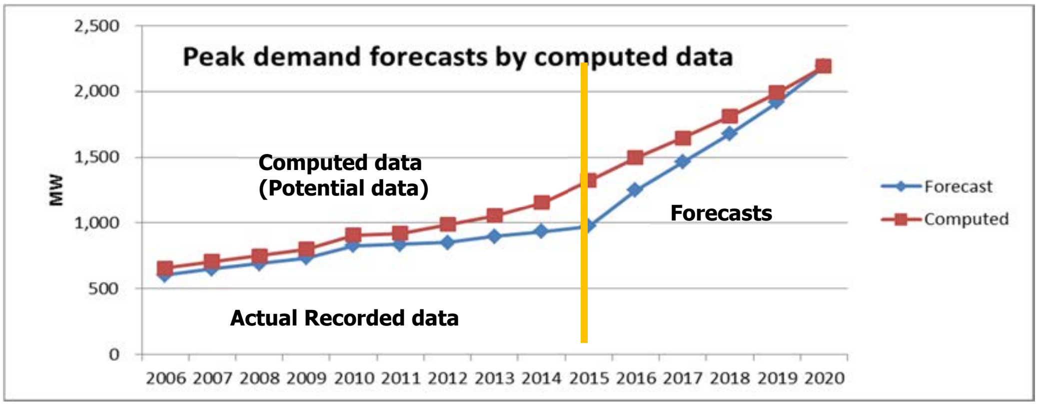
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Actural	**Actual power consumption**	**2,831**	**2,770**	**3,178**	**3,378**	**3,589**	**4,048**	**4,029**	**4,429**	**4,819**	**5,029**	**5,239**
data	Industry(T2*0.95+T3)	1,261	1,184	1,347	1,478	1,635	1,924	1,913	2,039	2,314	2,363	2,412
	Transport	0	0	0	0	0	0	0	0	0	0	0
	Residential (T1*0.9+D1)	1,105	1,098	1,276	1,320	1,377	1,587	1,472	1,678	1,855	1,921	1,986
	Commercial and Services (T1*0.1+T2*0.05)	133	122	149	165	181	224	209	244	276	287	297
	Agriculture/forestry	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16
	Government(T5)	186	204	231	229	258	175	277	299	219	282	345
	GOLD (T7+T8)	146	161	176	185	139	138	156	169	155	177	199
Potential	Industry	1.11	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.18	1.25
factor	Transport (Rail way)	1.11	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.18	1.25
Factor	Residential	1.11	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.18	1.25
	Commercial and public services	1.11	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.18	1.25
	Agriculture/forestry	1.11	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
	Government(T5)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	GOLD (T7+T8)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Potential	**Potential power consumption**	**3,106**	**3,010**	**3,455**	**3,674**	**3,909**	**4,421**	**4,388**	**4,825**	**5,263**	**5,829**	**6,413**
demand	Industry	1,400	1,303	1,481	1,626	1,799	2,116	2,105	2,243	2,545	2,776	3,015
	Transport	0	0	0	0	0	0	0	0	0	0	0
	Residential	1,226	1,208	1,403	1,452	1,515	1,746	1,620	1,846	2,040	2,257	2,483
	Commercial and public services	148	135	164	182	199	246	230	269	304	337	372
	Agriculture/forestry	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.17	0.18
	Government(T5)	186	204	231	229	258	175	277	299	219	282	345
	GOLD (T7+T8)	146	161	176	185	139	138	156	169	155	177	199

Source: The actual data source is TANESCO、Potential factor is estimated by PSMP2016 UPDATE

The relations between constrained electric energy demand and un-constrained electric energy demand are as follows;

a. Future electric energy demands are estimated by un-constrained electric energy demand
b. Constrained electric energy demand is calculated by un-constrained data.
c. The catch up rate is defined by "Constrained demand / Un-constrained demand". The value moves from 0 to 100 %.
d. When catch up rate reaches 100%, constrained and un-constrained data becomes the same value.
e. Catch up rates are set with 100% towards 2020. It means future electric energy demands will be reached to un-constrained electric energy demand by 2020.

By the above procedures, the forecasting electric energy demand at the starting years closes to the constrained (statistical) electric energy demand. However, the forecasting electric energy demand gradually closes to the un-constrained electric energy demand. The following table shows the movement of the forecasting electric energy demand in the range between constrained (statistical) electric energy demand and un-constrained electric energy demand. In the following table, the blue line means the un-constrained demand and red line means electric energy demand based on constrain (Statistical) data.



Note: As of 2015, the difference between the un-constrained data and the actual data is 22 %,

Figure 7.2.2-1 The relation among potential and statistical forecasting

(2) Electric energy ratio

The definition of "Electric energy ratio" is different from "Electrification rate". Electric energy ratio is defined by electric energy consumption share in final energy consumption. When looking at electric energy ratio in country wide, it is shown in the following table.

Table 7.2.2-2 Electric energy ratio in some countries and area

Unit: %

	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

Note: Electric energy ratio (%)= Electric energy consumption in a country (toe) / Final energy consumption (toe)
Source: "Energy and Economic Statistics Abstract 2014" by The institute of Energy economics, Japan

Electric energy ratio can be defined by sector classification such as Industry, Commercial & Services, Government and Residential sectors. Most of the electric energy ratios are increased year by year. As fossil energies are used so much in Transportation sectors, the electric energy ratio are lower than other sectors, otherwise, the electric energy ratios of Government and Commercial & Services sectors are comparatively so high that much electric energy is consumed in buildings as offices, hospitals and schools.

Table 7.2.2-3 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

Note: Electric energy ratio= Electric energy consumption (toe) / Final energy consumption (toe)
Source: PSMP2016 UPDATE

The electric energy ratios are not defined for Agriculture, Government and Transportation sectors by the reasons why Agriculture sector's electric energy consumption is very small, Government sector uses only electric energy and Transportation sector does not use any electricity. In 2040, it is felt what the electric energy ratio is 9.6 % in Tanzania is too small, however, when looking at current situation to consume huge woods and charcoal energies, the electric energy ratio in 2040 is reasonable, even though the contribution of woods and charcoal consumption in the final energy consumption is reduced toward 2040.

(3) Target of T/D loss rate

The following table shows T/D loss rates calculated by T/ D loss consumption. It is actual T/D loss rates from 2001 to 2015, and it is improved after 2016, and it will be reached to 11.4 % by 2025 and further years.

Table 7.2.2-4 Prediction of T/D loss

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		

Note: T/D Loss rate = T/D loss energy / Dispatched electric energy,
Dispatch electric energy = Final electric energy demand + T/D loss
The future T/D rate as TANESCO is 12.4 % in 2020 and 11.4 % in 2025.
Source: Actual data up to 2015 is TANESCO and future loss rates are TANESCO's targets.

(4) Load Factor

Load factor is calculated by using actual peak demand (source by TANESCO data) and power generation, the following is an expression for calculation. Regarding forecasting load factors, it is set under the precondition that the target of load factor is reached to 70 % after 2030.

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

Table 7.2.2-5 Load factor forecasts

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		

Note: Generation ＝ Final electric energy consumption ＋T/D loss + Own use ‐ Import + Export
Source: Actual load factor and future load factor are provided by TANESCO

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

Effect of EE&C policy appears power and fossil consumption of industry sector and fossil consumption in Residential sector. Each effect rate is 0.5 % per year after 2026. The effect rate is accumulated in the forecasted period. It means that the EE&C policy makes the demand reduction with 5 % after 10 years, and 10% reduction comparing to the demand without EE&C policy after 20 years.

7.3 Power demand Forecasts

7.3.1 Power demand forecasts by scenario case

Under the above preconditions, the send out electric energy demands of Tanzania are as the following table. The electric energy demand of Base case is 6,310 GWh in 2015, it becomes 22,430 GWh in 2025, it means 3.6 times for 10 years from 2015 to 2025. And it becomes 57,340 GWh in 2035, it means 9 times for 20 years from in 2015 to 2035, it becomes 87,890 GWh in 2040, it means 14 times for 25 years from 2015 to 2040. The average growth rates from 2015 to 2040 are 11.1 % in Base case, 13.4 % in High case and 9.6 % in Low case.

Table 7.3.1-1 Electric energy demand forecasts (Dispatched energy)

Unit: GWh

	2015	2016	2017	2018	2019	2020	2025	2030	2035	2040	2040/15
HIGH	6,310	7,870	9,070	10,460	12,040	13,840	24,640	45,270	82,830	145,470	13.4
BASE	6,310	7,820	8,970	10,270	11,740	13,440	22,430	36,000	57,340	87,890	11.1
LOW	6,310	7,640	8,650	9,780	11,060	12,470	19,450	29,250	43,660	63,090	9.6

Source: PSMP2016 UPDATE

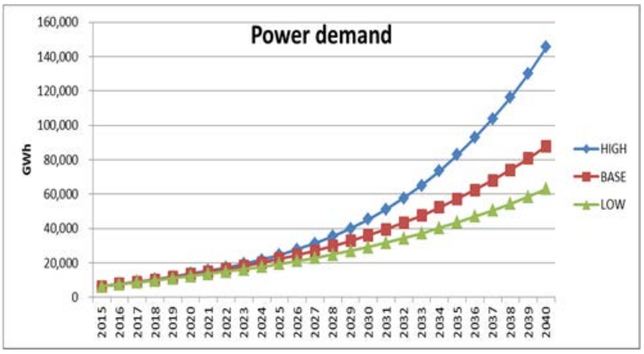
The peak power demand forecasts of Tanzania are shown in the following table. The peak power demand of Base case in 2015 is 974 MW, it becomes 2 times as 2,190 MW in 2020, 4 times as 3,660 MW in 2025, 10 times as 9,350 MW in 2035 and it becomes 15 times as 14,330 MW in 2040.

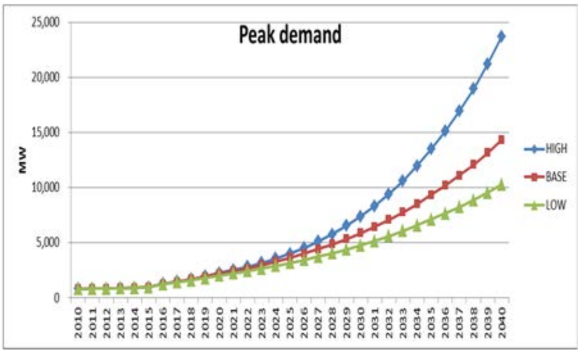
Table 7.3.1-2 Peak power demand forecasts

Unit: MW

	2015	2016	2017	2018	2019	2020	2025	2030	2035	2040	2040/15
HIGH	974	1,280	1,480	1,700	1,960	2,260	4,020	7,380	13,510	23,720	13.6
BASE	974	1,270	1,460	1,680	1,920	2,190	3,660	5,870	9,350	14,330	11.4
LOW	974	1,250	1,410	1,600	1,800	2,030	3,170	4,770	7,120	10,290	9.9

Source: PSMP2016 UPDATE





Source: PSMP2016 UPDATE

Figure 7.3.1-1 Electric Energy demand

Figure 7.3.1-2 Peak demand forecasts

7.3.2 Power demand by sector

(1) Base case

In Base case, the electric energy demands by sector and by power tariff category are as following table. The contributions of the electric energy demands in Industry sector and Commercial & Service sector are comparatively higher than others.

Table 7.3.2-1 Electric energy demand forecasts by sector (Base case)

Unit: GWh

		2015	2020	2025	2030	2035	2040
Power demand	Total	6,310	13,440	22,430	36,000	57,340	87,890
by Sector	Agriculture.Fishery	0	0	0	10	10	30
	Industry	2,410	5,590	9,510	15,140	24,240	36,730
	Commercial & Services	300	680	1,290	2,350	4,280	7,470
	Government	340	650	990	1,310	1,650	1,920
	Gold	200	210	210	220	230	230
	Residential	1,990	4,640	7,870	12,870	20,390	31,490
	T/S loss	1,070	1,670	2,560	4,100	6,540	10,020
Share	Total	100.0	100.0	100.0	100.0	100.0	100.0
by Sector	Agriculture.Fishery	0.0	0.0	0.0	0.0	0.0	0.0
	Industry	38.2	41.6	42.4	42.1	42.3	41.8
	Commercial & Services	4.8	5.1	5.8	6.5	7.5	8.5
	Government	5.4	4.8	4.4	3.6	2.9	2.2
	Gold	3.2	1.6	0.9	0.6	0.4	0.3
	Residential	31.5	34.5	35.1	35.8	35.6	35.8
	T/S loss	17.0	12.4	11.4	11.4	11.4	11.4

Source: PSMP2016 UPDATE

Table 7.3.2-2 Growth rates of electric energy demands by sector（Base case）

Unit: %

	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2025/15	2035/15	2040/15
Total	4.6	16.3	10.8	9.9	9.8	8.9	13.5	11.7	11.1
Agriculture.Fishery	0.0	0.0	0.0	0.0	0.0	24.6	0.0	0.0	0.0
Industry	4.7	18.3	11.2	9.7	9.9	8.7	14.7	12.2	11.5
Commercial & Services	6.4	17.8	13.7	12.7	12.7	11.8	15.7	14.2	13.7
Government	13.6	13.8	8.8	5.8	4.7	3.1	11.3	8.2	7.2
Gold	7.4	1.0	0.0	0.9	0.9	0.0	0.5	0.7	0.6
Residential	4.6	18.4	11.1	10.3	9.6	9.1	14.7	12.3	11.7
T/S loss	1.4	9.3	8.9	9.9	9.8	8.9	9.1	9.5	9.4

Source: PSMP2016 UPDATE

Table 7.3.2-3 Electric energy demand forecasts by tariff category (Base case)

Unit: GWh

		2015	2020	2025	2030	2035	2040
Power demand	Total	6,300	13,440	22,440	36,000	57,340	87,880
by Tariff category	T1 + D1	2,280	4,980	8,590	14,320	23,230	36,780
	T2 + T3	2,410	5,930	10,090	16,050	25,690	38,930
	T5	340	650	990	1,310	1,650	1,920
	T7 + T8	200	210	210	220	230	230
	T/D loss	1,070	1,670	2,560	4,100	6,540	10,020
Share	Total	100.0	100.0	100.0	100.0	100.0	100.0
by Tariff category	T1 + D1	36.2	37.1	38.3	39.8	40.5	41.9
	T2 + T3	38.3	44.1	45.0	44.6	44.8	44.3
	T5	5.4	4.8	4.4	3.6	2.9	2.2
	T7 + T8	3.2	1.6	0.9	0.6	0.4	0.3
	T/D loss	17.0	12.4	11.4	11.4	11.4	11.4

Note: D1: Domestic use: First 50 kWh/month 0 %, over 50 units consumption 71 %
T1: General use T2: Low Voltage T3: Medium Voltage T5 : High Voltage (Zanzibar bulk tariff)
T7, T8 : Gold mining special tariffs .
Source: PSMP2016 UPDATE

Table 7.3.2-4 Growth rate of electric energy demand by tariff category (Base case)

Unit: %

	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2025/15	2035/15	2040/15
Total	4.5	16.4	10.8	9.9	9.8	8.9	13.5	11.7	11.1
T1 + D1	4.7	16.9	11.5	10.8	10.2	9.6	14.2	12.3	11.8
T2 + T3	4.7	19.7	11.2	9.7	9.9	8.7	15.4	12.6	11.8
T5	13.6	13.8	8.8	5.8	4.7	3.1	11.3	8.2	7.2
T7 + T8	7.4	1.0	0.0	0.9	0.9	0.0	0.5	0.7	0.6
T/D loss	1.4	9.3	8.9	9.9	9.8	8.9	9.1	9.5	9.4

Note: the categories of D1, T1, T2, T3, T5, T7, T8 are same to above
Source: PSMP2016 UPDATE

(2) High case

In High case, the electric energy demand in Industry sector comparatively higher than others, after the year of 2035, the electric energy demand of Industry sector will occupy more than 50 % in the total electric energy demand.

Table 7.3.2-5 Electric energy demand forecast by sector and the shares (High case)

Unit: GWh

		2015	2020	2025	2030	2035	2040
Power demand	Total	6,310	13,840	24,640	45,270	82,830	145,470
by Sector	Agriculture.Fishery	0	0	0	10	10	30
	Industry	2,410	5,890	10,880	21,180	41,260	75,560
	Commercial & Services	300	710	1,420	2,980	6,190	12,210
	Government	340	670	1,060	1,590	2,250	2,920
	Gold	200	210	220	230	240	240
	Residential	1,990	4,640	8,250	14,120	23,440	37,930
	T/D loss	1,070	1,720	2,810	5,160	9,440	16,580
Share	Total	100.0	100.0	100.0	100.0	100.0	100.0
by Sector	Agriculture.Fishery	0.0	0.0	0.0	0.0	0.0	0.0
	Industry	38.2	42.6	44.2	46.8	49.8	51.9
	Commercial & Services	4.8	5.1	5.8	6.6	7.5	8.4
	Government	5.4	4.8	4.3	3.5	2.7	2.0
	Gold	3.2	1.5	0.9	0.5	0.3	0.2
	Residential	31.5	33.5	33.5	31.2	28.3	26.1
	T/D loss	17.0	12.4	11.4	11.4	11.4	11.4

Source: PSMP2016 UPDATE

Table 7.3.2-6 Growth rate of electric energy demand (High case)

Unit: %

	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2025/15	2035/15	2040/15
Total	4.6	17.0	12.2	12.9	12.8	11.9	14.6	13.7	13.4
Agriculture.Fishery	0.0	0.0	0.0	0.0	0.0	24.6	0.0	0.0	0.0
Industry	4.7	19.6	13.1	14.3	14.3	12.9	16.3	15.3	14.8
Commercial & Services	6.4	18.8	14.9	16.0	15.7	14.6	16.8	16.3	16.0
Government	13.6	14.5	9.6	8.4	7.2	5.4	12.0	9.9	9.0
Gold	7.4	1.0	0.9	0.9	0.9	0.0	1.0	0.9	0.7
Residential	4.6	18.4	12.2	11.3	10.7	10.1	15.3	13.1	12.5
T/D loss	1.4	10.0	10.3	12.9	12.8	11.9	10.1	11.5	11.6

Source: PSMP2016 UPDATE

Table 7.3.2-7 Power demand forecast by tariff category (High case)

	2015	2020	2025	2030	2035	2040
Total	6,300	13,840	24,640	45,270	82,830	145,480
T1 + D1	2,280	5,000	9,020	15,840	27,170	45,640
T2 + T3	2,410	6,240	11,530	22,450	43,730	80,100
T5	340	670	1,060	1,590	2,250	2,920
T7 + T8	200	210	220	230	240	240
T/D loss	1,070	1,720	2,810	5,160	9,440	16,580
Total	100.0	100.0	100.0	100.0	100.0	100.0
T1 + D1	36.2	36.1	36.6	35.0	32.8	31.4
T2 + T3	38.3	45.1	46.8	49.6	52.8	55.1
T5	5.4	4.8	4.3	3.5	2.7	2.0
T7 + T8	3.2	1.5	0.9	0.5	0.3	0.2
T/D loss	17.0	12.4	11.4	11.4	11.4	11.4

Source: PSMP2016 UPDATE

Table 7.3.2-8 Growth rate of electric energy demand by tariff category (High case)

Unit: %

	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2025/15	2035/15	2040/15
Total	4.5	17.0	12.2	12.9	12.8	11.9	14.6	13.7	13.4
T1 + D1	4.7	17.0	12.5	11.9	11.4	10.9	14.7	13.2	12.7
T2 + T3	4.7	21.0	13.1	14.3	14.3	12.9	16.9	15.6	15.0
T5	13.6	14.5	9.6	8.4	7.2	5.4	12.0	9.9	9.0
T7 + T8	7.4	1.0	0.9	0.9	0.9	0.0	1.0	0.9	0.7
T/D loss	1.4	10.0	10.3	12.9	12.8	11.9	10.1	11.5	11.6

Source: PSMP2016 UPDATE

(3) Low case

In Low case, the electric energy demands of Commercial and Residential sectors are higher than others, it is the reason why the growth rate of Industry sector that is economic pulling engine not so high in Low case.

Table 7.3.2-9 Electric energy demand forecast by sector (Low case)

		2015	2020	2025	2030	2035	2040
Power demand	Total	6,310	12,470	19,450	29,250	43,660	63,090
by Sector	Agriculture.Fishery	0	0	0	10	10	30
	Commercial & Services	300	640	1,200	2,150	3,840	6,540
	Government	340	620	920	1,180	1,450	1,630
	Gold	200	200	210	220	220	230
	Residential	1,990	4,340	7,030	10,970	16,580	24,440
	T/D loss	1,070	1,550	2,220	3,330	4,980	7,190
Share	Total	100.0	100.0	100.0	100.0	100.0	100.0
	Agriculture.Fishery	0.0	0.0	0.0	0.0	0.0	0.0
	Industry	38.2	41.1	40.5	38.9	38.0	36.5
	Commercial & Services	4.8	5.1	6.2	7.4	8.8	10.4
	Public Street light	0.0	0.0	0.0	0.0	0.0	0.0
	Gold	3.2	1.6	1.1	0.8	0.5	0.4
	Residential	31.5	34.8	36.1	37.5	38.0	38.7
	T/D loss	17.0	12.4	11.4	11.4	11.4	11.4

Source: PSMP2016 UPDATE

Table 7.3.2-10 Growth rate of electric energy demand (Low case)

Unit: %

	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2025/15	2035/15	2040/15
Total	4.6	14.6	9.3	8.5	8.3	7.6	11.9	10.2	9.6
Agriculture.Fishery	0.0	0.0	0.0	0.0	0.0	24.6	0.0	0.0	0.0
Commercial & Services	6.4	16.4	13.4	12.4	12.3	11.2	14.9	13.6	13.1
Government	13.6	12.8	8.2	5.1	4.2	2.4	10.5	7.5	6.5
Gold	7.4	0.0	1.0	0.9	0.0	0.9	0.5	0.5	0.6
Residential	4.6	16.9	10.1	9.3	8.6	8.1	13.5	11.2	10.6
T/D loss	1.4	7.7	7.4	8.4	8.4	7.6	7.6	8.0	7.9

Source: PSMP2016 UPDATE

Table 7.3.2-11 Electric energy demand forecast by tariff category (Low case)

Unit: GWh

		2015	2020	2025	2030	2035	2040
Power demand	Total	6,300	12,470	19,450	29,240	43,670	63,090
	T1 + D1	2,280	4,680	7,760	12,440	19,440	29,630
	T2 + T3	2,410	5,420	8,340	12,070	17,580	24,410
	T5	340	620	920	1,180	1,450	1,630
	T7 + T8	200	200	210	220	220	230
	T/D loss	1,070	1,550	2,220	3,330	4,980	7,190
Share	Total	100.0	100.0	100.0	100.0	100.0	100.0
	T1 + D1	36.2	37.5	39.9	42.5	44.5	47.0
	T2 + T3	38.3	43.5	42.9	41.3	40.3	38.7
	T5	5.4	5.0	4.7	4.0	3.3	2.6
	T7 + T8	3.2	1.6	1.1	0.8	0.5	0.4
	T/D loss	17.0	12.4	11.4	11.4	11.4	11.4

Source: PSMP2016 UPDATE

Table 7.3.2-12 Growth rate of electric energy demand by tariff category (Low case)

Unit: %

	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2025/15	2035/15	2040/15
Total	4.5	14.6	9.3	8.5	8.4	7.6	11.9	10.2	9.7
T1 + D1	4.7	15.5	10.6	9.9	9.3	8.8	13.0	11.3	10.8
T2 + T3	4.7	17.6	9.0	7.7	7.8	6.8	13.2	10.4	9.7
T5	13.6	12.8	8.2	5.1	4.2	2.4	10.5	7.5	6.5
T7 + T8	7.4	0.0	1.0	0.9	0.0	0.9	0.5	0.5	0.6
T/D loss	1.4	7.7	7.4	8.4	8.4	7.6	7.6	8.0	7.9

Source: PSMP2016 UPDATE

7.3.3 Power demand including export and additional demand to meet government target

The government of Tanzania has a policy target to expand its generation capacity up to 4,915MW by 2020. Comparing the base case peak demand of 2,190MW in 2020 and the generation capacity target of 4,915MW, the gap between the demand and the generation target is huge.

Therefore, demand forecast should be inflated in *"Government Target"* case so that generation capacity matches power demand without any excessive reserve. In order to incorporate the policy into demand forecast, some additional demands such as power export, unrecognized industrial demand and buck up for captive generators for large scale industries are added outside the econometric model in *"Government Target"* case. Such additional demands are assumed by the Task Force Team.

The power export from Tanzania is estimated with 600 MW per year from 2018 to 2040. The export is the same value in Base case, High case and Low case. The value of 600 MW is the exported peak supply, therefore, the required capacity for the export is calculated by "(Export value + Loss)*1.3". According to MEM and TANESCO, furthermore, it is expected for additional power demands that rural factories and mining sites to change their power supply from auto generation to power purchase from TANESCO grid system.

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

Table 7.3.3-1Additional power demand by rural factories and mining sites

Year	Geita : Gold Mining Co.	Mara : Two Gold mining Co.	Njombe: Iron Smelting	Mtwara : DANGOTE	Security For power supply	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

Year	Geita : Gold Mining Co.	Mara : Two Gold mining Co.	Njombe: Iron Smelting	Mtwara : DANGOTE	Security For power supply	Total
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

Note: The additional values from 2016 to 2019 are the same as the value in 2015

Two Gold mining in Mara includes "Buhemba Gold Mining" and "Kiabakari Gold Mining"

Source: MEM、TANESCO and Power Demand Regional Survey

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

The growth rate of the total power demand and capacity are in the next table. The growth rates of peak demand and capacity from 2015 to 2020 are comparatively higher than others.

Table 7.3.3-2 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

Note: Capacity of the all demands is 5,091 MW in 2020 and 6991 MW in 2025

The export value is a constant value of '600 MW+loss' from 2018 to 2040.

The capacity is calculated by "peak demand * 1.3".

Source: PSMP2016 UPDATE

Table 7.3.3-3 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: same to the above

7.3.4 Power demand promotion factors

It is considered that the future power demands of Tanzania will be increased due to high growth of Industry sector backed up the appreciate economic policy and high expanding power utilization in Residential sector in line with urbanization in the whole country. As already mentioned, the power demand growth (Peak demand) from 2015 to 2040 is average 11 % per year, the economic growth during the same year, it is 7% from 2015 to 2025 and it is 6 % from 2025 to 2040. Therefore, the average elasticity between the two is "1.8". It means that the expansion of the power supply system is required as soon as possible. The following table shows the elasticity between power demand growth rates and GDP growth rate.

Table 7.3.4-1 Elasticity between sectoral power demand and GDP

Sector	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
Peak demand	0.5	2.5	1.5	1.7	1.6	1.8	1.8
Total demand	0.8	1.8	1.6	1.6	1.6	1.8	1.7
Agriculture	1.2	8.9	2.0	2.3	2.2	2.6	3.6
Industry	0.7	1.9	1.6	1.6	1.6	1.7	1.7
Commercial	0.9	1.8	2.0	2.1	2.1	2.3	2.1
Government	2.2	1.9	1.3	1.0	0.8	0.6	1.1
Gold	1.2	0.1	0.1	0.1	0.1	0.1	0.1
Residential	0.7	1.9	1.6	1.7	1.6	1.8	1.7

Source PSMP2016 UPDATE

The power demand growths of Tanzania are expected in aspects of Industry sector and Residential sector. The following table shows the main factors for the power demand growth in Tanzania.

Table 7.3.4-2 Main factors for power demand growth

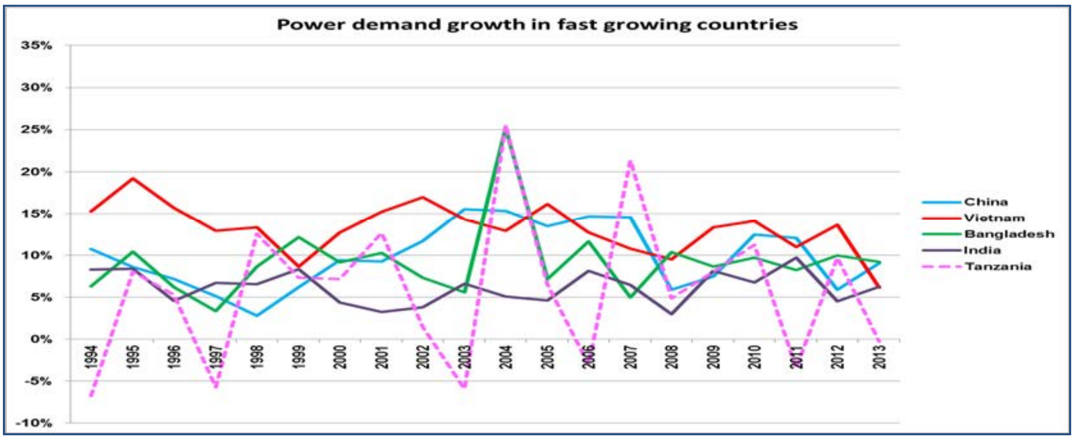
1	The past GDP growth rate of Tanzania was average 7% per year, and the future GDP growth rate will be continued with such growth rate. Because gas development, establishment of transportation infrastructure, increase of Foreign Direct Investment etc. are indicated as the main factors. The power demand growth rates for Industry and Commercial sectors will be expected with 18 % per year from 2015 to 2020. The growth rates toward 2040 are 11% for Industry and 13% for Commercial sector.
2	By promoting the gas development, gas incentive business will be promoted. Chemical industry, LNG industry, Transportation fuel industry etc. are shown as example. Such industries consume much electric power for their production activities.
3	Currently, wood and charcoal is the main sources of energy in rural area. The share of them in total final energy consumption in Tanzania is around 80% according to IEA data. In the future, wood and charcoal energies will be replaced by electric power and petroleum products in line with urbanization of Tanzania. Therefore, the power consumption in Residential sector increases a lot. The share of wood and charcoal energies in final energy consumption will decrease 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	The electrification rate of Tanzania in 2014 is 36% (Access base), there is a room for increasing the electrification rate. The future electrification rates are assumed by 50% (Access base) in 2020 and 90% in 2035. And power consumption per capita is 128 kWh per capita in 2015, it is rather small. In the future, it becomes 240 kWh / capita in 2020 and 1,050 kWh / capita in 2040.
5	Current power supply does not satisfy the demand. The shortage has to be resolved as soon as possible. During the period when the shortage is gradually relieved, power demand will grow at higher rate than normal. In the power demand forecasts of PSMP2016 UPDATE, the power shortage is resolved toward 2020. The power demand growth rate of Base case is 16.4 % per year from 2015 to 2020.

Source: PSMP2016 UPDATE

7.4 International Comparison of Electric Energy Demand

7.4.1 Comparison of fast power demand growth countries

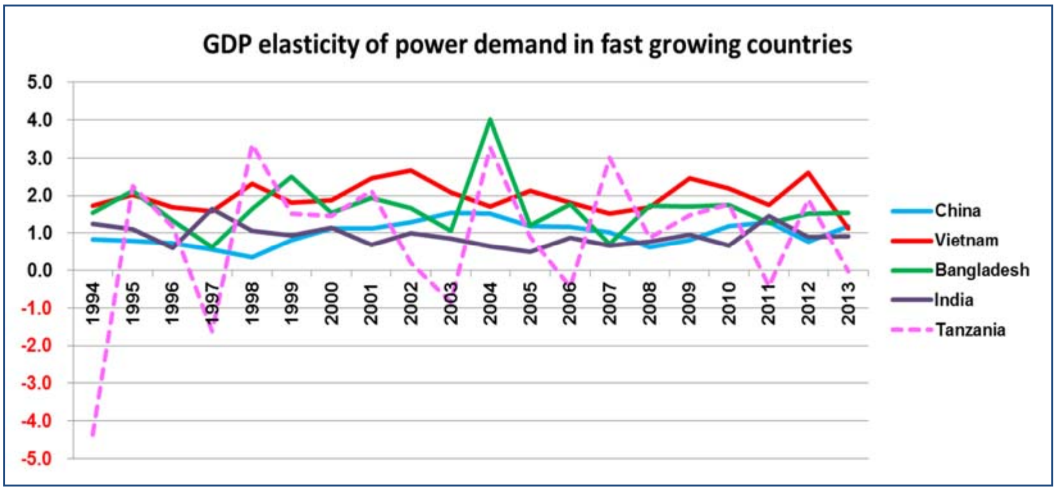
In the following figure, the countries with the fast economic growth and high power demand growth in recent years (Vietnam, Bangladesh, India and China) are selected. The power demand growth rates among the countries from 1994 to 2013 are shown in the figure. The average growth rates of the countries from 2000 to 2013 are around 10 % per year, and Vietnam and China had high power demand growth rates of 15~20 % per year, however, the high power demand growth rates do not continue more than three years. The power demand of Tanzania does not increase from 2011 to 2013.



Source: Web of International Energy Agency

Figure 7.4.1-1 Comparison among countries with high power demand

The elasticities of the countries between power demand growth rates and their GDP growth rates are as the following table. The most of the elasticities are located from 0.5 to 2.5, and the average elasticity among the countries is around 1.2. While, Tanzanian elasticity from 2015 to 2020 is 2.5, the value is almost the same as the highest elasticity in Vietnam in the year of 2002.

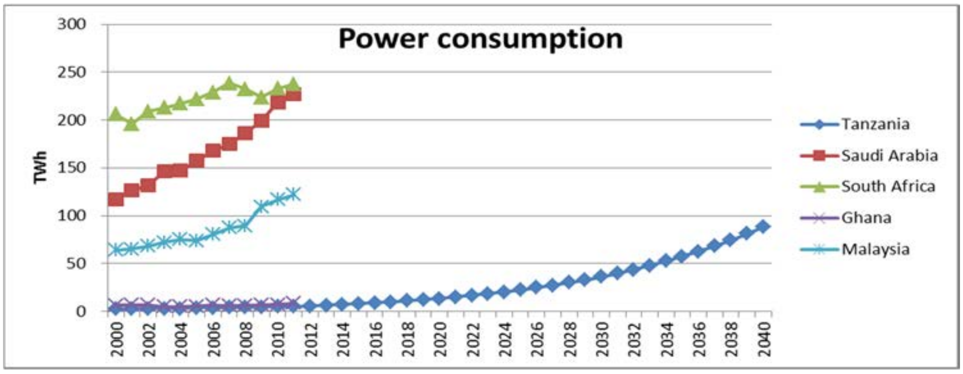


Note: Elasticity = Power demand growth rate / GDP growth rate
Source : The above data are calculated by PSMP2016 UPDATE team

Figure 7.4.1-2 Comparison Power demand elasticities to GDP

7.4.2 Comparison of electric energy consumption between Tanzania and others

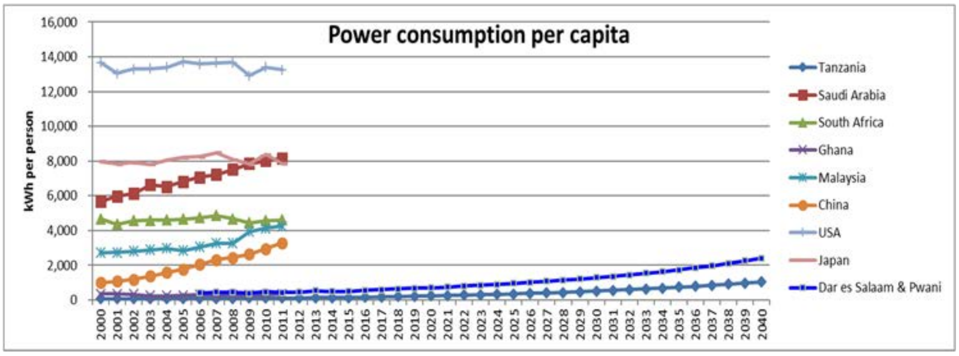
The following figure is the international comparison of electric energy consumption. The compared countries to Tanzania are Saudi Arabia, South Africa, Ghana, Malaysia, China USA and Japan. In 2040, Tanzania will consume electric energy with 87 TWh. The electric energy demand in 2040 is almost same to Malaysia as of 2008.



Source: PSMP2016 UPDATE

Figure 7.4.2-1 Electric energy consumption of Middle countries and Tanzania

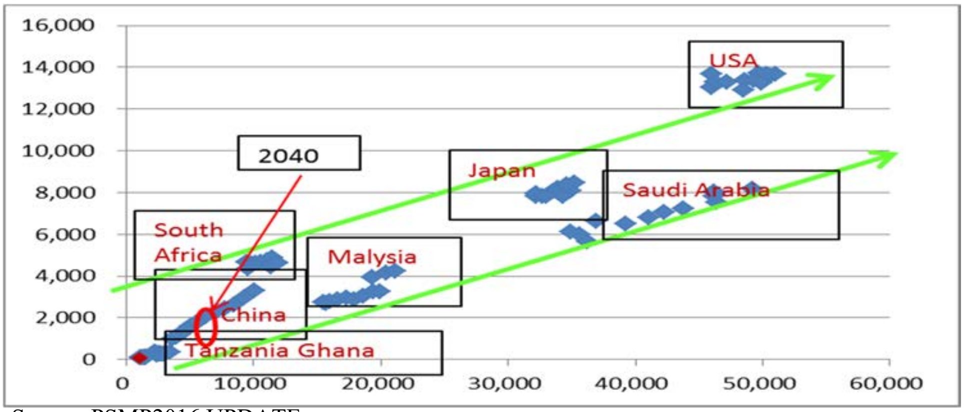
The electric energy consumption per capita of Tanzania was 130 kWh per capita in 2015, and the electric energy demand in 2040 will reach 1,050 kWh per capita. When looking at the electric energy demand per capita of Dar es Salaam in 2040, the value is 2,400 kWh per capita. It is almost same to Chinese electric energy demand per capita as of 2008.



Source: PSMP2016 UPDATE

Figure 7.4.2-2 Comparison of electric energy consumption per capita

It is well known that electric energy consumption per capita has strong relation to GDP per capita in the world wide. The following figure shows the comparison between GDP per capita and electric energy consumption per capita of the targeted countries by using actual data from 2000 to 2011. Regarding electric energy consumption per capita of Tanzania, the regional electric energy consumption per capita in 2040 is plotted in the figure. The following area in the red cycle shows the electric energy consumption per capita of Tanzania in 2040.



Source: PSMP2016 UPDATE

Figure 7.4.2-3 Electric energy consumption per capita measured by GDP per capita

7.4.3 Power demand forecasts comparison between Neighboring countries and Tanzania

When comparing the power demand forecasts of neighboring countries and Tanzania, the results are as the following table. The power demand growth rates of Ethiopia and Tanzania are comparatively higher than other countries.

Table 7.4.3-1 Power demand forecasts of neighboring countries and Tanzania

ID		Demand & Capacity (MW)				Growth rate (%)			
Country	Items	2015	2020	2025	2030	2020/15	2025/20	2030/25	2030/15
Tanzania	Domestic demand	970	2,200	3,700	5,900	17.8	11.0	9.8	12.8
	Export	0	300	300	300				
	Total demand	970	2,500	4,000	6,200	20.8	9.9	9.2	13.2
	Capacity(1.3)	1,300	3,300	5,200	8,100	20.5	9.5	9.3	13.0
Mozambique	Domestic demand	1,400	1,900	2,200		6.3	3.0		
	Export	300	0	0					
	Total demand	1,700	1,900	2,200		2.2	3.0		
	Capacity(1.3)	2,200	2,500	2,900		2.6	3.0		
Ethiopia	Domestic demand	2,200	6,300	14,700	19,100	23.4	18.5	5.4	15.5
	Export	300	1,200	2,300	3,900				
	Total demand	2,500	7,500	17,000	23,000	24.6	17.8	6.2	15.9
	Capacity(1.3)	3,300	9,800	22,100	29,900	24.3	17.7	6.2	15.8
Rwanda	Domestic demand	180	250	400	620	6.8	9.9	9.2	8.6
	Export	0	0	0	0				
	Total demand	180	250	400	620	6.8	9.9	9.2	8.6
	Capacity(1.3)	200	300	500	800	8.4	10.8	9.9	9.7
Uganda	Domestic demand	550	910	1,107		10.6	4.0		
	Export	10	120	200					
	Total demand	560	1,030	1,307		13.0	4.9		
	Capacity(1.3)	700	1,300	1,700		13.2	5.5		
Zambia	Domestic demand	2,900	3,600	4,000		4.4	2.1		
	Export	0	0	0					
	Total demand	2,900	3,600	4,000		4.4	2.1		
	Capacity(1.3)	3,800	4,700	5,200		4.3	2.0		

Source: the documents of the countries are as follows;

Countries	Sources of Power demand Forecasts	Donor & Planner	Open Date
Tanzania	Power System Master Plan 2015 (p 13)	JICA	Oct-2016
Mozambique	Master Plan Update Project, 2012 - 2027 (p42)	NEDAP (*1)	Apr-2014
Ethiopia	Bulk Power Development & Regional Interconnection (p 4)	EEP (*2)	Jan-2014
Rwanda	Electricity Development Plan for Geothermal Energy (p65)	JICA	Mar-2016
Uganda	Grid Development Plan 2014 - 2030 (p25)	UETCL(*3)	2014
Zambia	SAPP Annual Report 2015	SAPP	2015

(*1)NEDAP: National Energy Development and Access Program, (*2)EEP : Ethiopian Electric Power

(*3)UETCL: Uganda Electricity Transmission Company Limited

7.5 Regional electric energy demand forecast

7.5.1 Methodologies for regional electric energy demand

The regional electric energy demands are calculated by distributing the country wide electric energy demand. The distribution logics are as follows;

a. The electric energy demand is calculated region by region

b. The electric energy demands in a region are consisted of Residential demand and Productive sector (Agriculture, Industry and Commercial) demand

c. Residential electric energy demand is calculated by the following procedures. As key explanation variables, there are regional population, regional electrification rate and regional actual electric energy consumption in the past.

Table 7.5.1-1 Calculation procedures for regional Residential demand

Forecasting items	Calculation procedures
(A)Regional population forecasts (2013-2040)	Elasticity
(B)Electrification rate forecasts (2013-2040)	Setting Targets
(C)Population to use electric energy	(A)*(B)
(D)Actual regional electric energy consumption (2005 – 2012)	Data collection
(E)Electric energy consumption per capita to use electric energy (2013-2040)	(D)/(C)
(F)Future regional electric energy consumption (2013-2040)	(C)*(E)

d. The calculation procedures for regional industrial electric energy demand are as the following table. As key explanation variable, there are regional GDP((A)、(B), (C) in the following table), regional big projects with large electric energy consumption ((E) in the table) and the existing regional big users ((F) in the table). The two information are collected by the local consultant. The consultants visited regional TANESCO offices and district governments for the data collection.

Table 7.5.1-2 Calculating procedures for regional industrial demand

Forecasting items	Calculation procedures
(A)Actual industrial GDP (2010 – 2012)	Data collection
(B)Regional contribution of industrial GDP (2010-2012)	(A)/National-GDP
(C)Regional contribution of industrial GDP (2013-2040)	Time trends
(D)Future regional electric energy demand (2013-2040)	(C)*National -Electric energy demand
(E) Power demand prediction of Big projects (2015-2025)	Data collection by regional survey
(F) Power demand prediction of Big users(2015-2025)	Data collection by regional survey
(G)Future regional electric energy demand (2013-2040)	(D)+(E)+(F)

Note: The regional big projects include mining developments, Industrial parks, big commercial malls, Airport and harbor construction and so on. And the projects to consume the power demand over 0.5MW are targeted.

Note: As the existing big consumers gives big impacts to the local power demands, the future information of them are collected from regional TANESCO offices at time of regional survey.

7.5.2 Prediction of regional preconditions

(1) Prediction of regional population growth

For making the regional population in future, it is required to calculate elasticity between regional population growth rate and country population growth rate using censuses in 2002 and 2012. Regarding the regions with the elasticity more than elasticity 1.0, the elasticity is decreased gradually to close to the value of 1.0. The forecasted results of the regional population are as follows;

Table 7.5.2-1 Prediction of Regional population

Unit: 1000persons

	Region names	2015	2020	2025	2030	2035	2040	2040/15
1	Dodoma	2,234	2,472	2,706	2,932	3,146	3,347	1.6
2	Arusha	1,857	2,121	2,386	2,647	2,902	3,146	2.1
3	Kilimanjaro	1,739	1,893	2,044	2,186	2,319	2,444	1.4
4	Tanga	2,204	2,438	2,594	2,740	2,875	2,993	1.2
5	Morogoro	2,400	2,683	2,930	3,167	3,392	3,591	1.6
6	Pwani	1,181	1,312	1,441	1,566	1,685	1,790	1.7
7	Dar es Salaam	5,269	6,913	8,649	10,346	11,940	13,387	3.8
8	Lindi	892	933	971	1,005	1,036	1,064	0.7
9	Mtwara	1,324	1,405	1,481	1,552	1,617	1,676	0.9
10	Ruvuma	1,478	1,639	1,798	1,952	2,098	2,236	1.7
11	Iringa +Njombe	1,699	1,782	1,857	1,925	1,988	2,045	0.7
12	Mbeya	2,965	3,354	3,623	3,878	4,117	4,328	1.5
13	Singida	1,481	1,658	1,835	2,007	2,172	2,328	1.8
14	Tabora	2,527	2,911	3,294	3,674	4,045	4,404	2.2
15	Rukwa +Katavi	1,747	2,042	2,343	2,644	2,943	3,222	2.5
16	Kigoma	2,306	2,589	2,866	3,135	3,393	3,624	1.8
17	Shinyanga+ Simiyu	3,329	3,703	4,256	4,812	5,362	5,879	2.3
18	Kagera	2,733	3,151	3,434	3,704	3,960	4,186	1.7
19	Mwanza +Geita	4,962	5,690	6,865	8,096	9,221	10,179	2.9
20	Mara	1,894	2,134	2,376	2,613	2,841	3,058	1.9
21	Manyara	1,585	1,838	2,054	2,265	2,469	2,648	2.1
	Mainland total	47,807	54,660	61,802	68,846	75,520	81,575	2.2
22	Zanzibar total	1,439	1,679	1,836	2,024	2,172	2,315	1.9
	Total	49,246	56,339	63,639	70,869	77,692	83,891	2.2

Source: PSMP2016 UPDATE

Table 7.5.2-2 population growth rate by region

Unit: %

	Region names	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
1	Dodoma	2.1	2.0	1.8	1.6	1.4	1.3	1.6
2	Arusha	2.8	2.7	2.4	2.1	1.9	1.6	2.1
3	Kilimanjaro	1.8	1.7	1.5	1.4	1.2	1.1	1.4
4	Tanga	3.6	2.0	1.2	1.1	1.0	0.8	1.2
5	Morogoro	3.0	2.2	1.8	1.6	1.4	1.1	1.6
6	Pwani	2.2	2.1	1.9	1.7	1.5	1.2	1.7
7	Dar es Salaam	5.8	5.6	4.6	3.6	2.9	2.3	3.8
8	Lindi	0.9	0.9	0.8	0.7	0.6	0.5	0.7
9	Mtwara	1.2	1.2	1.1	0.9	0.8	0.7	0.9
10	Ruvuma	2.2	2.1	1.9	1.7	1.5	1.3	1.7
11	Iringa +Njombe	1.0	1.0	0.8	0.7	0.6	0.6	0.7
12	Mbeya	4.4	2.5	1.6	1.4	1.2	1.0	1.5
13	Singida	2.4	2.3	2.0	1.8	1.6	1.4	1.8
14	Tabora	3.2	2.9	2.5	2.2	1.9	1.7	2.2
15	Rukwa +Katavi	3.4	3.2	2.8	2.5	2.2	1.8	2.5
16	Kigoma	2.6	2.3	2.1	1.8	1.6	1.3	1.8
17	Shinyanga+ Simiyu	-1.7	2.2	2.8	2.5	2.2	1.9	2.3
18	Kagera	2.7	2.9	1.7	1.5	1.3	1.1	1.7
19	Mwanza +Geita	3.5	2.8	3.8	3.4	2.6	2.0	2.9
20	Mara	2.5	2.4	2.2	1.9	1.7	1.5	1.9
21	Manyara	4.4	3.0	2.2	2.0	1.7	1.4	2.1
	Mainland total	2.8	2.7	2.5	2.2	1.9	1.6	2.2
22	Zanzibar total	2.5	3.1	1.8	2.0	1.4	1.3	1.9
	Total	2.7	2.7	2.5	2.2	1.9	1.5	2.2

Source: PSMP2016 UPDATE

(2) Prediction of regional electrification

The regional electrification rates in the report use “Access method of IEA methodologies”. Regarding the future electrification rate, it is set by the following method. The electrification rate in 2025 is set with double value to one in 2014, double value in 2035 to one in 2025 and the growth rates of electrification rate from 2036 to 2040 are calculated by the same growth rate of the past electrification rate. As the results of the conditions, the electrification rate of Mainland in 2015 is 39 %, 50% in 2020, 64 % in 2025, 76% in 2030, 89 % in 2035 and 94 % in 2040.

Table 7.5.2-3 Prediction of regional electrification rates

Unit:%

		Unit	2013	2014	2015	2020	2025	2030	2035	2040
1	Dodoma	%	36.6	37.0	39.4	54.0	74.0	86.0	100.0	100.0
2	Arusha	%	43.4	44.3	47.2	64.7	88.6	94.1	100.0	100.0
3	Kilimanjaro	%	80.0	80.5	82.1	90.6	100.0	100.0	100.0	100.0
4	Tanga	%	32.2	32.9	35.0	48.0	65.8	81.1	100.0	100.0
5	Morogoro	%	38.8	39.6	42.2	57.8	79.2	89.0	100.0	100.0
6	Pwani	%	42.1	43.0	45.8	62.8	86.0	92.7	100.0	100.0
7	Dar es Salaam	%	88.7	89.0	89.9	94.8	100.0	100.0	100.0	100.0
8	Lindi	%	13.3	13.6	14.5	19.8	27.2	38.5	54.4	73.8
9	Mtwara	%	13.1	13.4	14.3	19.6	26.8	37.9	53.6	73.2
10	Ruvuma	%	17.8	18.2	19.4	26.6	36.4	51.5	72.8	85.3
11	Iringa +Njombe	%	27.6	28.2	30.0	41.2	56.4	75.1	100.0	100.0
12	Mbeya	%	35.4	36.2	38.6	52.8	72.4	85.1	100.0	100.0
13	Singida	%	22.1	22.6	24.1	33.0	45.2	63.9	90.4	95.1
14	Tabora	%	18.7	19.1	20.3	27.9	38.2	54.0	76.4	87.4
15	Rukwa +Katavi	%	7.4	7.6	8.1	11.1	15.2	21.5	30.4	55.1
16	Kigoma	%	27.2	27.8	29.6	40.6	55.6	74.6	100.0	100.0
17	Shinyanga+ Simiyu	%	22.1	22.6	24.1	33.0	45.2	63.9	90.4	95.1
18	Kagera	%	9.6	9.8	10.4	14.3	19.6	27.7	39.2	62.6
19	Mwanza +Geita	%	37.9	38.7	41.2	56.5	77.4	88.0	100.0	100.0
20	Mara	%	29.0	29.6	31.5	43.2	59.2	76.9	100.0	100.0
21	Manyara	%	41.7	42.6	45.4	62.2	85.2	92.3	100.0	100.0
22	Mainland total	%	36.4	37.1	39.0	50.3	65.0	75.9	89.5	93.8

Source: PSMP2016 UPDATE

Table 7.5.2-4 Electrification growth rates by region

Unit: %

		Unit	2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
1	Dodoma	%	2.1	6.5	6.5	3.1	3.1	0.0	3.8
2	Arusha	%	2.3	6.5	6.5	1.2	1.2	0.0	3.1
3	Kilimanjaro	%	1.1	2.0	2.0	0.0	0.0	0.0	0.8
4	Tanga	%	2.3	6.5	6.5	4.3	4.3	0.0	4.3
5	Morogoro	%	2.3	6.5	6.5	2.4	2.4	0.0	3.5
6	Pwani	%	2.3	6.5	6.5	1.5	1.5	0.0	3.2
7	Dar es Salaam	%	0.9	1.1	1.1	0.0	0.0	0.0	0.4
8	Lindi	%	2.3	6.5	6.5	7.2	7.2	6.3	6.7
9	Mtwara	%	2.3	6.5	6.5	7.2	7.2	6.4	6.8
10	Ruvuma	%	2.3	6.5	6.5	7.2	7.2	3.2	6.1
11	Iringa +Njombe	%	2.3	6.5	6.5	5.9	5.9	0.0	4.9
12	Mbeya	%	2.3	6.5	6.5	3.3	3.3	0.0	3.9
13	Singida	%	2.3	6.5	6.5	7.2	7.2	1.0	5.6
14	Tabora	%	2.3	6.5	6.5	7.2	7.2	2.7	6.0
15	Rukwa +Katavi	%	2.3	6.5	6.5	7.2	7.2	12.6	8.0
16	Kigoma	%	2.3	6.5	6.5	6.0	6.0	0.0	5.0
17	Shinyanga+ Simiyu	%	2.3	6.5	6.5	7.2	7.2	1.0	5.6
18	Kagera	%	2.3	6.5	6.5	7.2	7.2	9.8	7.4
19	Mwanza +Geita	%	2.3	6.5	6.5	2.6	2.6	0.0	3.6
20	Mara	%	2.3	6.5	6.5	5.4	5.4	0.0	4.7
21	Manyara	%	2.3	6.5	6.5	1.6	1.6	0.0	3.2
22	Mainland total	%	2.4	5.2	5.2	3.2	3.3	1.0	3.6

Source PSMP2016 UPDATE

(3) Prediction of regional GDP

By using regional actual industrial value added from 2010 to 2012, the future contributions of the regional industrial value added are calculated. The contributions are multiplied by real industrial GDP of the whole country for calculating future regional industrial value added. The results of the regional industrial value added (GDP at 2001price) are as follows;

Table 7.5.2-5 Prediction of regional industrial value added（Real values at 2001 price）

Unit: Billion TZS

		2015	2020	2025	2030	2035	2040
1	Dodoma	91	127	178	237	317	403
2	Arusha	3,798	5,307	7,414	9,889	13,189	16,786
3	Kilimanjaro	1,461	2,042	2,853	3,805	5,074	6,458
4	Tanga	2,523	3,525	4,925	6,569	8,761	11,151
5	Morogoro	3,075	4,296	6,002	8,005	10,677	13,588
6	Pwani	38	53	75	100	134	172
7	Dar es Salaam	6,475	9,115	12,832	17,228	23,130	29,601
8	Lindi	5	6	9	12	16	21
9	Mtwara	44	62	86	115	153	195
10	Ruvuma	80	112	156	208	277	353
11	Iringa +Njombe	347	485	678	905	1,207	1,536
12	Mbeya	236	330	461	615	820	1,044
13	Singida	22	26	30	34	38	42
14	Tabora	47	66	92	123	164	209
15	Rukwa +Katavi	14	20	28	38	50	64
16	Kigoma	57	79	111	148	197	250
17	Shinyanga+ Simiyu	204	285	398	531	708	901
18	Kagera	351	490	684	913	1,217	1,549
19	Mwanza +Geita	1,087	1,518	2,121	2,829	3,773	4,802
20	Mara	877	1,225	1,712	2,283	3,045	3,875
21	Manyara	113	130	150	170	192	213
	Mainland total	20,944	29,299	40,995	54,755	73,141	93,213
22	Zanzibar	642	901	1,263	1,690	2,262	2,887
	Total	21,586	30,200	42,258	56,445	75,403	96,100

Note: GDP is real GDP at 2001 price
Source PSMP2016 UPDATE

Table 7.5.2-6 Growth rate of regional industrial value added (Real value at 2001 price)

Unit: %

		2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
1	Dodoma	6.6	6.9	6.9	5.9	5.9	4.9	6.1
2	Arusha	6.6	6.9	6.9	5.9	5.9	4.9	6.1
3	Kilimanjaro	6.6	6.9	6.9	5.9	5.9	4.9	6.1
4	Tanga	6.6	6.9	6.9	5.9	5.9	4.9	6.1
5	Morogoro	6.6	6.9	6.9	5.9	5.9	4.9	6.1
6	Pwani	6.1	7.1	7.1	6.1	6.1	5.1	6.3
7	Dar es Salaam	6.1	7.1	7.1	6.1	6.1	5.1	6.3
8	Lindi	6.6	7.0	7.0	6.0	6.0	5.0	6.2
9	Mtwara	6.6	6.9	6.9	5.9	5.9	4.9	6.1
10	Ruvuma	6.6	6.9	6.9	5.9	5.9	4.9	6.1
11	Iringa +Njombe	6.6	6.9	6.9	5.9	5.9	4.9	6.1
12	Mbeya	6.6	6.9	6.9	5.9	5.9	4.9	6.1
13	Singida	4.4	2.9	2.9	2.5	2.5	2.1	2.6
14	Tabora	6.6	6.9	6.9	5.9	5.9	4.9	6.1
15	Rukwa +Katavi	6.6	6.9	6.9	5.9	5.9	4.9	6.1
16	Kigoma	6.6	6.9	6.9	5.9	5.9	4.9	6.1
17	Shinyanga+ Simiyu	6.6	6.9	6.9	5.9	5.9	4.9	6.1
18	Kagera	6.6	6.9	6.9	5.9	5.9	4.9	6.1
19	Mwanza +Geita	6.6	6.9	6.9	5.9	5.9	4.9	6.1
20	Mara	6.6	6.9	6.9	5.9	5.9	4.9	6.1
21	Manyara	4.4	2.9	2.9	2.5	2.5	2.1	2.6
	Mainland total	6.4	6.9	6.9	6.0	6.0	5.0	6.2
22	Zanzibar	15.4	7.0	7.0	6.0	6.0	5.0	6.2
	Total	6.6	7.0	7.0	6.0	6.0	5.0	6.2

Source: PSMP2016 UPDATE

(4) Prediction for Big projects and Existing big users

1) Big projects by region

The regional big projects include construction plans of Mining developments, Industrial parks, Big commercial malls, Airport and Harbor and so on. And the big projects to consume the power demand over 0.5 MW are targeted. As the results of the regional survey, the power demands of the big projects up to 2025 are in the following table.

Table 7.5.2-7 Power demands of big projects as regional survey results

	Big Users	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 survey in 2015

It is uncertainty that the big project plans in the regional survey are implemented on schedules. Therefore, "Realization probabilities (or Achieved probabilities)" are set by region. The probabilities are set by the researchers of Regional Survey. (The researchers are Bureau for Industrial Cooperation.)

Table 7.5.2-8 Realization probabilities of big projects

	Big Users	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
2	Arusha	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
7	Dar es Salaam	100.0%	99.0%	98.0%	97.0%	96.1%	95.1%	94.1%	93.2%	92.3%	91.4%	90.4%
1	Dodoma	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
11	Iringa +Njombe	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
18	Kagera	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
16	Kigoma	80.0%	77.6%	75.3%	73.0%	70.8%	68.7%	66.6%	64.6%	62.7%	60.8%	59.0%
3	Kilimanjaro	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
8	Lindi	80.0%	77.6%	75.3%	73.0%	70.8%	68.7%	66.6%	64.6%	62.7%	60.8%	59.0%
21	Manyara	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
20	Mara	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
12	Mbeya	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
5	Morogoro	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
9	Mtwara	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
19	Mwanza +Geita	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
6	Pwani	100.0%	99.0%	98.0%	97.0%	96.1%	95.1%	94.1%	93.2%	92.3%	91.4%	90.4%
15	Rukwa +Katavi	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
10	Ruvuma	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
17	Shinyanga+ Simiyu	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
13	Singida	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
14	Tabora	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
4	Tanga	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%
22	Zanzibar	100.0%	97.0%	94.1%	91.3%	88.5%	85.9%	83.3%	80.8%	78.4%	76.0%	73.7%

Source: PSMP2016 UPDATE and Regional Survey

The additional power demand of the big projects after the probability are defined by "Power demand of big projects in Regional Survey * Realization probability". The additional new power demands from the big projects are as the following table.

Table 7.5.2-9 Additional power demands from the existing big projects

		Unit	2015	2020	2021	2022	2023	2024	2025
2	Arusha	MW	1.2	36.8	36.3	35.7	35.2	34.6	34.1
7	Dar es Salaam	MW	92.0	113.2	118.8	124.3	129.7	135.0	140.2
1	Dodoma	MW	0.0	13.1	12.7	12.3	12.0	11.6	11.3
11	Iringa +Njombe	MW	0.0	0.4	0.5	0.5	0.5	0.6	0.6
18	Kagera	MW	1.4	44.5	50.0	55.2	60.1	64.6	68.7
16	Kigoma	MW	0.0	7.9	8.6	9.2	9.8	10.4	10.9
3	Kilimanjaro	MW	4.6	12.5	12.2	11.8	11.4	11.1	10.8
8	Lindi	MW	0.0	6.1	6.5	7.0	7.4	7.7	8.1
21	Manyara	MW	7.0	13.7	13.3	12.9	12.5	12.2	11.8
20	Mara	MW	0.0	3.4	3.7	3.9	4.1	4.3	4.4
12	Mbeya	MW	15.0	43.8	45.8	47.7	49.4	50.9	52.4
5	Morogoro	MW	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	Mtwara	MW	0.0	1.8	1.8	1.7	1.7	1.6	1.6
19	Mwanza +Geita	MW	7.5	46.3	48.4	50.3	52.0	53.6	55.1
6	Pwani	MW	1.8	30.4	40.1	49.6	58.9	68.0	76.9
15	Rukwa +Katavi	MW	1.7	11.9	12.5	13.1	13.6	14.1	14.6
10	Ruvuma	MW	0.0	2.1	3.3	4.4	5.5	6.5	7.4
17	Shinyanga+ Simiyu	MW	0.0	3.1	3.3	3.6	3.8	4.0	4.1
13	Singida	MW	0.3	0.6	0.6	0.5	0.5	0.5	0.5
14	Tabora	MW	0.0	12.9	13.9	14.9	15.8	16.6	17.3
4	Tanga	MW	10.0	17.2	16.7	16.2	15.7	15.2	14.7
22	Zanzibar	MW	7.0	8.6	8.3	8.1	7.8	7.6	7.4
	total	MW	149.5	430.4	457.4	483.0	507.4	530.7	552.8

Source : PSMP2016 UPDATE

2) Power demand of the existing big users

The future power demands of the existing big users up to 2025 are collected in the Regional survey. The targeted big users are consumers to use the power with over 0.5 MW at present. Three to Five existing big users are selected in each region (District). The power demand summations of the existing big users by region (District) are as the following table.

Table 7.5.2-10 Power demand estimation of the existing big users

		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

Source: PSMP2016 UPDATE

3) Power demands of the big projects and the existing big users

The totalized power demands of the big projects and the existing big users up to 2025 are as the following table.

Table 7.5.2-11 Totalized power demands of the big projects and the existing big users

		Unit	2015	2020	2021	2022	2023	2024	2025
2	Arusha	MW	24.2	62.8	62.3	61.7	61.2	60.6	60.1
7	Dar es Salaam	MW	220.0	268.2	276.8	287.3	295.7	302.0	312.2
1	Dodoma	MW	28.0	44.1	43.7	43.3	43.0	42.6	42.3
11	Iringa +Njombe	MW	12.3	16.2	16.2	16.3	16.3	16.3	16.4
18	Kagera	MW	13.4	52.5	58.0	63.2	70.1	77.6	82.7
16	Kigoma	MW	0.0	7.9	8.6	9.2	9.8	10.4	10.9
3	Kilimanjaro	MW	10.6	22.5	22.2	21.8	21.4	21.1	20.8
8	Lindi	MW	1.0	8.1	8.5	9.0	9.4	9.7	10.1
21	Manyara	MW	8.8	16.8	16.4	16.0	15.6	15.3	14.9
20	Mara	MW	16.0	31.9	34.2	34.4	35.7	35.9	36.0
12	Mbeya	MW	32.7	72.5	75.5	77.4	79.1	80.9	82.3
5	Morogoro	MW	21.1	28.0	28.0	28.0	28.0	28.0	28.0
9	Mtwara	MW	4.0	6.8	7.8	8.7	9.7	10.6	11.6
19	Mwanza +Geita	MW	30.5	86.3	92.4	95.3	97.0	102.6	112.1
6	Pwani	MW	31.8	85.4	96.1	107.6	117.9	128.0	138.9
15	Rukwa +Katavi	MW	3.7	13.9	14.5	15.1	15.6	16.1	16.6
10	Ruvuma	MW	0.0	2.1	3.3	4.4	5.5	6.5	7.4
17	Shinyanga+ Simiyu	MW	94.0	106.1	109.3	109.6	109.8	110.0	110.1
13	Singida	MW	2.3	3.6	3.6	3.5	3.5	3.5	3.5
14	Tabora	MW	2.0	14.9	15.9	16.9	17.8	18.6	19.3
4	Tanga	MW	42.0	74.2	73.7	73.2	72.7	72.2	71.7
22	Zanzibar	MW	7.0	8.6	8.3	8.1	7.8	7.6	7.4
	total	MW	605.3	1033.5	1075.4	1110.0	1142.5	1176.1	1215.2

Source: PSMP2016 UPDATE

The regional power demand shares of the above (the total =100) are as the following table. By the shares, the power demands of the productive sectors in country wide are divided to the regions.

Table 7.5.2-12 Power demand shares of the big projects and the existing big users

Unit: %

		2015	2020	2021	2022	2023	2024	2025
1	Dodoma	4.7	4.3	4.1	4.0	3.8	3.6	3.5
2	Arusha	4.0	6.1	5.8	5.6	5.4	5.2	5.0
3	Kilimanjaro	1.8	2.2	2.1	2.0	1.9	1.8	1.7
4	Tanga	7.0	7.2	6.9	6.6	6.4	6.2	5.9
5	Morogoro	3.5	2.7	2.6	2.5	2.5	2.4	2.3
6	Pwani	5.3	8.3	9.0	9.8	10.4	11.0	11.5
7	Dar es Salaam	36.6	26.2	25.9	26.1	26.1	25.8	25.8
8	Lindi	0.2	0.8	0.8	0.8	0.8	0.8	0.8
9	Mtwara	0.7	0.7	0.7	0.8	0.9	0.9	1.0
10	Ruvuma	0.1	0.2	0.3	0.4	0.5	0.6	0.6
11	Iringa +Njombe	2.1	1.6	1.5	1.5	1.4	1.4	1.4
12	Mbeya	5.5	7.1	7.1	7.0	7.0	6.9	6.8
13	Singida	0.4	0.3	0.3	0.3	0.3	0.3	0.3
14	Tabora	0.3	1.5	1.5	1.5	1.6	1.6	1.6
15	Rukwa +Katavi	0.6	1.4	1.4	1.4	1.4	1.4	1.4
16	Kigoma	0.1	0.8	0.8	0.8	0.9	0.9	0.9
17	Shinyanga+ Simi	15.7	10.4	10.2	9.9	9.7	9.4	9.1
18	Kagera	2.2	5.1	5.4	5.7	6.2	6.6	6.8
19	Mwanza +Geita	5.1	8.4	8.7	8.6	8.6	8.8	9.3
20	Mara	2.7	3.1	3.2	3.1	3.1	3.1	3.0
21	Manyara	1.5	1.6	1.5	1.5	1.4	1.3	1.2
0	Main land	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: PSMP2016 UPDATE

(5) Actual Power demand by region

According to National Statistics of Tanzania, the regional power demands from 2005 to 2012 are as the followings. The actual power demands are one of the starting points for future regional power demands.

Table 7.5.2-13 Actual Power demand by region

			2005	2006	2007	2008	2009	2010	2011	2012
1	Dodoma	GWh	48	49	59	68	79	83	86	94
2	Arusha	GWh	202	193	223	296	236	269	260	309
3	Kilimanjaro	GWh	102	96	110	109	88	124	118	138
4	Tanga	GWh	156	154	165	169	166	209	219	245
5	Morogoro	GWh	113	107	119	136	121	179	163	207
6	Pwani	GWh	100	100	100	104	94	106	116	142
7	Dar es Salaam	GWh	1110	1136	1574	1641	1200	1789	1664	1847
8	Lindi	GWh	10	12	12	11	11	13	14	15
9	Mtwara	GWh	20	20	29	23	29	27	30	34
10	Ruvuma	GWh	13	13	14	15	15	21	21	24
11	Iringa	GWh	60	61	79	79	85	101	92	102
12	Mbeya	GWh	95	99	109	115	125	139	132	150
13	Singida	GWh	18	26	28	18	26	26	23	29
14	Tabora	GWh	67	71	37	98	84	97	95	103
15	Rukwa	GWh	9	11	12	11	12	17	19	19
16	Kigoma	GWh	9	12	10	12	12	16	18	21
17	Shinyanga	GWh	176	177	195	196	253	313	310	279
18	Kagera	GWh	28	35	36	37	33	44	29	55
19	Mwanza	GWh	136	132	151	173	192	215	201	224
20	Mara	GWh	47	40	95	44	52	110	109	108
21	Manyara	GWh	14	14	14	14	17	16	17	18
22	Mainland total	GWh	2533	2558	3171	3369	2930	3914	3736	4163
23	Zanzibar	GWh	186	204	231	229	258	175	277	299
24	Total	GWh	2,719	2,762	3,402	3,598	3,188	4,089	4,013	4,462

Note Red values are estimation by PSMP2016 UPDATE

Source : National Statistical Bureau、Original TANESCO

7.5.3 Regional power demand forecasts

(1) Regional Power demands

The regional electric energy demands are as the following table. The electric energy demand of Dar es Salaam shares 47 % to the whole country in 2015. In 2040, the share is decreased to 37 % due that the other regional electric energy demands are increased with more high speed. The growth rate of the whole country is 11 % per year from 2015 to 2040, while, Dar es Salaam is 10 % per year during the same period. It means that the electric energy demand growth rate of Dar es Salaam is almost same to the average growth rate of the whole country.

Table 7.5.3-1 Regional power demand forecasts (Base case, Send out base)

Unit: GWh

		2015	2020	2025	2030	2035	2040
1	Dodoma	132	270	401	644	1,037	1,506
2	Arusha	356	987	1,569	2,442	3,756	5,691
3	Kilimanjaro	157	348	473	708	1,063	1,593
4	Tanga	285	640	973	1,591	2,588	3,849
5	Morogoro	251	502	818	1,294	2,011	3,003
6	Pwani	158	482	1,062	1,687	2,709	4,110
7	Dar es Salaam	2,973	5,353	8,626	13,590	20,946	32,352
8	Lindi	17	95	168	280	471	770
9	Mtwara	43	94	197	337	580	999
10	Ruvuma	31	86	242	426	750	1,226
11	Iringa +Njombe	114	216	340	577	973	1,430
12	Mbeya	211	556	927	1,488	2,392	3,590
13	Singida	40	88	144	255	455	693
14	Tabora	125	441	815	1,508	2,767	4,611
15	Rukwa +Katavi	19	73	128	218	376	721
16	Kigoma	28	154	296	500	848	1,278
17	Shinyanga+ Simiy	451	713	1,136	1,987	3,503	5,453
18	Kagera	62	260	567	933	1,560	2,610
19	Mwanza +Geita	307	938	1,776	2,917	4,746	7,238
20	Mara	159	387	655	1,113	1,884	2,846
21	Manyara	24	58	79	110	156	213
	Mainland total	5,942	12,740	21,394	34,606	55,571	85,783
22	Zanzibar	375	689	1,044	1,398	1,767	2,098
	Total	6,317	13,428	22,439	36,004	57,337	87,881

Source: PSMP2016 UPDATE

Table 7.5.3-2 Growth rate of regional power demand

Unit: %

		2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
1	Dodoma	5.2	15.4	8.2	9.9	10.0	7.8	10.2
2	Arusha	1.4	22.6	9.7	9.3	9.0	8.7	11.7
3	Kilimanjaro	0.5	17.2	6.4	8.4	8.5	8.4	9.7
4	Tanga	2.0	17.6	8.8	10.3	10.2	8.3	11.0
5	Morogoro	2.6	14.9	10.3	9.6	9.2	8.3	10.4
6	Pwani	3.9	24.9	17.1	9.7	9.9	8.7	13.9
7	Dar es Salaam	6.2	12.5	10.0	9.5	9.0	9.1	10.0
8	Lindi	1.6	40.5	12.1	10.7	10.9	10.4	16.4
9	Mtwara	5.3	16.8	16.0	11.4	11.5	11.5	13.4
10	Ruvuma	3.7	22.6	23.1	12.0	12.0	10.3	15.8
11	Iringa +Njombe	-1.7	13.6	9.5	11.2	11.0	8.0	10.6
12	Mbeya	4.3	21.4	10.8	9.9	10.0	8.5	12.0
13	Singida	4.6	16.9	10.4	12.2	12.2	8.8	12.1
14	Tabora	0.8	28.8	13.1	13.1	12.9	10.8	15.5
15	Rukwa +Katavi	-2.2	31.4	11.9	11.2	11.5	13.9	15.7
16	Kigoma	7.2	40.7	13.9	11.0	11.1	8.5	16.5
17	Shinyanga+ Simiy	3.2	9.6	9.8	11.8	12.0	9.3	10.5
18	Kagera	2.9	33.0	16.9	10.5	10.8	10.8	16.1
19	Mwanza +Geita	2.9	25.1	13.6	10.4	10.2	8.8	13.5
20	Mara	3.2	19.5	11.1	11.2	11.1	8.6	12.2
21	Manyara	4.0	19.2	6.5	7.0	7.1	6.5	9.1
	Mainland total	4.2	16.5	10.9	10.1	9.9	9.1	11.3
22	Zanzibar	11.1	12.9	8.7	6.0	4.8	3.5	7.1
	Total	4.6	16.3	10.8	9.9	9.8	8.9	11.1

Source: PSMP2016 UPDATE

(2) Regional peak demand

The regional peak demands are as the following table. The load factors used for the calculation are 70% from 2015 to 2040.

Table 7.5.3-3 Regional peak demand (Base case, Send out base)

Unit: MW

		2015	2020	2025	2030	2035	2040
1	Dodoma	20	44	65	105	169	246
2	Arusha	55	161	256	398	613	928
3	Kilimanjaro	24	57	77	115	173	260
4	Tanga	44	104	159	259	422	628
5	Morogoro	39	82	133	211	328	490
6	Pwani	24	79	173	275	442	670
7	Dar es Salaam	459	873	1,407	2,216	3,416	5,276
8	Lindi	3	16	27	46	77	126
9	Mtwara	7	15	32	55	95	163
10	Ruvuma	5	14	39	69	122	200
11	Iringa +Njombe	18	35	55	94	159	233
12	Mbeya	33	91	151	243	390	586
13	Singida	6	14	23	42	74	113
14	Tabora	19	72	133	246	451	752
15	Rukwa +Katavi	3	12	21	36	61	118
16	Kigoma	4	25	48	82	138	208
17	Shinyanga+ Simiy	70	116	185	324	571	889
18	Kagera	10	42	92	152	254	426
19	Mwanza +Geita	47	153	290	476	774	1,180
20	Mara	24	63	107	181	307	464
21	Manyara	4	9	13	18	25	35
	Mainland total	917	2,078	3,489	5,644	9,062	13,989
22	Zanzibar	58	112	170	228	288	342
	Total	974	2,190	3,659	5,872	9,351	14,332

Source: PSMP2016 UPDATE

Table 7.5.3-4 Growth rates of regional peak demands

Unit: %

		2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2040/15
1	Dodoma	4.6	16.7	8.2	9.9	10.0	7.8	10.5
2	Arusha	0.8	24.0	9.7	9.3	9.0	8.7	12.0
3	Kilimanjaro	-0.1	18.6	6.4	8.4	8.5	8.4	10.0
4	Tanga	1.4	18.9	8.8	10.3	10.2	8.3	11.2
5	Morogoro	2.0	16.1	10.3	9.6	9.2	8.3	10.7
6	Pwani	3.3	26.3	17.1	9.7	9.9	8.7	14.2
7	Dar es Salaam	5.5	13.7	10.0	9.5	9.0	9.1	10.3
8	Lindi	1.1	42.1	12.1	10.7	10.9	10.4	16.6
9	Mtwara	4.7	18.1	16.0	11.4	11.5	11.5	13.7
10	Ruvuma	3.1	23.9	23.1	12.0	12.0	10.3	16.1
11	Iringa +Njombe	-2.3	14.9	9.5	11.2	11.0	8.0	10.9
12	Mbeya	3.7	22.7	10.8	9.9	10.0	8.5	12.3
13	Singida	4.0	18.2	10.4	12.2	12.2	8.8	12.3
14	Tabora	0.3	30.2	13.1	13.1	12.9	10.8	15.8
15	Rukwa +Katavi	-2.8	32.8	11.9	11.2	11.5	13.9	16.0
16	Kigoma	6.6	42.3	13.9	11.0	11.1	8.5	16.8
17	Shinyanga+ Simiy	2.6	10.8	9.8	11.8	12.0	9.3	10.7
18	Kagera	2.3	34.5	16.9	10.5	10.8	10.8	16.4
19	Mwanza +Geita	2.4	26.5	13.6	10.4	10.2	8.8	13.7
20	Mara	2.6	20.9	11.1	11.2	11.1	8.6	12.5
21	Manyara	3.4	20.5	6.5	7.0	7.1	6.5	9.4
	Mainland total	3.7	17.8	10.9	10.1	9.9	9.1	11.5
22	Zanzibar	0.3	14.2	8.7	6.0	4.8	3.5	7.4
	Total	3.4	17.6	10.8	9.9	9.8	8.9	11.4

Source: PSMP2016 UPDATE

Table 7.5.3-5 Regional Power demand contributions

Unit: %

		2015	2020	2025	2030	2035	2040
1	Dodoma	2.2	2.1	1.9	1.9	1.9	1.8
2	Arusha	6.0	7.7	7.3	7.1	6.8	6.6
3	Kilimanjaro	2.6	2.7	2.2	2.0	1.9	1.9
4	Tanga	4.8	5.0	4.5	4.6	4.7	4.5
5	Morogoro	4.2	3.9	3.8	3.7	3.6	3.5
6	Pwani	2.7	3.8	5.0	4.9	4.9	4.8
7	Dar es Salaam	50.0	42.0	40.3	39.3	37.7	37.7
8	Lindi	0.3	0.7	0.8	0.8	0.8	0.9
9	Mtwara	0.7	0.7	0.9	1.0	1.0	1.2
10	Ruvuma	0.5	0.7	1.1	1.2	1.4	1.4
11	Iringa +Njombe	1.9	1.7	1.6	1.7	1.8	1.7
12	Mbeya	3.6	4.4	4.3	4.3	4.3	4.2
13	Singida	0.7	0.7	0.7	0.7	0.8	0.8
14	Tabora	2.1	3.5	3.8	4.4	5.0	5.4
15	Rukwa +Katavi	0.3	0.6	0.6	0.6	0.7	0.8
16	Kigoma	0.5	1.2	1.4	1.4	1.5	1.5
17	Shinyanga+ Simiyu	7.6	5.6	5.3	5.7	6.3	6.4
18	Kagera	1.1	2.0	2.6	2.7	2.8	3.0
19	Mwanza +Geita	5.2	7.4	8.3	8.4	8.5	8.4
20	Mara	2.7	3.0	3.1	3.2	3.4	3.3
21	Manyara	0.4	0.5	0.4	0.3	0.3	0.2
22	Zanzibar	5.9	5.1	4.7	3.9	3.1	2.4
	Country total	100.0	100.0	100.0	100.0	100.0	100.0

Note: Red values mean expansion of power demand contribution

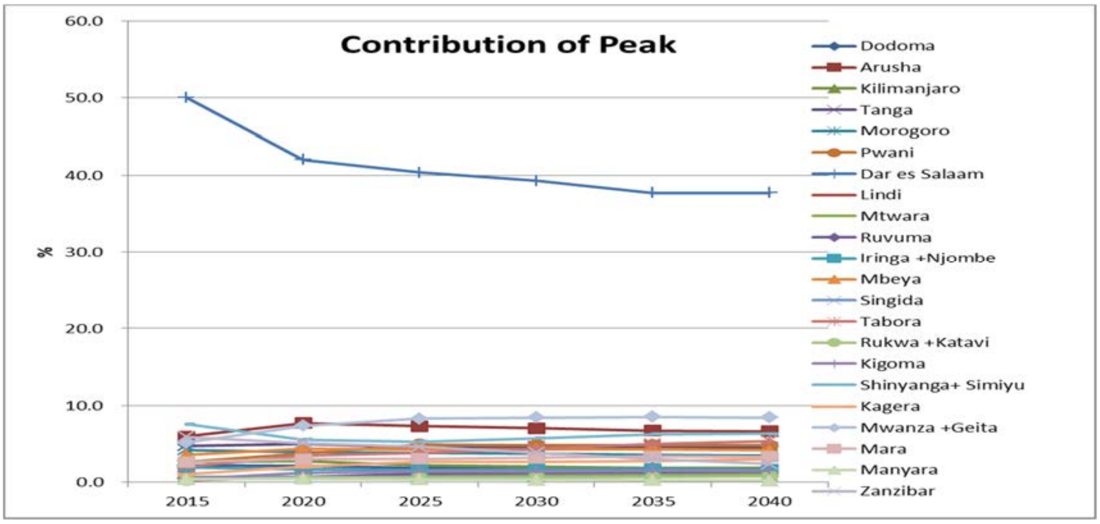


Figure 7.5.3-1 Trends of regional power demand contribution

7.6 Final Energy Demand Forecasts

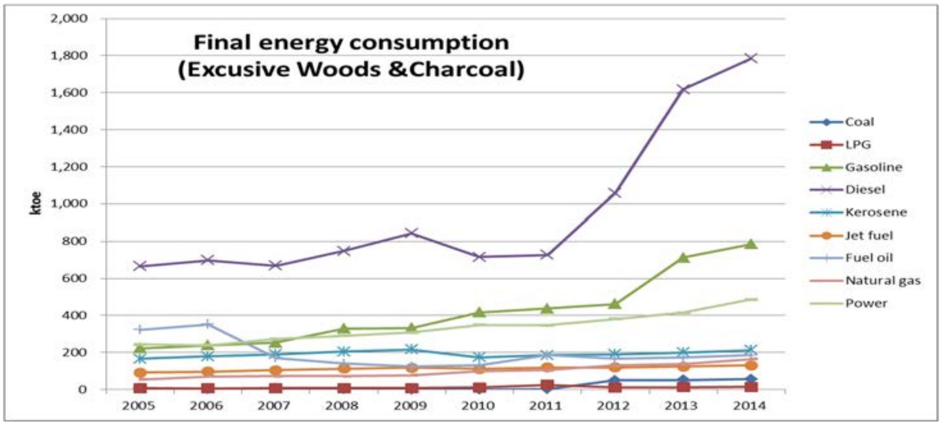
7.6.1 Current final energy consumption

Tanzanian final energy consumption trends are as the following table. When looking at the contributions of the consumption, the contribution of woods and charcoal is higher than others, it is 94 % in 2000, 88 % in 2005, 86 % in 2010 and 82 % in 2014. And the primary energy consumption per capita of the selected countries is that USA and Saudi Arabia are 16 times to Tanzania, Japan is 8 times and Malaysia is 6 times. It is required that the fossil energies (Oil products, Natural gas, Coal etc.) as final energy demand of Tanzania are forecasted in company with considering Energy Efficiency policy, Domestic energy supply and Environmental issues.

Table 7.6.1-1 Actual final energy demand of Tanzania

	Used sectors	Unit	2000	2005	2010	2011	2012	2013	2014
Final energy	Coal	ktoe	30	7	0	2	49	51	56
Demand	LPG	ktoe	3	6	10	26	11	13	14
	Gasoline	ktoe	100	223	416	437	463	712	786
	Diesel	ktoe	292	665	715	727	1,059	1,618	1,785
	Kerosene	ktoe	96	166	174	185	190	200	213
	Jet fuel	ktoe	61	91	111	119	119	125	131
	Fuel oil	ktoe	136	323	131	185	166	172	185
	Natural gas	ktoe	0	55	100	104	130	137	164
	Power	ktoe	158	243	348	346	381	414	487
	Bio (Woods Charcoal)	ktoe	12,458	13,566	15,657	15,793	16,154	16,940	17,895
	Total	ktoe	13,333	15,345	17,661	17,924	18,721	20,382	21,714
Contribution	Coal	%	0.2	0.0	0.0	0.0	0.3	0.3	0.3
	LPG	%	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	Gasoline	%	0.8	1.5	2.4	2.4	2.5	3.5	3.6
	Diesel	%	2.2	4.3	4.0	4.1	5.7	7.9	8.2
	Kerosene	%	0.7	1.1	1.0	1.0	1.0	1.0	1.0
	Jet fuel	%	0.5	0.6	0.6	0.7	0.6	0.6	0.6
	Fuel oil	%	1.0	2.1	0.7	1.0	0.9	0.8	0.9
	Natural gas	%	0.0	0.4	0.6	0.6	0.7	0.7	0.8
	Power	%	1.2	1.6	2.0	1.9	2.0	2.0	2.2
	Bio (Woods Charcoal)	%	93.4	88.4	88.6	88.1	86.3	83.1	82.4
	Total	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: The data are come from IEA database, some data are revised by MEM data
Source: IEA and MEM data of Tanzania



Note: Woods and Charcoal are exclusive in the figure
Source: IEA and MEM data of Tanzania

Figure 7.6.1-1 Trends of final energy consumption

7.6.2 Methodologies of final energy consumption forecasts

The final energy consumption by energy is forecasted by means of dividing the final energy consumption by the energy contribution ratios of the sectors. The contribution ratios are changed year by year, usually energy consumption are changed from woods and charcoal to fixed fuels, liquid fuels, gas fuels and electricity. In the study, it is assumed that the woods and charcoals are substituted by other energies because the Government has already established the policy reducing woods and charcoal consumption. The details are as follows;

Table 7.6.2-1 Substitution energies of woods and charcoal

Sector	Substitution energies
Agriculture	As woods and charcoal for food processing will be not changed even in future, any substitution energies are not alternated.
Industry	Woods and charcoal are used for burning boilers in Tanzania, the some are substituted by natural gas and coal in future.
Commercial and Services	Woods and charcoal are used for cocking and heating, the some are substituted by natural gas and LPG in future.
Residential	Woods and charcoal are used for cocking and heating, the some are substituted by electricity, natural gas and LPG in future.
Electric power	Though there is some bagasse for power generation, it cannot be expected that the bagasse become bigger energy resources in future than now.

Under considering substitution of woods and charcoals, the methodologies of final energy demand forecasts are as follows;

Table 7.6.2-2 Methodologies of final energy demand forecasts by energy

	Items	Contents
Step 1	Consideration of energy consumption structures	The targets are reduction of woods and charcoal consumption or decreasing the growth rates
Step 2	Outlook the domestic energy supply as alternative energies	In case of Tanzania, those are natural gas, LPG, coal briquette and rural electrification activities.
Step 3	Analysis final energy structure of woods and charcoal	Analysis final energy structure of Agriculture, Industry, Commercial & Service and Residential sectors
Step 4	Predict the structure of final energy consumption	Estimate final energy consumption structure by the above sector
Step 5	Forecasts final energy consumption	Energy demand forecasts by the above sector
Step 6	Examine the growth rates of final energy consumption	Consistence check between growth rates of energy consumption and total energy consumption.
Step 7	Adequacy check the trends of energy consumption structures	Examine the contribution of the above final energy consumption in the sectoral total consumption

7.6.3 Final energy consumption

The following table shows the final energy consumption by sector and the growth rate.

Table 7.6.3-1 Sectoral final energy consumption forecasts by energy

Unit: ktoe

		2015	2020	2025	2030	2035	2040
Agriculture.Fishery	Fuel oil	23	29	38	50	65	82
	Bio	891	1,021	1,223	1,445	1,682	1,929
	Power	0.01	0.17	0.33	0.62	1.18	2.18
	Total	914	1,050	1,262	1,496	1,748	2,013
Industry	Coal	61	93	163	262	458	751
	Fuel oil	169	270	475	761	1,210	1,555
	Natural gas	166	351	859	1,911	4,221	6,924
	Bio	2,906	4,056	5,748	7,074	7,837	8,412
	Power	207	494	848	1,358	2,180	3,311
	Total	3,510	5,264	8,094	11,365	15,905	20,953
Commercial & Service	LPG	1	6	16	36	71	161
	Diesel	21	28	39	51	66	78
	Natural gas	1	9	43	87	170	384
	Bio	601	752	955	1,137	1,289	1,172
	Power	26	59	112	205	373	650
	Total	650	853	1,165	1,516	1,968	2,444
Government	Power for Zanzibar	30	56	85	113	142	165
	Power for Street light	0.00	0.00	0.01	0.01	0.01	0.02
	Power for Gold mining	17	18	18	19	19	20
	Total	47	73	103	132	161	185
Transportation	Gasoline	552	761	1,062	1,419	1,898	2,421
	Diesel	1,067	1,472	2,053	2,743	3,668	4,681
	Natural gas	0	0	0	0	0	0
	Total	1,620	2,234	3,115	4,162	5,566	7,102
Residential	LPG	105	163	87	392	683	1,153
	Kerosene	62	79	101	119	135	149
	Natural gas	31	131	722	1,306	2,278	3,843
	Bio	15,264	18,363	21,663	23,526	24,344	23,607
	Power	171	399	677	1,106	1,753	2,707
	Total	15,634	19,135	23,249	26,449	29,193	31,459
Other end users	Jet fuel(Airplane)	151	192	240	295	358	425
	Fuel oil(Internal Marine)	62	73	86	100	115	130
	Total	213	265	327	395	472	555

		2015	2020	2025	2030	2035	2040
Total	Oil	2,275	3,166	4,361	6,228	8,726	11,586
	Natural gas	198	491	1,625	3,304	6,668	11,152
	Bio	19,662	24,191	29,589	33,182	35,152	35,119
	Power	451	1,025	1,741	2,801	4,469	6,855
	Total	22,586	28,873	37,315	45,514	55,014	64,712
Contribution	Oil	10.1	11.0	11.7	13.7	15.9	17.9
	Natural gas	0.9	1.7	4.4	7.3	12.1	17.2
	Bio	87.1	83.8	79.3	72.9	63.9	54.3
	Power	2.0	3.6	4.7	6.2	8.1	10.6
	Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: PSMP2016 UPDATE

Table 7.6.3-2 The growth rate of final energy consumption by energy in sectors

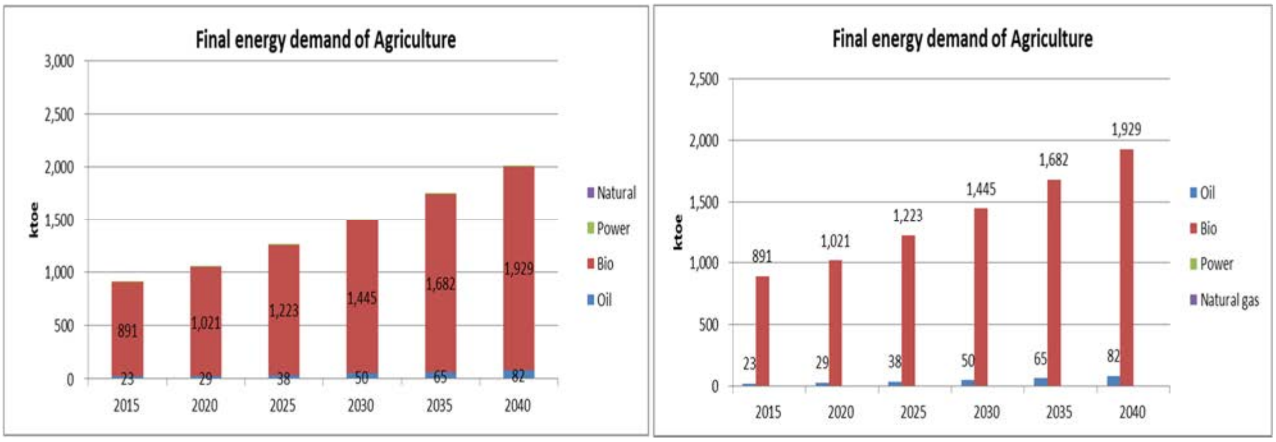
Unit: %

		2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2025/15	2035/15	2040/15
Agriculture.Fishery	Fuel oil	6.0	4.9	5.8	5.5	5.2	4.9	5.3	5.4	5.3
	Bio	3.8	2.8	3.7	3.4	3.1	2.8	3.2	3.2	3.1
	Power	7.8	65.3	14.0	13.8	13.5	13.1	37.3	24.9	22.5
	Total	3.8	2.8	3.8	3.5	3.2	2.9	3.3	3.3	3.2
Industry	Coal	0.0	8.7	12.0	9.9	11.8	10.4	10.3	10.6	10.6
	Fuel oil	20.4	9.8	12.0	9.9	9.7	5.1	10.9	10.3	9.3
	Natural gas	10.6	16.2	19.6	17.3	17.2	10.4	17.9	17.6	16.1
	Bio	7.0	6.9	7.2	4.2	2.1	1.4	7.1	5.1	4.3
	Power	4.6	18.9	11.4	9.9	9.9	8.7	15.1	12.5	11.7
	Total	7.9	8.4	9.0	7.0	7.0	5.7	8.7	7.8	7.4
Commercial & Service	LPG	0.0	34.8	22.8	18.5	14.4	17.7	28.7	22.4	21.5
	Diesel	5.6	6.0	6.9	5.5	5.0	3.4	6.4	5.8	5.4
	Natural gas	0.0	47.6	37.7	14.9	14.4	17.7	42.5	27.8	25.8
	Bio	3.6	4.6	4.9	3.5	2.5	-1.9	4.7	3.9	2.7
	Power	5.9	18.1	13.8	12.8	12.7	11.7	15.9	14.3	13.8
	Total	3.8	5.6	6.4	5.4	5.4	4.4	6.0	5.7	5.4
Government	Power for Zanzibar	14.5	13.5	8.8	5.8	4.7	3.1	11.1	8.1	7.1
	Power for Street light	14.5	8.4	8.4	7.2	7.2	6.0	8.4	7.8	7.4
	Power for Gold mining	7.6	0.7	0.7	0.6	0.6	0.5	0.7	0.6	0.6
	Total	11.6	9.5	7.1	4.9	4.2	2.8	8.3	6.4	5.7
Transportation	Gasoline	9.1	6.6	6.9	6.0	6.0	5.0	6.8	6.4	6.1
	Diesel	6.4	6.6	6.9	6.0	6.0	5.0	6.8	6.4	6.1
	Natural gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	7.3	6.6	6.9	6.0	6.0	5.0	6.8	6.4	6.1
Residential	LPG	37.3	9.1	-11.9	35.2	11.8	11.0	-1.9	9.8	10.0
	Kerosene	-22.8	5.0	4.8	3.4	2.6	1.9	4.9	3.9	3.5
	Natural gas	0.0	33.5	40.7	12.6	11.8	11.0	37.0	24.0	21.3
	Bio	4.3	3.8	3.4	1.7	0.7	-0.6	3.6	2.4	1.8
	Power	4.6	18.5	11.2	10.3	9.6	9.1	14.8	12.3	11.7
	Total	4.2	4.1	4.0	2.6	2.0	1.5	4.0	3.2	2.8
Other end users	Jet fuel(Airplane)	5.1	4.9	4.6	4.2	3.9	3.5	4.8	4.4	4.2
	Fuel oil(Internal Marine)	5.6	3.5	3.3	3.0	2.8	2.5	3.4	3.1	3.0
	Total	5.3	4.5	4.3	3.9	3.6	3.3	4.4	4.1	3.9

		2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2025/15	2035/15	2040/15
Total	Oil	6.6	6.8	6.6	7.4	7.0	5.8	6.7	7.0	6.7
	Natural gas	14.6	19.9	27.0	15.3	15.1	10.8	23.4	19.2	17.5
	Bio	4.7	4.2	4.1	2.3	1.2	0.0	4.2	2.9	2.3
	Power	5.3	17.9	11.2	10.0	9.8	8.9	14.5	12.2	11.5
	Total	4.9	5.0	5.3	4.1	3.9	3.3	5.1	4.6	4.3
Contribution	Oil	1.6	1.7	1.3	3.2	3.0	2.5	1.5	2.3	2.3
	Natural gas	9.2	14.2	20.7	10.8	10.8	7.3	17.4	14.0	12.7
	Bio	-0.3	-0.8	-1.1	-1.7	-2.6	-3.2	-0.9	-1.5	-1.9
	Power	0.3	12.2	5.6	5.7	5.7	5.5	8.9	7.3	6.9
	Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

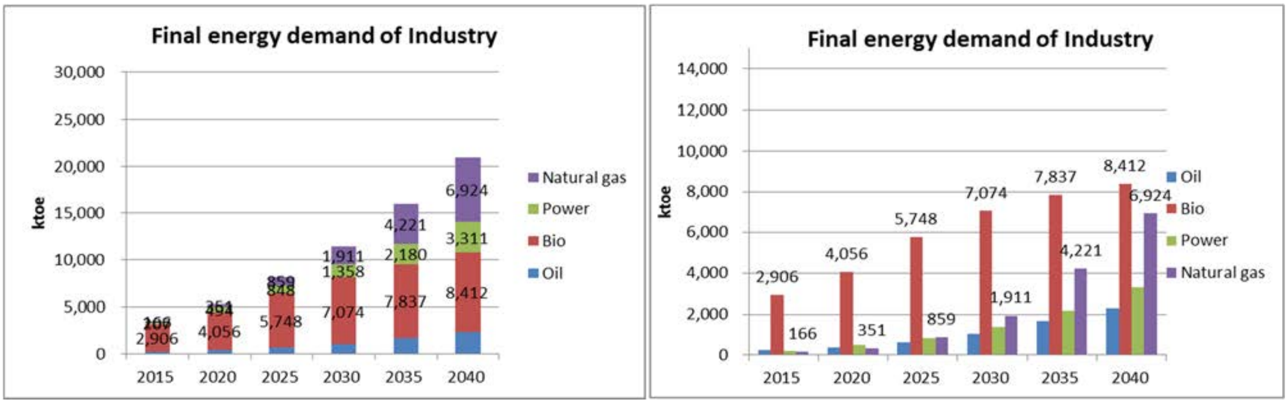
Source: PSMP2016 UPDATE

The future trends of final energy consumption are as the following figures. As final energy used in the sectors, natural gas, oil, electric power (Conversion factor 1kWh=860kcal) and bio (wood and charcoal) are shown in the figures.



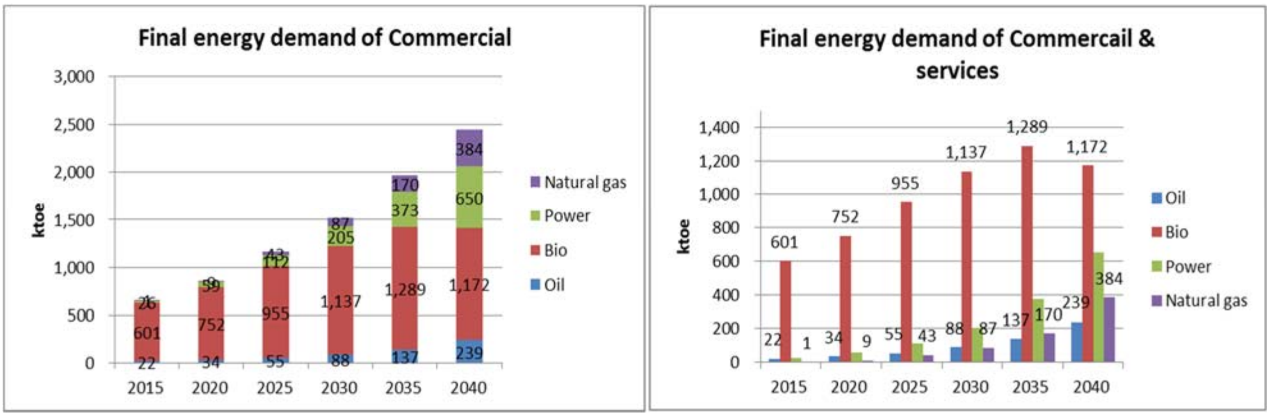
Source: PSMP2016 UPDATE

Figure 7.6.3-1 Final energy demand of Agriculture



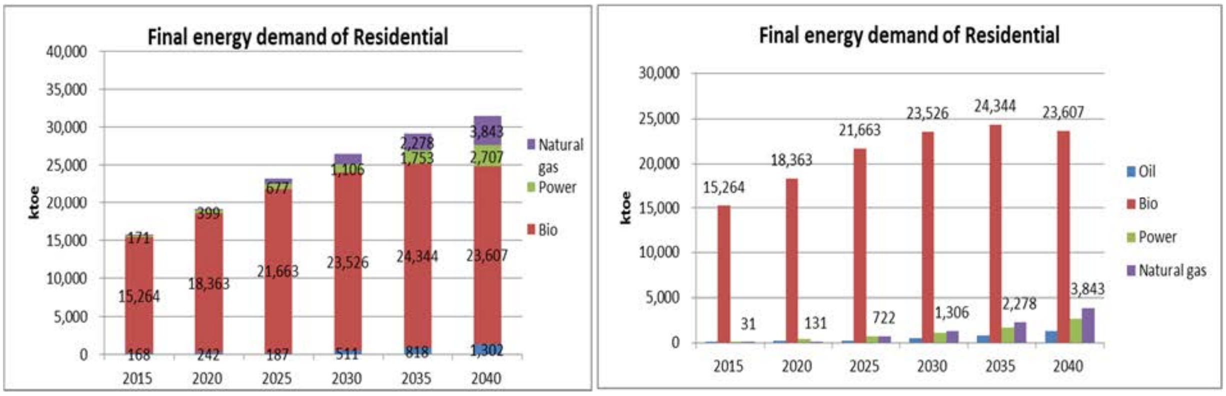
Source: PSMP2016 UPDATE

Figure 7.6.3-2 Final energy demand of Industry sector



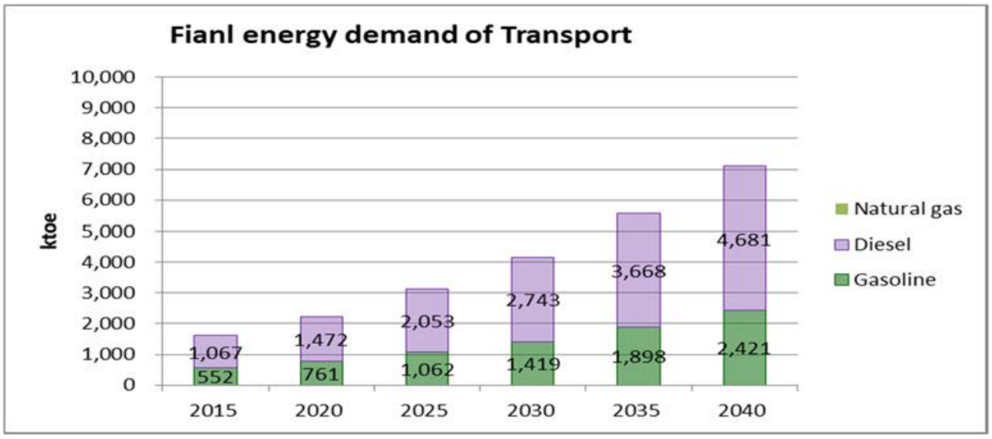
Source: PSMP2016 UPDATE

Figure 7.6.3-3 Final energy demand of Commercial and Service sector



Source: PSMP2016 UPDATE

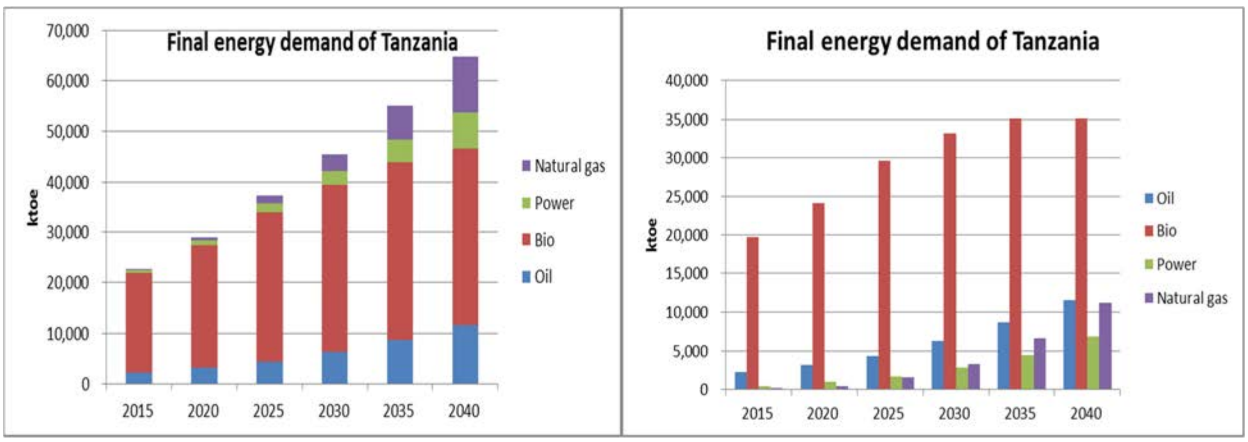
Figure 7.6.3-4 Final energy demand of Residential sector



Note: Gasoline and diesel are used in Transportation sector. According to TPDC information, natural gas utilization is considered.

Source: PSMP2016 UPDATE

Figure 7.6.3-5 Final energy demand of Transportation sector

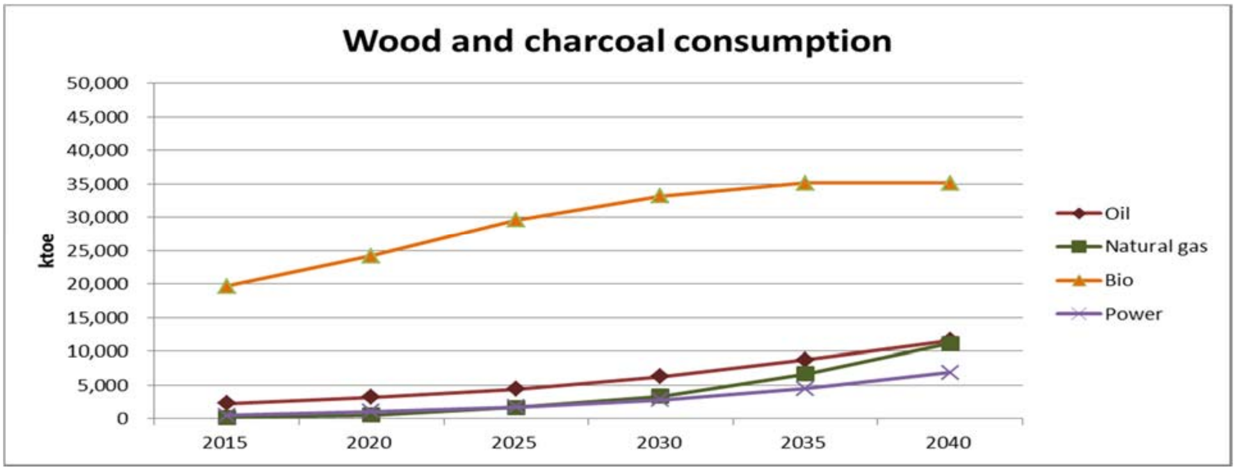


Source: PSMP2016 UPDATE

Figure 7.6.3-6 The total final energy consumption by energy

7.6.4 Contribution of final energy demand

The contribution of woods and charcoal is 83 % in 2015 and 47 % in 2040. The contribution in 2040 is decreased less than half to one in 2015. The average growth rates by energy from 2015 to 2040 are 17.5% for natural gas, 11.5% for electric power, 2.3% for woods and charcoal and 4.3% for the total final energy consumption.



Note: 82% contribution of woods and charcoal in 2015 is calculated from IEA data and the reduction of the contribution is the policy of Rural Energy Agency (REA).
Source: PSMP2016 UPDATE

Figure 7.6.4-1 Final energy demand forecasts by energy

7.7 Primary energy demand forecasts

7.7.1 Primary demand forecast

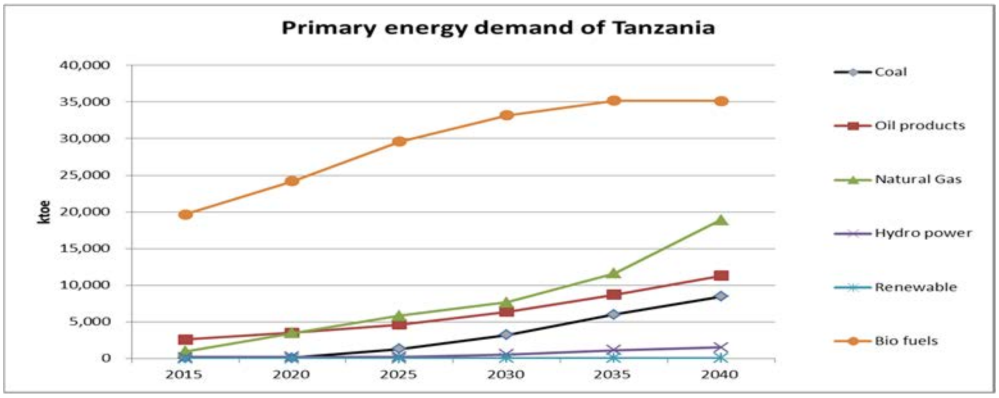
The significant point of the primary energy consumption in Tanzania is the most of the primary energy are supplied by woods and charcoal in the past years. The contribution of woods and charcoal as of 2015 is 84 % in the primary energies, and the second one is oil products with 11 % and third one is natural gas with 4 %. Under considering the recent development plans of natural gas and coal, the primary energy demands are forecasted as the following table.

Table 7.7.1-1 Primary energy demand forecasts (Base case)

Unit: Energy: ktoe Contribution: %

		Unit	2015	2020	2025	2030	2035	2040
Primary energy consumption	Coal	ktoe	61	93	1,301	3,226	6,002	8,487
	Oil products	ktoe	2,617	3,538	4,658	6,391	8,705	11,311
	Natural Gas	ktoe	971	3,485	5,833	7,693	11,618	18,929
	Hydro power	ktoe	183	218	236	563	1,139	1,544
	Renewable	ktoe	14	14	37	60	60	60
	Bio fuels	ktoe	19,669	24,199	29,600	33,195	35,169	35,141
	Total	ktoe	23,508	31,539	41,653	51,115	62,675	75,450
Contribution Primary energy	Coal	%	0.3	0.3	3.1	6.3	9.6	11.2
	Oil products	%	11.1	11.2	11.2	12.5	13.9	15.0
	Natural Gas	%	4.1	11.0	14.0	15.1	18.5	25.1
	Hydro power	%	0.8	0.7	0.6	1.1	1.8	2.0
	Renewable	%	0.1	0.0	0.1	0.1	0.1	0.1
	Bio fuels	%	83.7	76.7	71.1	64.9	56.1	46.6
	Total	%	100.0	100.0	100.0	100.0	100.0	100.0

Note: The demand forecasts include energy consumption of the power generation plan in PSMP2016 UPDATE
Note: As natural gas for fertilizer, natural gas is consumed with 26 Bcf in 2020 and 53 Bcf after 2026.
Source: PSMP2016 UPDATE



Source: PSMP2016 UPDATE

Figure 7.7.1-1 Primary energy consumption trends

The following table is the growth rates of the primary energies from 2015 to 2040. Coal demand and natural gas demand are increased in company with introducing fired power plants and fertilizer plants.

Table 7.7.1-2 Growth rates of primary energy demand (Base case)

Unit: %

		2015/10	2020/15	2025/20	2030/25	2035/30	2040/35	2025/15	2035/15	2040/15
Primary energy consumption	Coal	0.0	8.7	69.6	19.9	13.2	7.2	35.8	25.8	21.8
	Oil products	8.8	6.2	5.7	6.5	6.4	5.4	5.9	6.2	6.0
	Natural Gas	8.7	29.1	10.8	5.7	8.6	10.3	19.6	13.2	12.6
	Hydro power	-4.1	3.6	1.5	19.0	15.1	6.3	2.6	9.6	8.9
	Renewable	0.0	0.0	20.7	10.0	0.0	0.0	9.9	7.3	5.8
	Bio fuels	4.7	4.2	4.1	2.3	1.2	0.0	4.2	2.9	2.3
	Total	5.2	6.1	5.7	4.2	4.2	3.8	5.9	5.0	4.8

Source: PSMP2016 UPDATE

7.7.2 Future contribution of primary energies

Regarding future primary energy contribution, reduction of woods and charcoal, the increase of fossil energy as natural gas and coal in company with the development and increase of gasoline and diesel for transportation sector will be happened. In the phenomenon, the natural gas and coal development plans will become important agendas for Tanzania government. The total primary energy demands are increased from 24 million toe in 2015 to 76 million toe in 2040. It is three time between 2015 and 2040. The growth rate from 2015 to 2040 is 4.8 % per year. In this forecasting, the contribution of natural gas is increased from 4% in 2015 to 25% in 2040, and the contribution of coal is increased from less than 1% in 2015 to 11% in 2040.

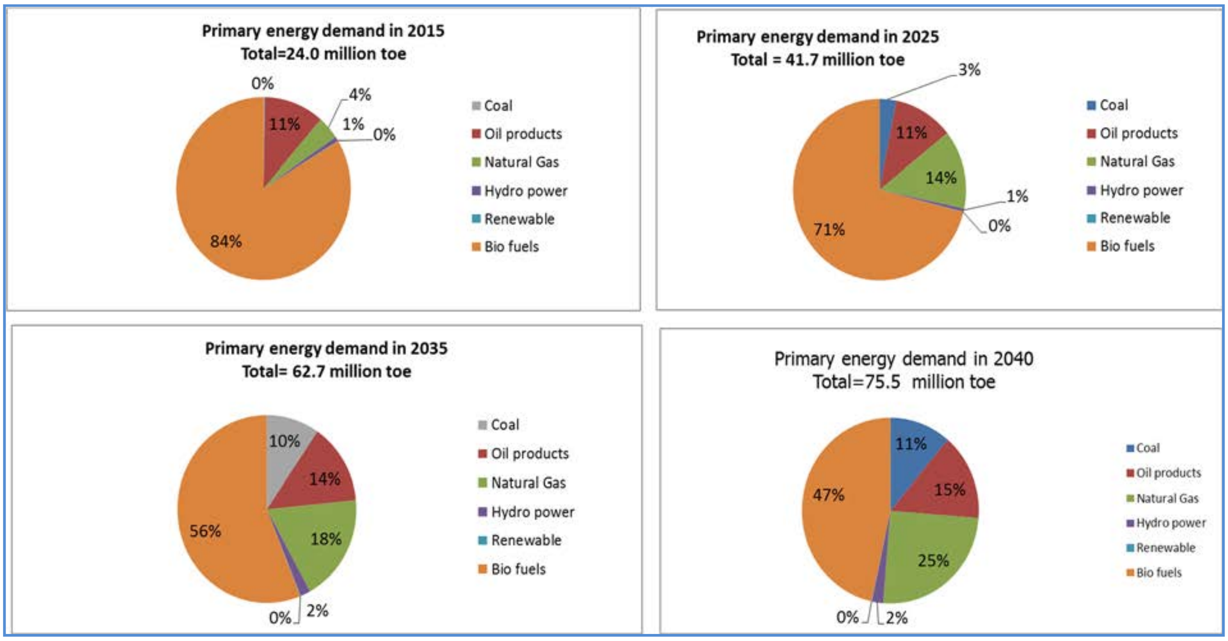


Figure 7.7.2-1 Contribution of Primary energy

Chapter 8 Power Development Plan

8.1 Existing Power Generating Facilities

8.1.1 Thermal Power Generation Facilities

Table 8.1.1-1 shows the thermal power stations that are currently in operation. The total rated output of thermal power generating facilities is 796.7 MW, which accounts for approximately 59% of all power generating facilities (total 1,345 MW) connected to the national transmission grid in Tanzania. TANESCO and IPP thermal power stations include units that use petroleum-based fuels such as fuel oil, diesel, etc., and since these entail high cost structures, there are issues concerning switching of fuel to natural gas.

Table 8.1.1-1 Existing Thermal Power stations

Plant	Fuel	Units	Installed Capacity MW	Available Capacity MW	Station service %	Net Available Capacity MW	FOR %	Combined Outage Rate %	Max. Plant Factor %	Available Energy GWh	Year Installed (Jan)	Nominal Service Life Years	Retire-ment Year (Dec)
IPP UNITS													
Songas 1	Gas		42.0	38.3	1.6	37.7	5	13	80	251	2004	20	2023
Songas 2	Gas	3	120.0	110.0	1.6	108.2	5	13	80	721	2005	20	2024
Songas 3	Gas	1	40.0	37.0	1.6	36.4	5	13	80	242	2006	20	2025
Tegeta IPTL	HFO	10	103.0	100.0	1.6	98.4	8	18	75	595	2002	20	2021
TPC	Biomass		17.0	17.0	1.6	16.7	5	13	50	70	2011	20	2030
TANWAT	Biomass		2.7	2.40	1.6	2.4	5	13	50	10	2010	20	2029
Subtotal			**324.7**	**304.7**		**299.8**				**1888**			
TANESCO													
Ubungo I	Gas	12	102.0	100.0	1.6	98.4	5	13	80	655	2007	20	2026
Tegeta GT	Gas	5	45.0	43.0	1.6	42.3	5	13	80	282	2009	20	2028
Ubungo II	Gas	3	105.0	100.0	1.6	98.4	5	13	80	655	2012	20	2031
Zuzu D	IDO	1	7.0	5.0	1.6	4.9	8	18	75	31	1980	20	2019
Nyakato	HFO	10	63.0	63.0	1.6	62.0	8	18	75	375	2013	20	2032*
Kinyerezi-I	Gas	4	150.0	150.0	1.6	147.6	5	13	80	1034	2015	20	2035
Subtotal			**472.0**	**461.0**		**453.6**				**1998**			
TOTAL			**796.7**	**765.7**		**753.5**				**3886**			

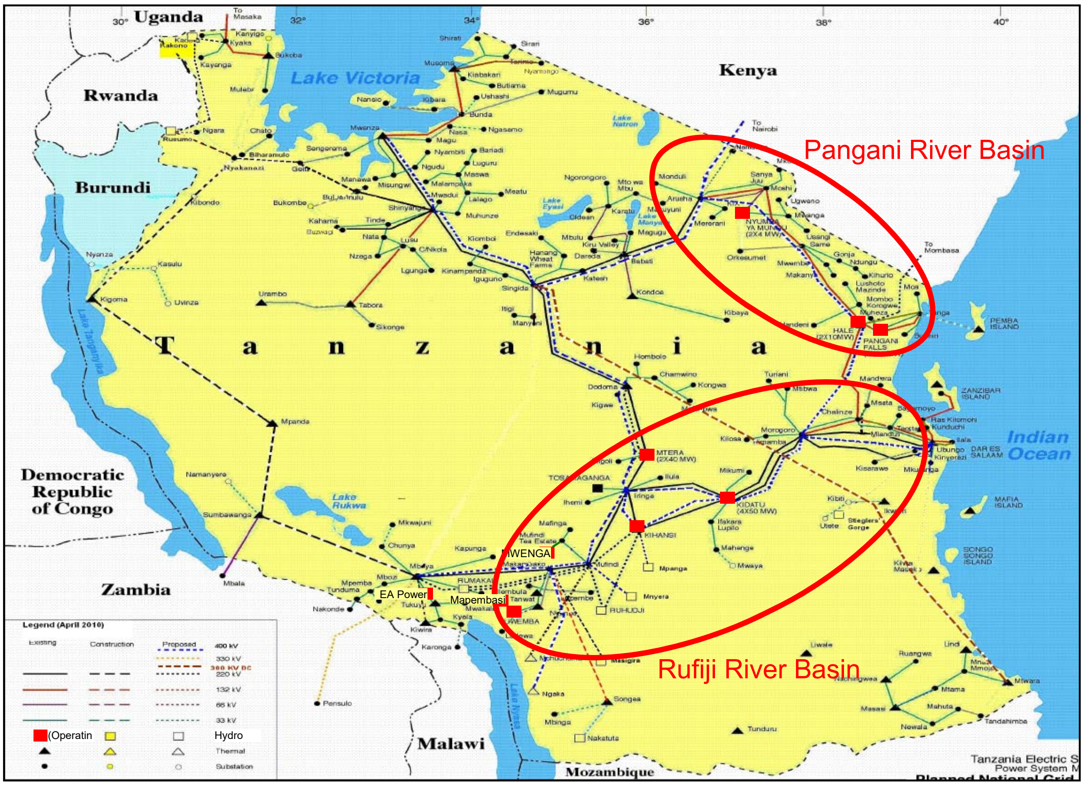
Available energy (MWh) = Available capacity (MW) * 8.76*(100-FOR)*max plant factor/100
Small diesels assumed to stay in service to December 2012 as reserve
FOR = Forced Outage Rate
*: To be operated as a standby after 2021

8.1.2 Hydro Power Generation Facilities

Thirteen hydro power plants with a total installed capacity of 573MW were in operation of which nine hydro plants with a total installed capacity of 567MW are interconnected to the National Grid as of the end of December 2016 (see Table 8.1.2-1). Three plants with a total installed capacity of 97MW are located in the Pangani River Basin, 8 plants with a total installed capacity of 475MW are located in the Rufiji River Basin, and 2 plants with a total installed capacity of 1MW are located in other river basins (see Figure 8.1.2-1).

Among these existing hydro power plants, seven plants with a total installed capacity of 562MW are owned and operated by TANESCO. In addition to these, two plants[1] with a total installed capacity of 2MW are owned by TANESCO, although they are not working. No hydro power plants have been developed by TANESCO since Kihansi hydro power plant was built in 2000.

The remaining six existing hydro power plant are owned and operated by private companies which made a Standardized Power Purchase Agreement (SPPA) with TANESCO for each project under the Small Power Project (SPP) Framework.



Source: TANESCO, with additions

Figure 8.1.2-1 Location Map of Operating Hydro Power Plants interconnected to National Grid

1 Mbalizi Hydro Power Plant with installed capacity 358kW (179kW x 2 units) located in Mbeya Region and Tosamaganga Hydro Power Plant with installed capacity 1,220kW (840kW + 380kW) located in Iringa Region

Table 8.1.2-1 (1) Operating Hydro Power Plants Interconnected to National Grid (as of the end of December 2016)

Item			Hydro Power Plant						
			Hale	Nyumba Ya Mungu	New Pangani Falls	Kidatu	Mtera	Uwemba	Kihansi
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: Made by JICA Study Team with reference to "Websaite of TANESCO", "Suppliers yearly kWh (TANESCO)", "PSMP 2012 update (May 2013, MEM)", "Annual report of each plant" and Hearing from TANESCO in October 2014

Table 8.1.2-1(2) Hydro Power Plants operated under SPP (as of the end of December 2016)

Item			Hydro Power Plant							
			Mwenga	Mapembasi	EA Power	Darakuta *	Yovi	Tulila *	Ikondo *	Mbangamao *
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.
*: Currently connected to isolated grids.
Source: TANESCO, REA and PSMP2012 Update

8.2 Development Plans in the Implementation/Planning Stage

8.2.1 Thermal Power Generating Facilities

(1) Outline of Planned Thermal Power Projects

1) Kinyerezi I gas-fired thermal power station

It uses four GE gas turbines (type: LM6000PF, Simple Cycle GT) and has total output of 150 MW (44.43 MW × 2, 35.94 MW × 2). The EPC contractor is Jacobson Elektro (Norway). It was originally scheduled to start operation in 2014, however, this has been postponed due to delays in fundraising. In October 2015, first 2 GT was operated and the rest 2 GT were commissioned in early 2016.

It utilizes natural gas from Mnazi Bay, Songo Songo gas field for fuel. Concerning gas supply, a gas terminal that will satisfy the demand of all power stations from Kinyerezi I to IV was constructed on adjacent land. Also, in consideration of the risk of gas supply being interrupted, two emergency use Jet-A1 fuel tanks (7,500m^3) will also be constructed. As the transmission system, it is constructed two 220kV transmission lines and connect them to the Ubungo - Morogoro line (π connection). Voltage is stepped down to 132kV at the switching station and then transmitted to the Factory Zone II substation.

There are future plans to construct an additional 185 MW of capacity and to introduce a combined cycle system. Additional simple cycle GT expansion is conducted in advance of combined cycle system. It is scheduled to start operation in 2017.

2) Kinyerezi II gas-fired thermal power station

This combined cycle (multi-axial CCGT: 3 on 1) gas turbine thermal power station uses gas turbines (6) made by MHPS with total output of 240 MW (GT output: 30 MW x 6, ST output: 30 MW x 2). The EPC contractor is Sumitomo Corporation. It was originally planned to commence operation in December 2015, however, the start of construction has been delayed due to delays in the loan agreement. The loan agreement was concluded in March 2016 with a view to commencing operation in 2018.

As in the case of Kinyerezi I power station, it is planned to obtain natural gas from Mnazi Bay and Songo Songo gas field as fuel.

3) Kinyerezi III, IV gas-fired thermal power station

Both Kinyerezi III and IV gas-fired thermal power stations are planned as combined cycle gas turbine thermal power facilities. Both power stations are scheduled to start operation in 2018 and 2019, respectively.

Kinyerezi III gas-fired thermal power station is a PPP project being implemented by Shang Tan Power Generation Company, which is jointly funded by Shanghai Electric Power Company of China, and TANESCO (the share of capital is 60:40 Shanghai Electric: TANESCO). It is a combined cycle gas turbine thermal power station with total output of 600 MW (Phase 1:300 MW, Phase 2: 300 MW). The F/S has been completed and the plans are currently undergoing amendment in response to comments made by the Ministry of Finance.

Kinyerezi IV gas-fired thermal power station is a PPP project being implemented by Poly Group of China and TANESCO. It was initially planned to construct a combined cycle gas turbine thermal power station with total output of 450 MW, but scale has since been pared down to 330 MW. The F/S has been completed and the plans are currently being reviewed by TANESCO.

4) Somanga Fungu gas-fired thermal power station

Somanga Fungu gas-fired thermal power station is an IPP project owned by Kilwa Energy. It entails construction of a combined cycle gas turbine thermal power station. It is planned to introduce a simple cycle gas turbine system in Phase 1 and to adopt a combined cycle system in Phase 2. Total output is planned as 320 MW (Phase 1: 210 MW, Phase 2: 110 MW).

5) Mtwara gas-fired thermal power station

Mtwara gas-fired thermal power station is a PPP project being implemented by Symbion Power (United States) and TANESCO. However, no progress has been made so far. Therefore, TANESCO has changed its policy and is planning to utilize concessional loan to develop Mtwara combined cycle power plant with the installed capacity of 300MW by itself.

6) Zinga gas-fired thermal power station

Zinga gas-fired thermal power station is an IPP project for construction of a combined cycle gas turbine thermal power station with total output of 200 MW. Currently the F/S is undergoing review.

7) Mkuranga gas-fired thermal power station

Two gas-fired thermal power station projects have been implemented in Mkuranga.

The first project, which is a JV/PPP undertaking between the World Bank and TANESCO, aims to construct a combined cycle gas turbine thermal power station. Total output of 250 MW is planned.

The second project is a joint undertaking with the National Social Security Fund (NSSF) based on 10% funding by TANESCO, 20% by the NSSF, and the remaining 70% by the developer. It is planned to construct a 300 MW combined cycle gas turbine thermal power station.

However, no progress has been made for the above mentioned two projects so far. Therefore, the former PPP project is relocated to Somanga and named “Somanga (PPP)” and the latter is transformed into Somanga (TANESCO) which is to be developed by export credit and own finance.

8) Mchuchuma coal-fired thermal power station

This coal-fired thermal power station is planned as a component of Mchuchuma mine development. It was initially planned as a colliery power generation project for 300 MW, 400 MW, and 300 MW in PSMP 2012. Following the F/S, the unit mix was reviewed and revised to 150 MW x 4 units (total 600 MW). Sub-critical (Sub-C) power generation at 38.8% efficiency (generating end: HHV) is planned. This is lower than generating efficiency at current sub-critical power stations in Japan (roughly 41% efficiency, generating end: HHV). TCIMRL is under negotiation for PPA contract with TANESCO.

9) Kiwira/Ngaka coal-fired thermal power station

This coal-fired thermal power station at the colliery is planned as a component of Kiwira mine development. Two units of 200 MW each (total 400 MW) are planned. Since the F/S has not yet been implemented, the details are still unknown.

Similarly, Ngaka coal-fired thermal power station is planned as a colliery power station with total output of 400 MW (200 MW x 2), however, since the F/S has not yet been implemented, the details are still unknown.

Judging from the scale of facilities, it is thought that both power stations will be sub-critical (Sub-C) coal-fired power stations, however, in order to effectively utilize limited energy resources, it is desirable to construct coal-fired power stations based on higher efficiency systems such as super critical (SC), ultra-super critical (USC), advanced sub-critical (advanced sub-C) and so on.

10) Development status at other project sites

In addition to the abovementioned sites, numerous other candidate locations for coal-fired power stations are planned in PSMP 2012. Seven locations for Coastal Coal and Local Coal I~VI are envisaged, although there are currently no concrete plans.

(2) Status of ongoing and planned hydro power projects

The projects that are planned or in progress were ranked in view of the state of progress of each plant described in 8.2 Development Plans in the Implementation/Planning Stage.

The rankings were se as follows.

A: Projects for which funding has been secured and work is underway

B: Projects for which the major agreements, for example, PPA, BOT, EPC, etc. have already been signed

C: Projects for which the F/S has been implemented and is undergoing review

D: Projects for which the F/S and pre-F/S have not yet been implemented

Based on the above ranks, an extra 1 year is added to the construction period (3 years in the case of coal-fired thermal power stations, 2 years in the case of gas-fired thermal power stations) as development delay risk in cases where funding has not yet been secured, 1 year is added for cases that are still under negotiation, 0.5 year is added when the F/S is under review, and 1 year is added if the F/S has not yet been implemented. Moreover, since it is difficult to simultaneously start operation in Phase 2 of such projects, it is assumed that operation will start in two years. Based on the above, Table 8.2.1-1 shows the earliest years in which operation can be started in the projects.

As can be gathered from the table, almost all the projects have been delayed past the start years set in PSMP2012 and there are concerns over supply shortages.

Table 8.2.1-1 Progress on Thermal Generation Projects

	Financing	Contract	F/S	Rank	Earliest commissioning year	Remark
Kinyerezi I Extension (Simple cycle-185MW)	Financing concluded	Under final negotiation with Jacobsen Elektro for the extension work	F/S and detail design completed	A	2017	-Committed -US$182 mm is budgeted for the project by the GOT
Kinyerezi II (Combined cycle-240MW)	Financing concluded	EPC contract completed	F/S is completed	A	2017	- On power date in 2017 - GOT to secure 15% portion - Project cost US$344 m - 3-on-1 (120MW) x 2 block -Japan Bank for International Cooperation – 85% -Government – 15%
Kinyerezi III-1 (Simple cycle-300MW)	Not secured	-EPC Contract not signed -PPA not signed	Feasibility study for Phase-1 (simple cycle) completed	D	End of 2018	- This project is waiting for government approval. - JV arrangements with Shanghai Electric Power Company of China signed. - Water supply project for Kinyerezi complex is under consideration.
Kinyerezi III-2 (Combined cycle-300MW)	Not secured	-EPC Contract not signed -PPA not signed	F/S not conducted	D	End of 2018	- Implementation of Phase-1 is a condition for Phase-2.
Kinyerezi IV (330MW)	Not secured	-EPC Contract not signed -PPA not signed	pre-F/S completed	C	2019	
Mchuchuma I (150MW)	Not secured	- EPC Contract not signed - PPA not signed	F/S completed	C	2019	-TCIMC is the project developer, JV between NDC(20%) and Sichuang Hongda (China:80%) -MOU is to be signed with TANESCO and a developer
Mchuchuma II (150MW)	Not secured	- EPC Contract not signed - PPA not signed	F/S completed	C	2019	
Mchuchuma III (150MW)	Not secured	- EPC Contract not signed - PPA not signed	F/S completed	C	2020	
Mchuchuma IV (150MW)	Not secured	- EPC Contract not signed - PPA not signed	F/S completed	C	2020	
Kiwira I (200MW)	Not secured	-EPC Contract not signed -PPA not signed	F/S needs to be updated	C	2020	- Project developer secured.
Kiwira II (200MW)	Not secured	-EPC Contract not signed -PPA not signed	F/S needs to be updated	C	2024	
Ngaka I (200MW)	Not secured	-EPC Contract not signed -PPA not signed	F/S not started	D	2020	Procurement of consultant for F/S is in process
Ngaka II (200MW)	Not secured	-EPC Contract not signed -PPA not signed	F/S not started	D	2024	same as above
Somanga Fungu-1 (210MW)	Not secured	PPA completed	- F/S is completed	B	2018	- Financing for transmission line has been secured by TANESCO and compensation for right of way started. - Financial closure for transmission line is a condition for financing power plant construction.
Somanga Fungu-2 (110MW)	Not secured	PPA completed	- F/S is completed	B	2019	- after completion of Phase 1, Phase 2 start - CC (add HRSG)
Mtwara (Combined cycle-400MW)	Not secured	-EPC Contract not signed -PPA not signed	- F/S under progress	C	2019	- MOU signed is for 600MW. - Comments for F/S were sent to the investor and is revising it.
Bagamoyo (Zinga) (200MW)	Not secured	-EPC Contract not signed -PPA not signed	- F/S under progress	D	2020	- Almost two years have passed without any response since the comments on F/S were sent to the IPP developer. - IPP project
Somanga PPP (300MW)	Not secured	-EPC Contract not signed -PPA not signed	pre-F/S completed	C	2019	- Full F/S to be conducted. - PPP pilot project with WB - The project site was shifted from Mkuranga to Somanga and the capacity was increased from 250MW to 300 MW.
Mkuranga (300MW)	Not secured	-EPC Contract not signed -PPA not signed	F/S not conducted	D	2019	- 10% TANESCO, 20% NSSF, 70% Strategic partner - Procurement of strategic investor is in progress.

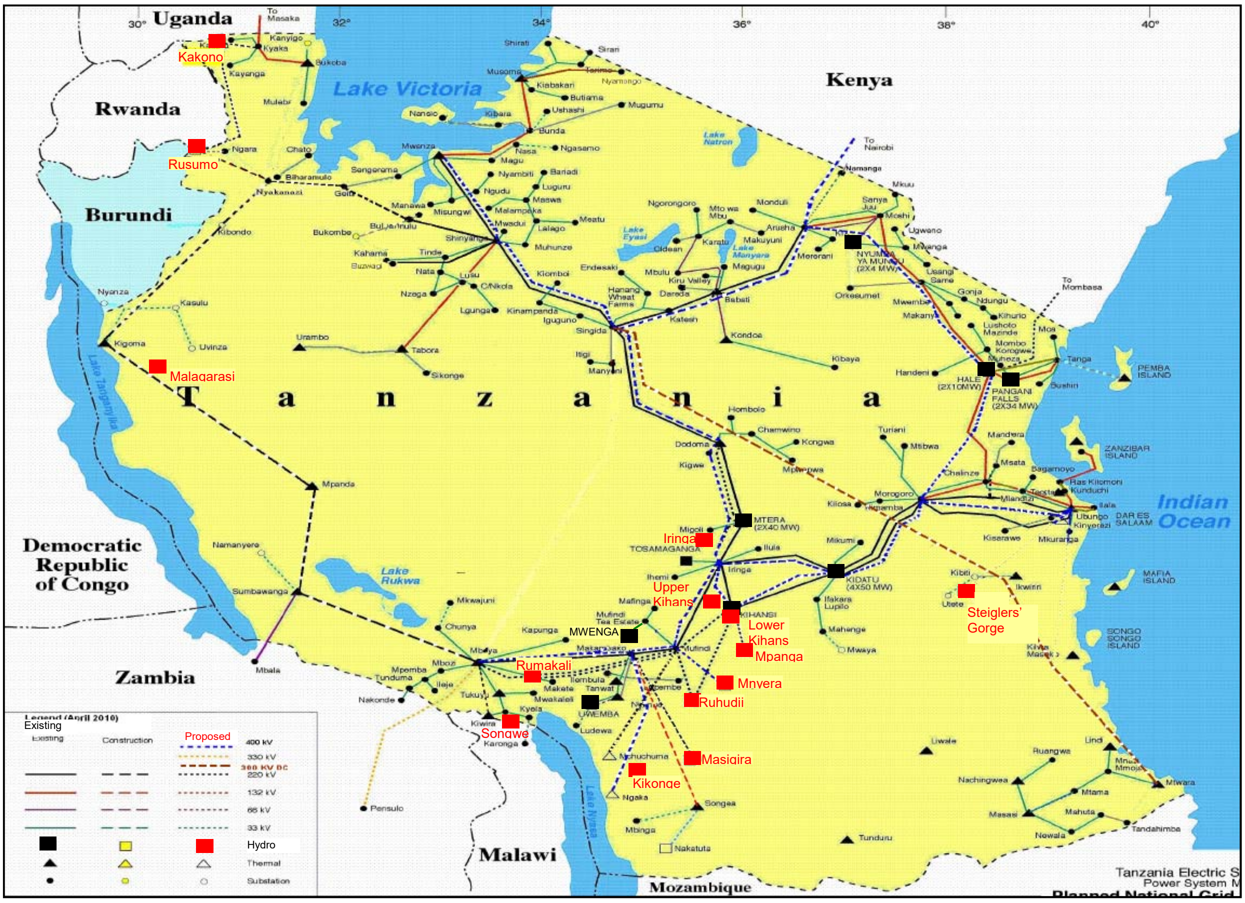
Rank	Description of Ranking	Required time to reach "Rank A"
A	Financing Closed or Construction started	N/A
B	PPA (BOT/EPC) contract signed	**+1 year**: Negotiation for financing (1year)
C	F/S, pre-F/S completed	**+2.5 years**: Approval for F/S (0.5 year), Negotiation for PPA (1year), Negotiation for financing (1year)
D	F/S, pre-F/S not completed	**+3.5 years**: F/S (1year), Approval for F/S (0.5year), Negotiation for PPA (1year), Negotiation for financing (1year)

Source: Task Force Team (MEM and TANESCO)

8.2.2 Hydro Power Generation Facilities

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, 23 projects with a total installed capacity of 4,765MW are identified as power development options in previous studies, including the power system master plan as shown in Table 8.2.2-1 and Figure 8.2.2-1. 4 planned projects out of those, i.e. Rumakali, Rusmo, 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 2015.



Source: TANESCO, with additions

Figure 8.2.2-1 Location Map of Planned Hydro Power Projects

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

Table 8.2.2-1 Planned Hydro Power Projects

			Planned Project		Installed Capacity (MW)	Current Status of Studies (as of December 2015)	Remarks
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	- Joint development project with 3 governments of Tanzania, Rwanda and Burundi - WB committed financing for the power plant - AfDB committed financing for the transmission line
2		Planning	Malagarasi Stage III		44.7	- F/S was completed in Sep-2011 - ESIA Certificate was issued by NEMC in 2014	- Procurement of consultant for updating F/S, detailed design and preparation of bidding document is in progress - Procurement of transaction advisor is also in progress
3			Rumakali		222.0	- F/S and ESIA study were completed in May-1998	- Procurement of consultant to update F/S is in progress
4			Ruhudji		358.0		
5			Steiglers Gorge	Phase 1	1,048.0	- Pre-F/S was completed in 2012 - ESIA study commenced in Dec-2014	- Joint development project with RUBADA and Odebrecht of Brazil
6				Phase 2	1,048.0		
7			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	- Two governments of Tanzania and Malawi will recruit participants including donors and investors
8				Sofre (Middle)	158.9		
9				Bipugu (Upper)	29.4		
10			Mpanga		160.0	- Pre-F/S was completed in Jun-2010 - ESIA Certificate was issued by NEMC in 2012	- Joint development project with RUBADA and Sinohydro Corporation Ltd. of China
11			Masigira		118.0	- F/S was completed	- Joint development project with Tanzanian and Chinese private companies
12			Lower Kihansi Expansion		120.0	- Preliminary study was completed in Mar-1997	- Government will secure finance
13			Upper Kihansi		47.0	- Pre-F/S was completed in Oct-1990 - ESIA study was conducted	
14			Kakono		87.0	- F/S and ESIA study were completed in Sep-2014 - ESIA was approved by NEMC	- Procurement of consultant for detailed design and preparation of bidding document is in progress - Procurement of transaction advisor is also in progress
15			Kikonge		300.0	- Reconnaissance study was completed in Feb-2014	- Negotiation with UK AID through CRIDF and African water Facility to perform a joint feasibility study
16			Iringa	Ibosa	36.0	- Pre-F/S was completed in May-2013	- Joint development project with RUBADA and K-water of South Korea
17				Nginayo	52.0		
18			Mnyera	Ruaha	60.3	- Pre-F/S was completed in Jun-2012 - ESIA study was completed in 2014 - NEMC reviewed ESIA study report	- Joint development project with RUBADA and Queiroz Galvao of Brazil
19				Mnyera	137.4		
20				Kwanini	143.9		
21				Pumbwe	122.9		
22				Taveta	83.9		
23				Kisingo	119.8		
Total					4,755.1		

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: Made by JICA Study Team with reference to "Previous study reports on each planned project" and Hearing from TANESCO, RUBADA and Ministry of Water during December 2015 to February 2016

(1) Outline of Planned Large and Medium-Scale Hydro Power Projects

The outline of development plans for planned large and medium-scale hydro power projects is shown in Table 8.2.2-2.

< One Project at the Stage of Implementation >

1) Rusumo Hydro Power Project

Rusumo Project is planned as a reservoir type power plant with a total installed capacity of 80MW, comprised of three 27MW units (see Table 8.2.2-2 (1))[3]. The Project is located in the northwestern part of Tanzania, and the generated power is planned to be supplied to not only Tanzania but also Rwanda and Burundi (see Figure 8.2.2-1).

The Project will be developed by Rusumo Hydropower Company Ltd., which is a Special Purpose Company (SPC) sponsored by the 3 governments of Tanzania, Rwanda and Burundi. According to TANESCO, the World Bank has committed to finance the company. For the construction of transmission lines on the Tanzanian side, the African Development Bank has committed to finance TANESCO.

The process of bidding for contractors has started as of December 2015. Operation of plant will start in April 2019.

< Twenty tow Projects under Planning>

2) Malagarasi Stage III Hydro Power Project

The pre-feasibility study on Malagarasi River hydropower projects was carried out in 2000[4], and Malagarasi Stage III Project was located at a downstream site as one of three cascade development projects. The installed capacity of the Project was planned to be 12MW because this study aimed to develop small hydro power projects interconnected to 33kV transmission lines.

Since then the feasibility study on the Project was carried in 2011[5], and the installed capacity was reviewed with the object of maximizing use of water resources. The Project is currently planned as a pondage type power plant with a total installed capacity of 44.7MW, comprised of three 14.9MW units (see Table 8.2.2-2 (1)).

The Project is located in the western part of Tanzania (see Figure 8.2.2-1). This area is isolated from the National Grid, and electric power supply depends heavily on diesel power plants for which generation costs are hugely expensive. Therefore, the priority of the Project is high for TANESCO.

The environmental and social impact assessment (ESIA) study on the Project was completed in October 2012. In addition, the ESIA study for the Project was approved by the National Environment Management Council (NEMC) in 2014.

According to TANESCO, procurement of consultant for updating F/S, detailed design and preparation of bidding document is in progress as of December 2015. Procurement of transaction advisor is also

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[3] 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)

[4] Pre-Investment Report on Mini Hydro Development – Case Study on the Malagarasi River – Final Report (March 2000, SECSD(P) Ltd.)

[5] Malagarasi Stage III Project - Power Plant Feasibility Study Final Report (September 2011, ESB International Ltd.)

in progress.

3) Rumakali Hydro Power Project

The feasibility study on Rumakali Project was carried out in 1998[6], and the Project was planned as a reservoir type power plant with a total installed capacity of 222MW, comprised of three 74MW units (see Table 8.2.2-2 (1)). In addition, the ESIA study was also conducted around the same time as the feasibility study.

TANESCO intends to develop the Project under the Public Private Partnership (PPP) Framework. Although TANESCO entered into the memorandum of understanding (MOU) on joint development of the Project with China Gezhouba Group Company in October 2013, the MOU expired in October 2014.

According to TANESCO, procurement of consultant to update F/S is in progress as of December 2015.

4) Ruhudji Hydro Power Project

The feasibility study on Ruhudji Project was carried out in 1998[7], and the Project was planned as a reservoir type power plant with a total installed capacity of 358MW, comprised of four 89.5MW units (see Table 8.2.2-2(3)). In addition, the ESIA study was also conducted around the same time as the feasibility study.

TANESCO intends to develop the Project under the PPP framework. Although TANESCO entered into the MOU on joint development of the Project with an American private company a few years ago, the MOU expired before October 2014.

According to TANESCO, procurement of consultant to update F/S is in progress as of December 2015.

5) Steiglers Gorge Hydro Power Project (Phase 1 and Phase 2)

Initially, Steiglers Gorge Project was planned as a multipurpose project with power generation and flood control to be developed by Rufiji Basin Development Authority (RUBADA), and the pre-feasibility study was carried out in 1980[8]. This study planned that construction of the power plant was to be phased in 3 stages and finally expanded to 2,100MW.

Since then the pre-feasibility study was updated by Odebrecht of Brazil in 2012[9]. In this updated pre-feasibility study, the dam was changed to a concrete faced rock fill type and the powerhouse was changed to an underground type.

The Project is located within Selous Game Reserve which is registered as a World Heritage Site. However, according to RUBADA, implementation of an ESIA study on the Project was agreed at the

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6 Tanzania Power VI Project Feasibility Studies for Rumakali Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)

7 Tanzania Power VI Project Feasibility Studies for Ruhudji Hydropower Project - Final Report (May 1998, SwedPower and Norconsult)

8 Stiegler's Gorge Power and Flood Control Development Project Planning Report (July 1980, Hafslund)

9 Stiegler's Gorge Hydropower Project – Report and Proposal of Development (2012, Odebrecht)

meeting of United Nations Educational, Scientific and Cultural Organization (UNESCO) held in Doha in 2014. Also, UNESCO and the Ministry of Natural Resources and Tourism of Tanzania gave voice to endorse development of the Project at the Tanzanian stakeholder meeting held in January 2015.

The ESIA study commenced in December 2014. The scooping report of the ESIA study was already reviewed by UNESCO. RUBADA is finalizing the scooping report in accord with UNESCO's comments as of February 2016.

RUBADA intends to develop the Project under the PPP framework, and entered into the MOU on joint development of the Project with Odebrecht in October 2014[10]. The feasibility study will be conducted after NEMC issues the ESIA Certificate for the Project and UNESCO approves development of the Project.

<Steiglers Gorge Phase 1 Hydro Power Project>

In the updated pre-feasibility study above, at the phase 1 stage, it was planned to construct a reservoir type power plant with a total installed capacity of 1,048MW, comprised of four 262MW units under the left bank (see Table 8.2.2-2(5)).

<Steiglers Gorge Phase 2 Hydro Power Project>

At the phase 2 stage, it was planned to add a power plant with a total installed capacity of 1,048MW under the right bank when electric power demand increases (see Table 8.2.2-2(5)).

However, the updated pre-feasibility study above focused on the electric power facilities for the phase 1 and the dam facilities, and the report of the study has little description of the electric power planning for the phase 2. Stated differently, it seems that the energy generation taken in consideration of common use/operation with the phase 1 of the reservoir has not been calculated and the basic design for the phase 2 of the electric power facilities including the waterway has not been carried out.

6) Songwe River Hydro Power Projects（Bipugu (Upper), Sofre (Middle), Manolo (Lower)）

The governments of both Tanzania and Malawi are jointly implementing "Songwe River Basin Development Programme". Under the Programme, 3 dams, namely Upper Dam, Middle Dam and Lower Dam, are planned to be constructed for the purpose of electric power generation, irrigation, river stabilization, flood control and so on. Songwe River Hydro Power Projects are a part of these multipurpose dam projects, and 3 hydro power plants are planned for development, i.e. Bipugu (Upper), Sofre (Middle) and Manolo (Lower), as a cascade in the Songwe River.

The feasibility study on the Projects was carried out in 2003 and updated in 2014[11] as part of the Programme,

[10] Information provided by TANESCO in October 2014

[11] 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)

< Songwe Bipugu (Upper) Hydro Power Project>

Songwe Bipugu (Upper) Project is planned to have 2 powerhouses with a total installed capacity of 29.4MW (see Table 8.2.2-2(2)). One of the powerhouses is planned as a reservoir type power plant with a total installed capacity of 28.2MW, comprised of three 9.4MW units. The other powerhouse is to be located immediately below the dam and planned as a run-off-river type power plant using environmental flow with a total installed capacity of 1.2MW, comprised of two 0.6MW units.

However, as a result of the feasibility study, the Ministry of Water, the project management unit of the Programme on the Tanzanian side, canceled the Upper Dam Project including Songwe Bipugu (Upper) Hydro Power Project for the following reasons.

- Not economically feasible on its own (Economic Internal Rate of Return (EIRR) is 3.0% as an individual project)
- Resettlement issues are significant
- Large area of good cropping land inundated

< Songwe Sofre (Middle) Hydro Power Project>

Songwe Sofre (Middle) Project is planned to have 2 powerhouses with a total installed capacity of 158.9MW (see Table 8.2.2-2(2)). One of the powerhouses is planned as a reservoir type power plant with a total installed capacity of 155.7MW, comprised of three 51.9MW units. The other powerhouse is to be located immediately below the dam and planned as a run-off-river type power plant using environmental flow with a total installed capacity of 3.2MW, comprised of two 1.6MW units.

< Songwe Manolo (Lower) Hydro Power Project>

Songwe Manolo (Lower) Project is planned to have 2 powerhouses with a total installed capacity of 177.9MW (see Table 8.2.2-2(2)). One of the powerhouses is planned as a reservoir type power plant with a total installed capacity of 172.8MW, comprised of three 57.6MW units. The other powerhouse is to be located immediately below the dam and planned as a run-off-river type power plant using environmental flow with a total installed capacity of 5.1MW, comprised of three 1.7MW units.

The Ministry of Water intends to implement Lower Dam Project including Songwe Manolo (Lower) Hydro Power Project prior to Middle Dam Project for the following reasons.

- Economically feasible on its own (EIRR is 11.0% as an individual project)
- Crucial to river stabilization and flood management
- No major resettlement, social or environmental issues

Therefore, the ESIA study, detailed design study and preparation of tender documents on Lower Dam Project have already been completed. The ESIA study report is being reviewed by NEMC as of December 2015.

However, according to the Ministry of Water, project participants including donors and investors have not yet been fixed and will be recruited in future.

7) Mpanga Hydro Power Project

Initially, Mpanga Project was planned as a power plant with a total installed capacity of 144MW,

comprised of two 72MW units in the preliminary study[12] carried out in 1997.
Since then the pre-feasibility study was carried out by Sinohydro Corporation Ltd. of China in 2010[13]. In this pre-feasibility study, dam height and plant discharge were reviewed. The Project is currently planned as a reservoir type power plant with a total installed capacity of 160MW, comprised of two 80MW units (see Table 8.2.2-2(4)).
According to RUBADA, ESIA study on the Project was completed in May 2012 and the ESIA report has already been approved by NEMC.
RUBADA intends to develop the Project under the PPP framework, and entered into the MOU on joint development of the Project with Sinohydro in August 2013[14]. However, financing arrangements are stuck because it was decided that a government guarantee would not be issued. Therefore, RUBADA and Sinohydro agree to go for Build Own Operate Transfer (BOOT) scheme, and RUBADA is preparing for discussion on a power purchase agreement with TANESCO as of February 2016.

8) Masigira Hydro Power Project

Masigira Project was planned as a pondage type power plant with a total installed capacity of 118MW, comprised of two 59MW units in the preliminary study[15] carried out in 1997 (see Table 8.2.2-2(1)).
Although 17 years have passed since the Project was planned, land use and land form of the proposed construction site have not been changed as a result of site reconnaissance conducted in July 2014 for this JICA Study. Therefore, it was judged that it was not particularly necessary to reconsider generation schemes for the Project, including reservoir size and waterway route planned in the previous study (see Supplement S-5).
According to TANESCO, the MOU on joint development of the Project was signed between a Tanzanian private company and Chinese company. The feasibility study has been completed and the ESIA study has not been carried out as of December 2015.

9) Lower Kihansi Expansion Hydro Power Project

For Lower Kihansi Expansion Project, there were plans to add two 60MW units to existing Kihansi hydro power plant with a current total installed capacity of 180W and increase its total capacity to 300MW in the preliminary study[16] carried out on 1997 (see Table 8.2.2-2(3)).
Although 17 years have passed since the Project was planned, land use and land form of the proposed construction site have not been changed as a result of site reconnaissance conducted by TANESCO in June 2014.

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12 Tanzania Power VI Project Feasibility Studies for Hydropower Project – Interim Report No.2 Final Volume 1 (March 1997, SwedPower and Norconsult)
13 Mpanga Hydropower Project - Project Proposal (June 2010, Sinohydro Corporation Ltd)
14 Information provided by TANESCO in October 2014
15 Tanzania Power VI Project Feasibility Studies for Hydropower Project – Interim Report No.2 Final Volume 1 (March 1997, SwedPower and Norconsult)
16 Tanzania Power VI Project Feasibility Studies for Hydropower Project – Interim Report No.2 Final Volume 1 (March 1997, SwedPower and Norconsult)

The unit construction rate per kW of the Project is more expensive than that of gas fired power plant, but cheaper than that of coal fired power plant. This means that the Project is not necessarily effective as a method for enhancing peak power supply capability (see next section (2)). In addition, planned plant factor of the Project is extremely low and only 7%, since increase of generated energy owing to the Project is limited. Therefore, generation cost of the Project is very expensive and the Project is less economical than other hydro power projects (see after-mentioned section 6.2.2(3)).

On the other hand, the Project does not need new construction of dam and transmission line and new land acquisition, and its lead time is relatively short. Therefore, the government of Tanzania expects the Project will be one of measures for supply capability improvement to be taken promptly, and intends to secure the finance to the Project.

10) Upper Kihansi Hydro Power Project

Upper Kihansi Project was planned as a reservoir type power plant with one 47MW unit in the pre-feasibility study[17] carried out in 1990 (see Table 8.2.2-2(3)).

In this previous study report, the Project did not have high economic and financial feasibility as follows even though the construction cost was estimated in 1989 price level. It is considered that the Project is less economical than other hydro power projects.

- Economic Internal Rate of Return (EIRR) = 11.26%
- Benefit and Cost Ration (B/C) = 1.07
- Financial Internal Rate of Return (FIRR) = 6.49%

According to TANESCO, the ESIA study was carried out in years past. However, the study should be updated because a long time has past after the completion of the study.

11) Kakono Hydro Power Project

Kakono Project was planned as a pondage type power plant with a total installed capacity of 40MW in the pre-feasibility study[18] carried out in 1976.

Since then the feasibility study[19] was carried out in 2014, and generation plans including power generation type and dam height were changed. The Project is currently planned as a run-off-river type power plant with a total installed capacity of 87MW, comprised of two 43.5MW units (see Table 8.2.2-2(1)).

The Project is located in the northwestern part of Tanzania (see Figure 8.2.2-1). This area is isolated from the National Grid, and electric power supply depends heavily on diesel power plants for which generation costs are hugely expensive. Therefore, the priority of the Project is high for TANESCO.

An ESIA study on the Project was carried out in parallel with the feasibility study, and was completed by September 2014. The ESIA was approved by NEMC in 2015.

According to TANESCO, procurement of consultant for detailed design and preparation of bidding

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

[18] Kagera Rver Basin Development Phase II - Prefeasibility Studies - Kagera River Hydropower Developments (April 1976, Norconsult and ELECTROWATT)

[19] Feasibility Study of Kakono Hydropower Project and Transmission Line - Draft Final Feasibility Report (September 2014, Norplan)

document is in progress as of December 2015. Procurement of transaction advisor is also in progress.

12) Kikonge Hydro Power Project

Kikonge Project was planned as a reservoir type power plant with a total installed capacity of 300MW, comprised of three 100MW units in the preliminary study[20] carried out in 2014 (see Table 8.2.2-2(1)).

According to TANESCO, through Climate Resilient Infrastructure Development Facility (CRIDF)[21] of the United Kingdom and African Water Facility, TANESCO is negotiating with DFID[22] to perform a joint feasibility study on the Project

13) Iringa Hydro Power Projects (Ibosa and Nginayo)

Iringa Projects were planned in the Rufiji Basin hydropower master plan study[23] carried out in 1984. At first there were plans to develop 2 hydro power plants, i.e. Ibosa (installed capacity: 35MW) and Nginayo (installed capacity: 42MW), as a cascade in the Little Ruaha River.

Since then the pre-feasibility study[24] was carried out in 2013 by K-Water of South Korea, and generation plans including installed capacity and dam height were changed (see Table 8.2.2-2(4)).

RUBADA intends to develop the Project under the PPP framework, and entered into the MOU on joint development of the Project with K-Water in November 2013[25].

An ESIA study on the Project has not yet conducted as of February 2016, although RUBADA and K-Water agreed to commence the ESIA study in May 2015.

< Iringa Ibosa Hydro Power Project>

Iringa Ibosa Project was planned as a run-off-river type power plant with a total installed capacity of 36MW, comprised of two 18MW units.

< Iringa Nginayo Hydro Power Project>

Iringa Nginayo Project was planned as a run-off-river type power plant with a total installed capacity of 52MW, comprised of two 26MW units.

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[20] Ruhuhu Valley Multi-Purpose Scheme - Dams and Hydropower Report (February 2014, Climate Resilient Infrastructure Development Facility)

[21] CRIDF is DFID's (British Government's Department for International Development) new flagship water infrastructure programme for southern Africa.

[22] British Government's Department for International Development

[23] Rufiji Basin Hydropower Master Plan - Appendices 2 (April 1984, Norconsult)

[24] Preliminary Feasibility Study on Iringa Hydropower Project (May 2013, K-Water)

[25] Information provided by TANESCO in October 2014

14) Mnyera River Hydro Power Projects (Ruaha, Mnyera, Kwanini, Pumbwe, Taveta and Kisingo)

Mnyera River Projects were planned in the Rufiji Basin hydropower master plan study[26] carried out in 1984. At first there were plans to develop 2 hydro power plants, i.e. Ikondo (installed capacity: 450MW) and Taveta (installed capacity: 145MW), as a cascade in the Mnyera River.

Since then the pre-feasibility study[27] was carried out in 2012 by Queiroz Galvao of Brazil. In order to maximally utilize the head of Mnyera River which runs from E.L. 1,730m to E.L. 290m, the generation plans were changed to develop 6 hydropower plants, i.e. in the order of location from upstream to downstream, Ruaha, Mnyera, Kwanini, Pumbwe, Taveta and Kisingo (see Table 8.2.2-2(3), (4)).

According to RUBADA, an ESIA study on the Projects was completed in 2014, and RUBADA has already applied to NEMC for approval for the ESIA report. NEMC conducted a site reconnaissance in January 2015 and has already reviewed the ESIA report as of February 2016. NEMC will approve the ESIA study after water use permit will be granted from Ministry of Water.

The feasibility study on the Projects will be carried out after NEMC issues the ESIA Certificate for the Projects.

RUBADA intends to develop the Mnyera River Projects under the PPP framework, and entered into the MOU on joint development for the Mnyera River Projects with Queiroz Galvao in February 2013[28].

< Mnyera-Ruaha Hydro Power Project>

Mnyera-Ruaha Project was planned as a reservoir type power plant with a total installed capacity of 60.3MW, comprised of two 30.15MW units.

< Mnyera-Mnyer Hydro Power Project>

Mnyera-Mnyer Project was planned as a run-off-river type power plant with a total installed capacity of 137.4MW, comprised of two 68.7MW units.

< Mnyera-Kwanini Hydro Power Project>

Mnyera-Kwanini Project was planned as a run-off-river type power plant with a total installed capacity of 143.9MW, comprised of two 71.95MW units.

< Mnyera-Pumbwe Hydro Power Project>

Mnyera-Pumbwe Project was planned as a run-off-river type power plant with a total installed capacity of 122.9MW, comprised of two 61.45MW units.

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[26] Rufiji Basin Hydropower Master Plan - Appendices 2 (April 1984, Norconsult)

[27] Muyera River - Implementation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao)

[28] Information provided by TANESCO in October 2014

< Mnyera-Taveta Hydro Power Project>

Mnyera-Taveta Project was planned as a run-off-river type power plant with a total installed capacity of 83.9MW, comprised of two 41.95MW units.

< Mnyera-Kisingo Hydro Power Project>

Mnyera-Kisingo Project was planned as a run-off-river type power plant with a total installed capacity of 119.8MW, comprised of two 59.9MW units.

Table 8.2.2-2(1) Outline of Development Plans for Planned 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 8.2.2-2(2) Outline of Development Plans for Planned 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 8.2.2-2(3) Outline of Development Plans for Planned 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 8.2.2-2(4) Outline of Development Plans for Planned Large and Medium-Scale Hydro Power Projects

Item			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)

Note: "Planned Project" is the spanning header over the six project columns.

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 8.2.2-2(5) Outline of Development Plans for Planned 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)
(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)

(2) Status of ongoing and planned hydro power projects

Compared to the PSMP 2012 Update produced by MEM, planned operation start year of the Rusumo Project is delayed by 1 year as of February 2015. In addition, commitment to the Rumakali Project and the Ruhudji Project is currently cancelled. As noted above, most development plans are not implemented on schedule and are usually delayed in Tanzania.

Therefore, in this section, the long term power source development plan, based on the optimum scenario as shown in Section 8.3.3, was optimized with consideration for realization of each project.

Accordingly, realization of the planned projects was divided into 4 ranks as shown in Table 8.2.2-3, which take into consideration the progress of studies and financing arrangements as of December 2015. At that time, a delay of between 0 and 5 years corresponding to the realization rank was estimated (see Table 8.2.2-4). In addition, projects, that are not feasible due to big environmental and social issues that would arise upon construction at this time, were excluded from power development options.

As a result, the Songwe Bipugu (Upper) Project was excluded from power development options as shown in Table 8.2.2-4. In addition, the earliest installation years for 21 projects out of the remaining 22 projects were modified after taking into consideration delays in the development schedule (see Table 8.3.4-3). Also, the base year for estimation of possible earliest installation years was modified to 2015 corresponding to the year for realization ranking above, although the base year for estimation of possible earliest installation year was set to 2014 in Section 8.3.2

The schedule for start of operation for each planned project will be optimized by re-conducting WASP simulation after the simulation conditions for earliest installation years are changed as described above.

Table 8.2.2-3 Realization Rank of Planned Large and Medium-Scale Hydro Power Projects

Realization Rank	Current Status	Estimated Delay (Year)	Remarks
A	- F/S is completed - ESIA study is completed - Financing is secured	0	
B	- F/S is completed - ESIA study is completed	3	Valid term of ESIA Certificate is considered. * ESIA Certificate expires if construction works are not commenced within 3 years from the date of issue.
C	- Other than Ranks A, B or D	5	Terms of re-surveys/studies and updating are considered.
D	- Not feasible due to environmental and social issues	To be canceled	

Table 8.2.2-4 Modified Earliest Installation Year of Planned Large and Medium-Scale Hydro Power Projects

	Realization Rank	Planned Project	Current Status			Earliest Earliest Installation Year		
			Technical Study	ESIA	Financing Arrangement	Possible Earliest Installation Year	Estimated Delay	Modified Earliest Installation Year
1	A	Rusumo	- F/S (2012)	- ESIA approved (2014)	WB committed for power plant AfDB committed for transmission line	2019	0	2019
2	B	Malagarasi Stage III	- F/S (2011)	- ESIA approved (2014)	- Not secured	2021	3	2024
3		Kakono	- F/S (2014)	- ESIA approved (2015)	- Not secured	2023		2026
4		Songwe Manolo (Lower)	- F/S (2014)	- ESIA study (2015) - NEMC reviewing ESIA study	- Not secured	2023		2026
5	C	Songwe Sofre (Middle)	- F/S (2014)	- Not studied	- Not secured	2028	5	2031
6		Mnyera - Ruaha	- Pre-F/S (2012)	- ESIA study (2014) - NEMC reviewing ESIA study	- Not secured	2021		2026
7		Mnyera - Mnyera				2022		2027
8		Mnyera - Kwanini				2022		2027
9		Mnyera - Pumbwe				2022		2027
10		Mnyera - Taveta				2022		2027
11		Mnyera - Kisingo				2022		2027
12		Iringa - Ibosa	- Pre-F/S (2013)	- Not studied	- Not secured	2021		2026
13		Iringa - Nginayo				2021		2026
14		Steiglers Gorge Phase 1	- Pre-F/S (2012)	- Under ESIA study	- Not secured	2028		2033
15		Steiglers Gorge Phase 2	- Not studied	- Not studied	- Not secured	2028		2033
16		Rumakali	- F/S (1998)	- ESIA study (1998)	- Not secured	2025		2030
17		Ruhudji	- F/S (1998)	- ESIA study (1998)	- Not secured	2025		2030
18		Lower Kihansi Expansion	- Preliminary study (1997)	- Not studied	- Tanzania Government will secure	2019		2024
19		Upper Kihansi	- Pre-F/S (1990)	- Not studied	- Not secured	2026		2031
20		Kikonge	- Preliminary study (2014)	- Not studied	- Not secured	2026		2031
21		Mpanga	- Pre-F/S (2010)	- ESIA approved (2012)	- Not secured	2024		2029
22		Masigira	- F/S (2015)	- Not studied	- Not secured	2024		2029
23	D	Songwe Bipugu (Upper)	- F/S (2014)	- Significant impact on environment & society	- Not secured	To be cancelled		

Note: F/S and ESIA study of Rumakali and Ruhudji should be updated because these previous studies were carried out approx. 20 years ago.

(3) Economic Efficiency of Planned Large and Medium-Scale Hydro Power Projects

In this study, economic efficiency of planned large and medium-scale hydro power projects was evaluated by using 1) average generation cost and 2) unit construction rate per kW.

Average generation cost was calculated by means of the following expression same as WASP (Wien Automatic System Planning Package).

$$AGC = \frac{CFR \times I + 12 \times OM_{fix}}{AEG}$$

$$CFR = \frac{i \times (1+i)^T}{(1+i)^T - 1}$$

Where, AGC : Average generation cost during service life (US-cent/kWh)

CFR : Capital recovery factor

I : Construction cost excluding interest during construction indicated in Table 8.2.2-3 (USD) (see Supplement S-3-2)

OM_{fix} : Fixed O&M cost = 2.6USD/kW-month (see Supplement S-3-2)

AEG : Annual energy generation indicated in Table 8.2.2-3 (kWh)

i : Discount rate = 10%

T : Service life = 50years (see Section Supplement S-3-2)

Unit construction rate per kW was calculated by means of the following expression.

UR_{kW} = I/IC

Where, UR_{kW} : Unit construction rate per kW (USD/kW)

IC : Installed capacity indicated in Table 8.2.2-3 (kW)

Table 8.2.2-5 shows index for economic efficiency calculated above.

1) Evaluation for Average Generation Costs

Average generation costs of most of planned projects are cheaper than 13.1US-cent/kWh[29] of actual average purchase cost by TANESCO from IPPs and EPPs in 2013. In addition, average generation costs of about half of planned projects are cheaper than 6.24 US-cent/kWh[30] of actual average purchase cost by TANESCO from SONGAS IPP power plant which is the cheapest among existing IPPs in 2012.

This suggests that it is possible to decrease purchase costs of TANESCO, i.e. power supply costs of TANESCO, if economically efficient hydro power projects are developed.

2) Evaluation for Unit Construction Rate per kW

From the view of unit construction rate per kW, rates of all planned projects are more expensive than 900USD/kW of gas turbine power plant.

This indicates that all planned projects are less economical for peak power supply plants than gas turbine power plants.

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29 Purchased energy: 2,709,793,796GWh, Purchased cost: 568,304 million Tsh

30 Information provided by TANESCO in October 2014

Table 8.2.2-5 Index for Economic Efficiency of Planned Large and Medium-Scale Hydro Power 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	90.0	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.

8.3 Optimal power development plan

8.3.1 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), will be 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:

- Depreciable investment cost: Equipment and installation cost (I)
- Residual value of investment cost (S)

- Non-depreciable investment cost: Fuel store, replacement parts, etc. (L)
- Fuel cost (F)
- Non-fuel operation and maintenance cost (M)
- 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 B_j in all development plan candidates j becomes the minimum.

Figure 8.3.1-1 shows the simplified flowchart of WASP-IV indicating the flow of information and data files between various WASP modules.

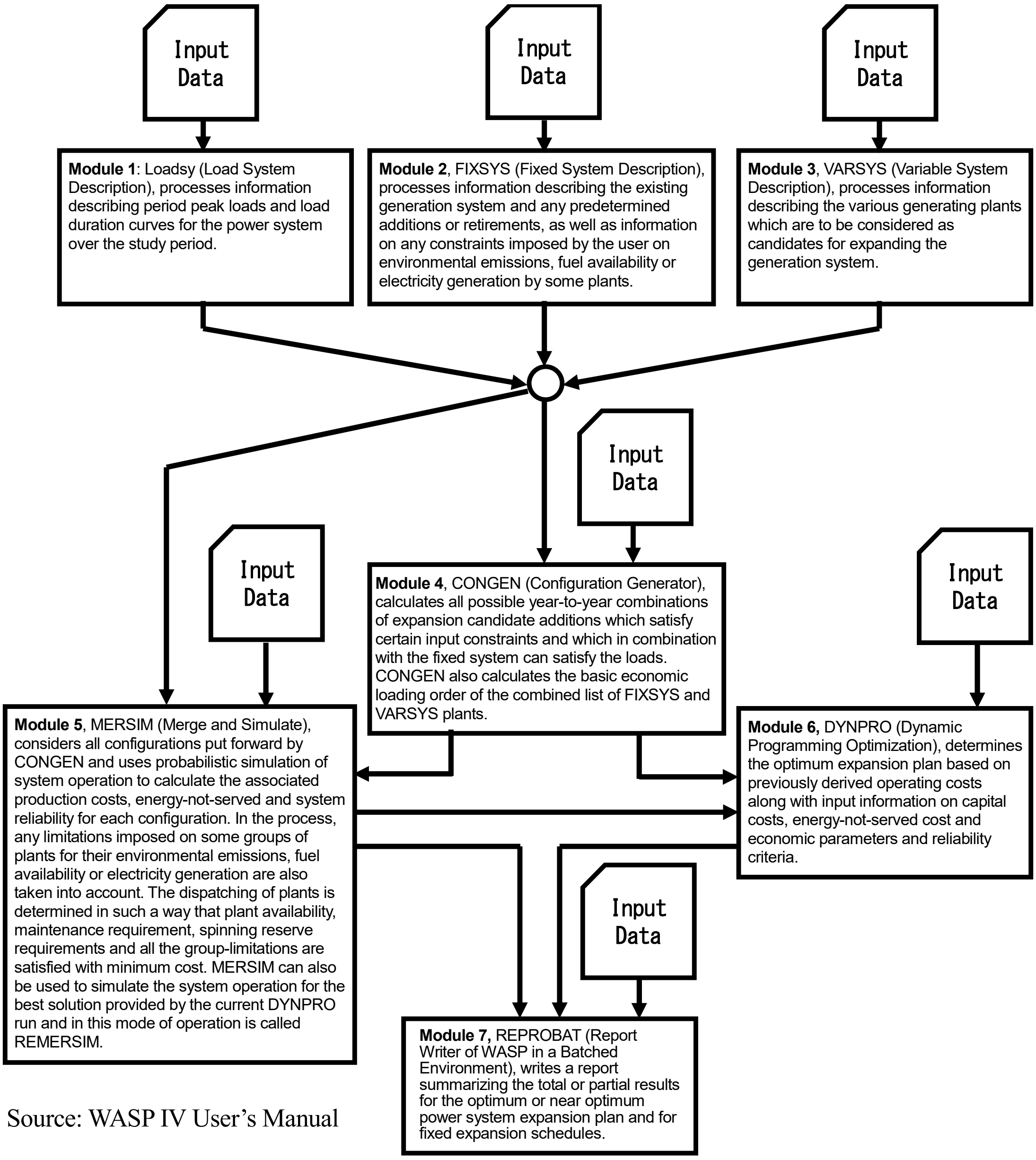


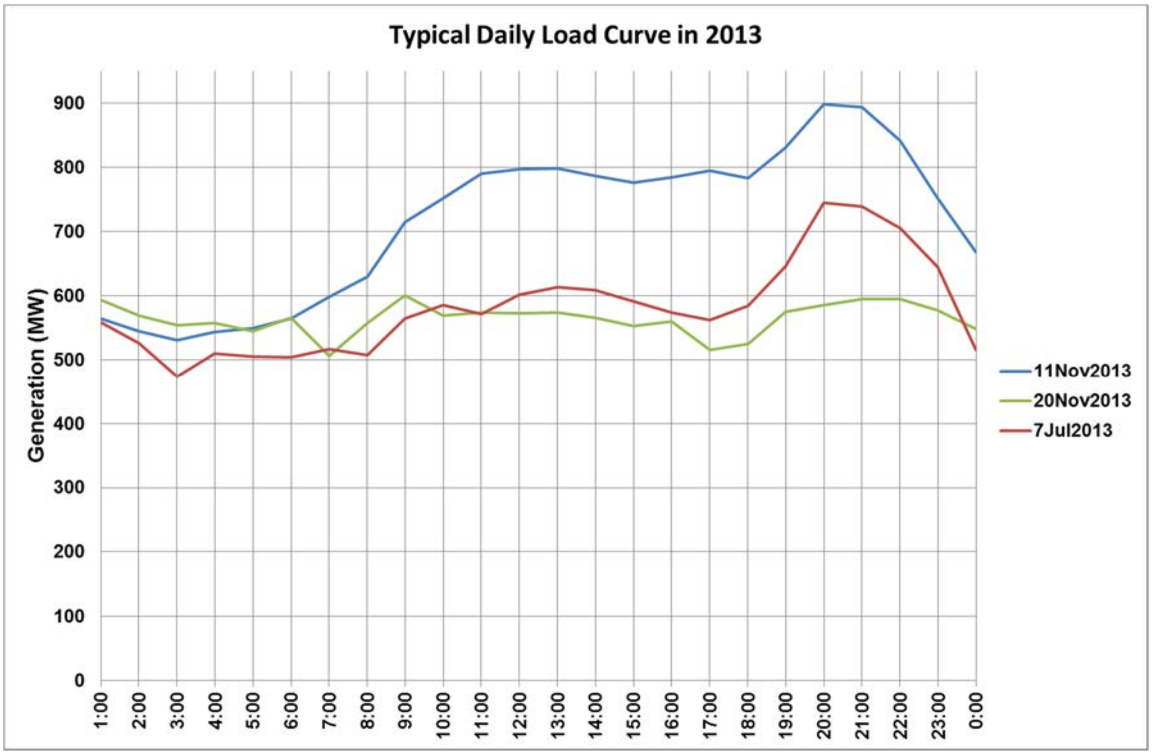
Figure 8.3.1-1 WASP-IV Flowchart

8.3.2 Examination conditions

8.3.2.1 Load Duration Curve

(1) Daily Load Curve in Tanzania

Daily load curve of Tanzania is categorized as "lighting peak type" which has the highest demand during evening to night time when people turn on lighting facilities. The tendency of daily load curve remains same regardless of business days or holidays. Figure 8.3.2-1 shows typical daily load curves in Tanzania. The blue line represents the daily load curve on 11th November 2013 (Mon) when the annual highest peak load was recorded while the red line shows the curve on 7th July 2013 (Sun). Both curves have the highest load in a day around 8pm. The green line is the curve on 20th November 2013 (Wed) which has less fluctuation of hourly loads throughout the day. This is due to the curtailment of the loads because of the constraint of supply side.



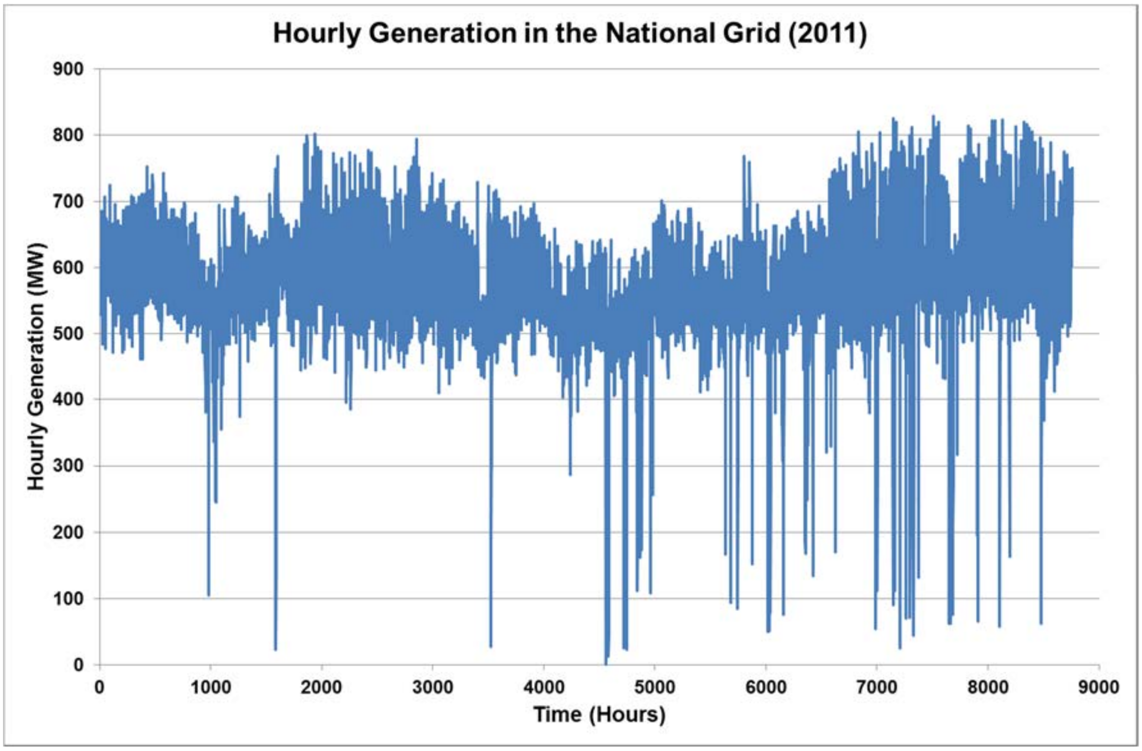
Source: TANESCO

Figure 8.3.2-1 Typical daily load curve in 2013

(2) Load duration curve

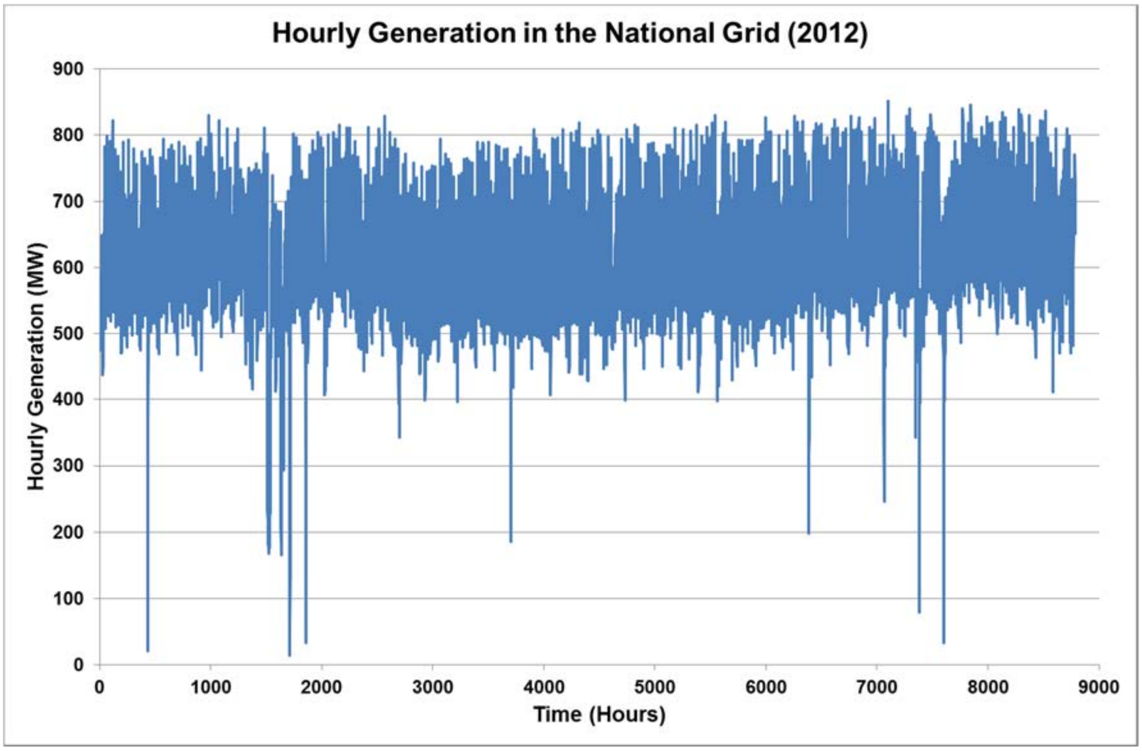
As shown in Figure 8.3.2-2 to 8.3.2-4 which describe hourly generation in recent years, sudden decrease of generation is frequently observed in 2011. In addition, hourly generation in 2011 was unstable even in the period when generators did not suffer from break down. The situation has been improved year by year until 2013. Unstable power generation in 2011 was attributed to the significant decrease in power output from hydro power plants due to drought.

Figure 8.3.2-5 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.



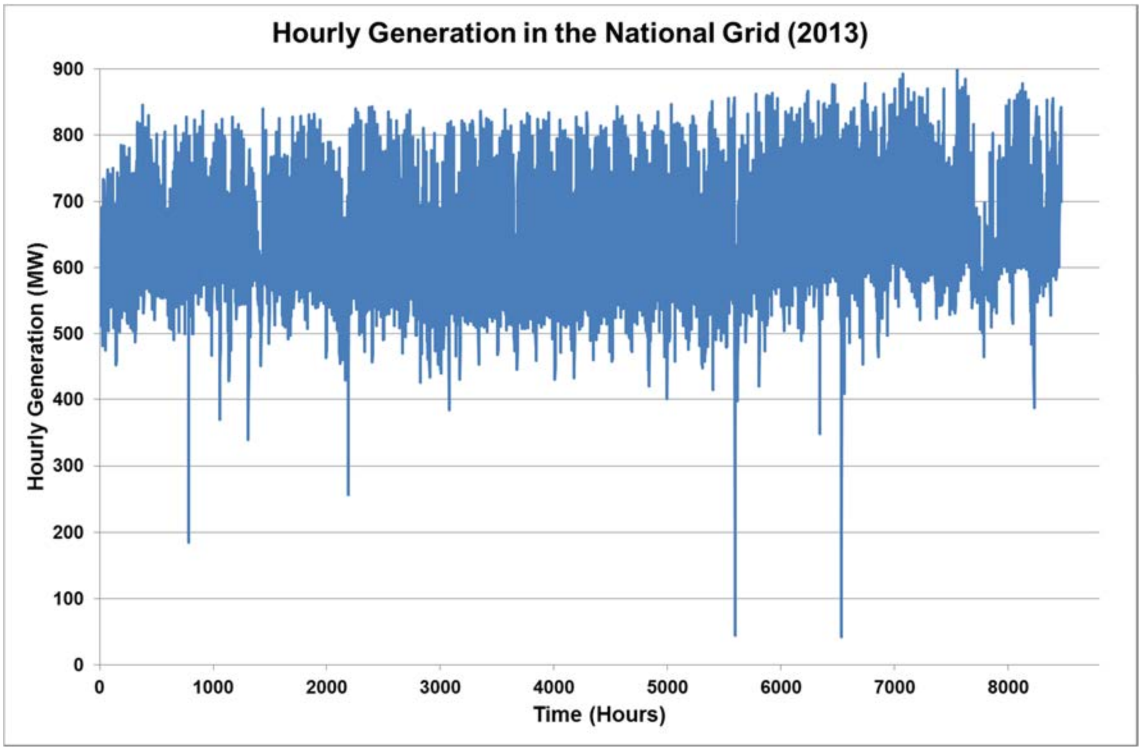
Source: TANESCO

Figure 8.3.2-2 Hourly generation in 2011



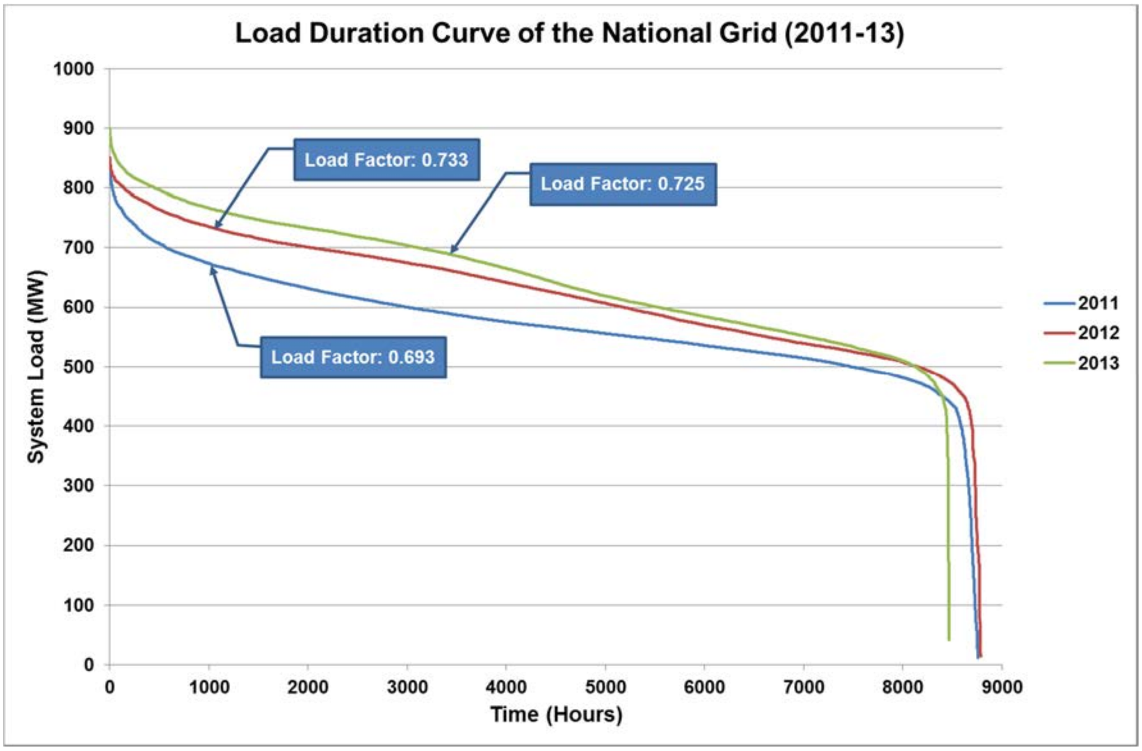
Source: TANESCO

Figure 8.3.2-3 Hourly generation in 2012



Source: TANESCO

Figure 8.3.2-4 Hourly generation in 2013



Source: TANESCO

Figure 8.3.2-5 Load duration curves in Tanzania

8.3.2.2 Supply reliability standard

The LOLP (Loss Of Load Probability) will be used as the indicator for evaluating the reliability of power supply, and the power source development plan possessing the necessary reserve power for satisfying the target LOLP will be compiled. LOLP is widely applied throughout the world 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) adopts 3 days/year and Kenya adopts 1 day/year. In PSMP 2012, the target LOLP is not stated, however, in the PSMP 2009 Update, the LOLE (Loss Of Load Expectation, used synonymously with LOLP) is set at 5 days/year. In the Project, it is intended to adopt LOLP 5 days/year as the target reliability standard.

8.3.2.3 Maximum allowable single unit capacity

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 this relationship.

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

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 to reduce demand. Currently, the largest single unit capacity is 60MW at Kihansi hydro and 50MW at Kidatu follows it. 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.

【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

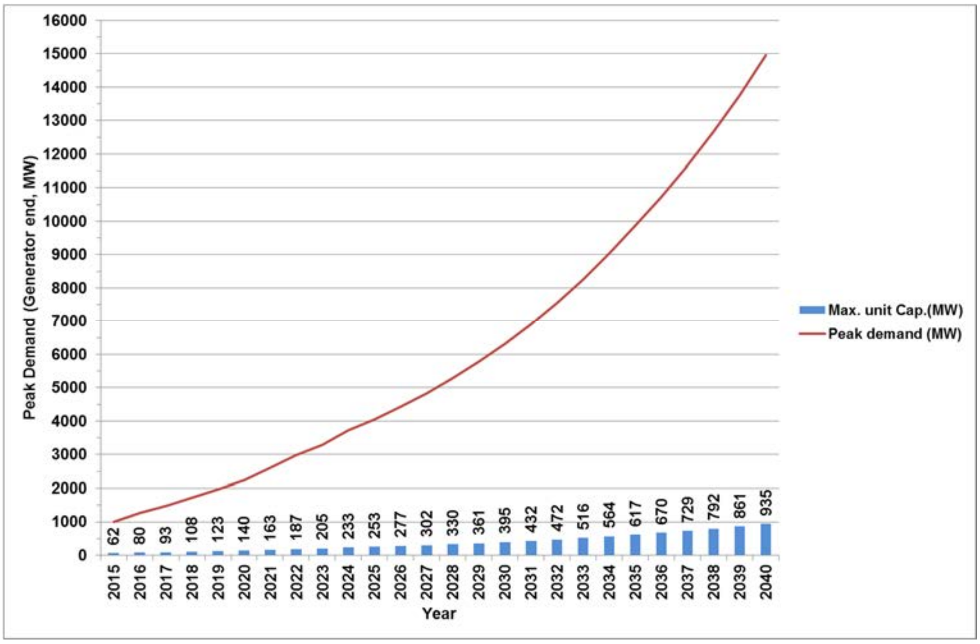
【Calculation of system constant】

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

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 8.3.2-6

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



Source: JICA Study Team

Figure 8.3.2-6 Maximum allowable single unit capacity which can maintain system frequency

8.3.2.4 Fuel cost

Table 8.3.2-1 shows the cost of natural gas and coal to be used for economic calculation for generation expansion planning.

Table 8.3.2-1 Fuel cost assumption

Type	PSMP 2012 Update	PSMP 2016 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)	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: Made by JICA TEAM hearing from NDC, TPDC and TANESCO

8.3.2.5 Power development candidates

Table 8.3.2-2 shows the thermal power generation development candidates under planning and /or ongoing.

Table 8.3.2-2 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: Made by JICA TEAM hearing from TANESCO

Construction sites for new coal-fired thermal power station have largely not been decided, with PSMP 2012 only stating Coastal Coal and Local Coal I~VI.

Regarding new gas-fired thermal power stations, only projects in the planning stage are stated, but nothing is indicated regarding candidate power sources for future development.

Moreover, concerning thermal power facilities currently in the planning or implementation stage, PSMP 2012 does not clearly indicate the basis for calculation and other details, so it is necessary to carefully investigate the contents.

Summing up, model plants were set concerning promising primary energies such as natural gas and coal, and the construction cost and O&M cost components for inputting to the power source development planning software (WASP: Wien Automatic System Planning Package) were examined. Concerning the WASP inputting 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).

(1) Coal-fired thermal power stations

1) 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.

2) 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 Japan, such facilities were first introduced in the early 1980s and they have contributed to higher generating efficiency.

3) 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 Japan, such facilities were 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, we recommend that ample consideration also be given to the introduction of ultra-supercritical pressure facilities.

Moreover, in Japan, since almost 20 years have passed since introduction and Japanese makers have honed their technology for ultra-supercritical pressure facilities in the coal-fired thermal power generation field, merits can be anticipated through introducing this technology.

4) 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).

5) 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.

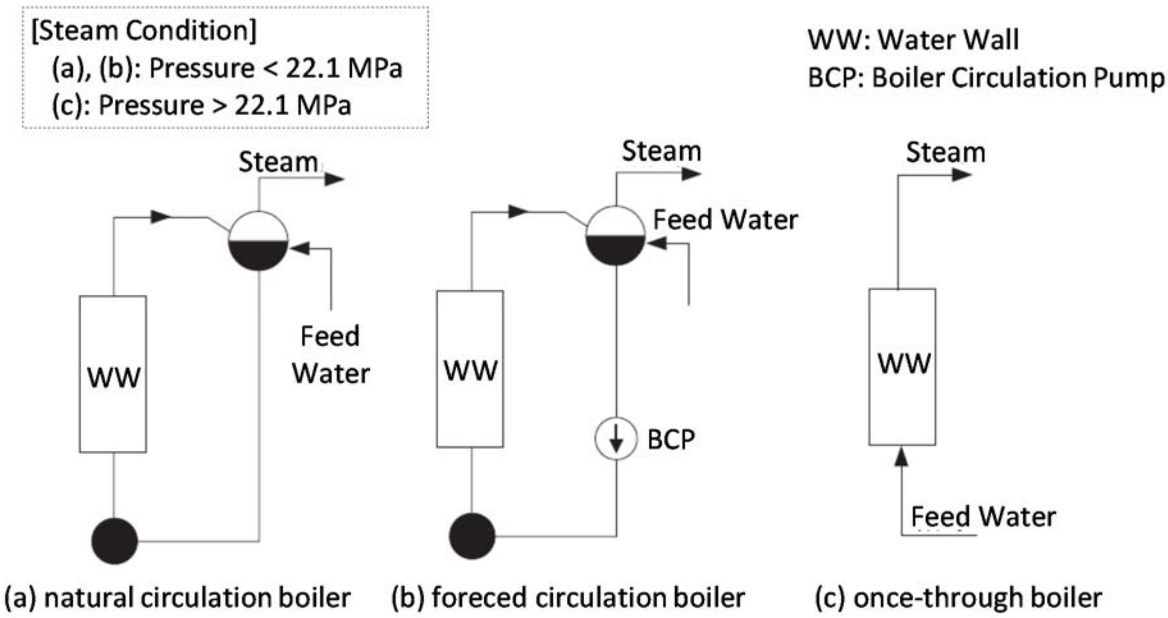


Figure 8.3.2-7 Differences between subcritical pressure boiler (Drum boiler) and Supercritical pressure boiler (once-through boiler)

(2) Gas-fired thermal power stations

1) 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 is SGT-800 gas turbines made by Siemens in Ubungo II gas-fired thermal power station and plans to introduce LM6000PF gas turbines made by GE to 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.

2) 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) made by Mitsubishi Heavy Industries possesses the highest thermal efficiency (61% or more) and power capacity (approximately 460 MW) in the world.

(3) Selection of model units for variable candidates

Table 8.3.2-3 shows a list of model units for variable expansion candidates.

Concerning model units for existing power sources and gas turbine power station development plans currently being implemented and formulated, because the PSMP 2012 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 in Japan 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 sources.

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

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

Table 8.3.2-3 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: Hearing from supplier
Gas Turbine World 2012 GTW Handbook (2012)

(4) Hydro Power Generation Facilities

At the stage of screening for an optimum scenario using WASP simulation, all existing planned hydro power projects mentioned in Section 8.2.2, i.e. a total of 23 projects including 1 project under implementation, were nominated as power development options. Although these projects include some projects for which average generation costs are expensive, as shown in Table 8.2.2-3, all existing planned projects were considered as power development options in order to increase the number of options for WASP simulation.

Table 8.2.2-4 shows a list including major characteristics of proposed hydro power projects for power source development. The details of WASP input data including construction cost and possible earliest installation year are shown in Section S-3-2 of Supplement S-2.

Table 8.3.2-4 Proposed Hydro Power Projects for Power Development

		River Basin	Planned Projects	Installed Capacity (MW)	Annual Energy Generation (GWh)	Plant Factor (%)	Construction Cost in Price Level 2014 (Million	Possible Earliest Installation Year
Large and medium-scale	1	Lake Victria	Rusumo	90.0	456.33	58	150.32	2019
	2		Kakono	87.0	573.00	75	383.88	2022
	3	Lake Tanganyika	Malagarasi Stage III	44.7	168.12	43	165.20	2020
	4	Lake Nyasa	Rumakali	222.0	1,188.01	61	559.87	2023
	5		Masigira	118.0	597.62	58	261.20	2023
	6		Kikonge	300.0	1,141.20	43	670.68	2025
	7		Songwe Manolo(Lower)	177.9	617.46	40	469.18	2022
	8		Songwe Sofre (Middle)	158.9	528.38	38	468.28	2022
	9		Songwe Bipugu (Upper)	29.4	94.56	37	200.57	2020
	10	Rufiji	Ruhudji	358.0	1,799.73	57	666.02	2023
	11		Mnyera - Ruaha	60.3	290.83	55	255.08	2020
	12		Mnyera - Mnyera	137.4	662.26	55	274.07	2021
	13		Mnyera - Kwanini	143.9	693.79	55	164.12	2021
	14		Mnyera - Pumbwe	122.9	592.18	55	219.15	2021
	15		Mnyera - Taveta	83.9	403.84	55	205.75	2021
	16		Mnyera - Kisingo	119.8	577.28	55	313.53	2021
	17		Mpanga	160.0	796.00	57	420.23	2023
	18		Lower Kihansi Expansion	120.0	62.10	6	220.75	2022
	19		Upper Kihansi	47.0	213.35	52	519.89	2025
	20		Iringa - Ibosa	36.0	186.09	59	123.06	2020
	21		Iringa - Nginayo	52.0	262.75	58	125.46	2020
	22		Steiglers Gorge Phase 1	1,048.0	4,558.67	50	2,455.99	2027
	23		Steiglers Gorge Phase 2	1,048.0	N/A	-	N/A	
	Total			4,765.1	16,463.5	-	9,292.3	-

Note: The construction cost does not include the interest during construction and transmission line and substation costs.
The base year for estimation of possible earliest installation year is set 2014.

(5) Renewable energy and import

The table below shows the candidate of renewable energy and import projects which will be included in generation expansion plans. Definition of ranking is shown in Table 8.3.2-5.

Table 8.3.2-5 Candidates for 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)

Table 8.3.2-6 Definition of ranking for renewable energy and import projects

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

8.3.2.6 Power development scenarios

(1) Scenarios to be considered

The potential generation capacity determined form each energy resources is a basis for setting the scenarios. Potential of natural gas and its allocation for various purposes are shown in Table 8.3.2-7, Fig. 8.3.2-8 and 9.

[Energy potential and possible generation capacity]

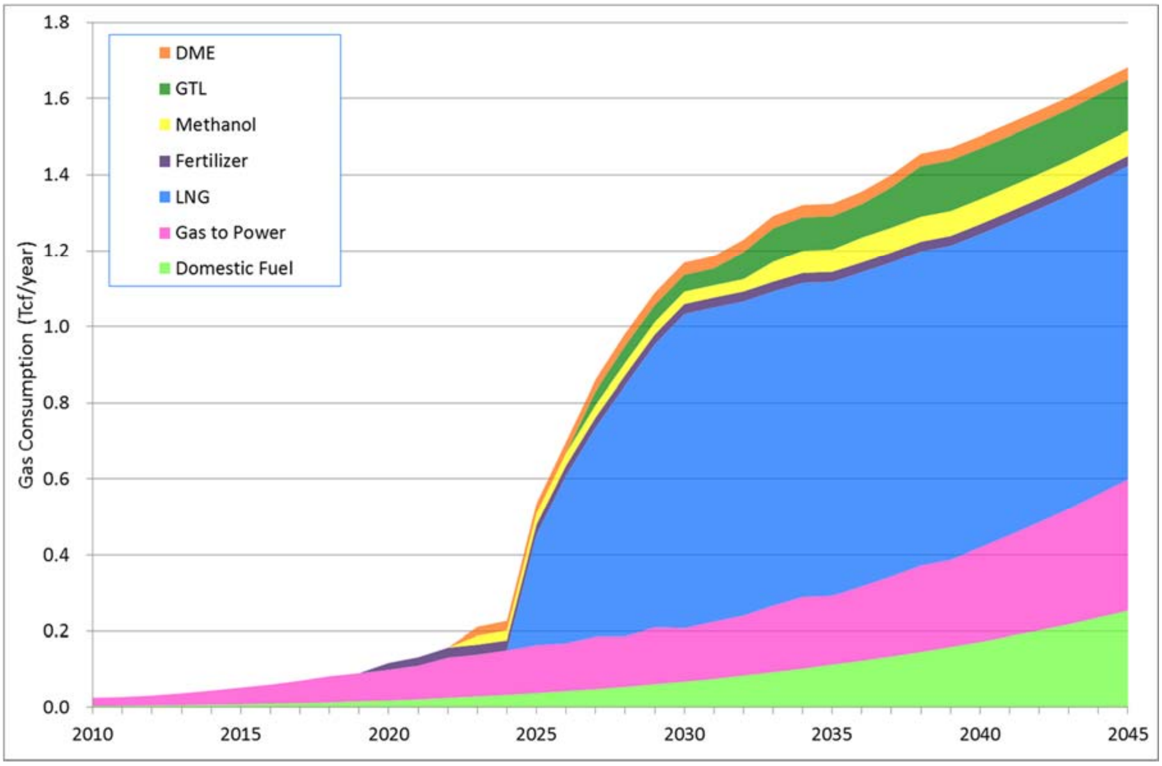
- Gas: Assuming that 20% of recoverable natural gas reserve (70% of 57.25Tcf=40.075Tcf) is allocated to power sector, 8.015 Tcf can be used for power generation. It can support around 8,000MW combined cycle power plants for 20 years.
- Coal: Combined coal reserve in Mchuchuma, Ngaka, Kiwira, Mbeya and Rukwa is around 870mil.ton. It can support 9,900MW coal fired power plants for 30 years.
- Hydro: Identified hydro potential in Tanzania is approx. 4,700MW. The capacity of existing hydro power is 567MW.
- 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.

Five generation expansion scenarios which have different share of energy sources considering the energy potential described above are set as shown in Table 8.3.2-7.

Table 8.3.2-7 Natural gas reserve in Tanzania

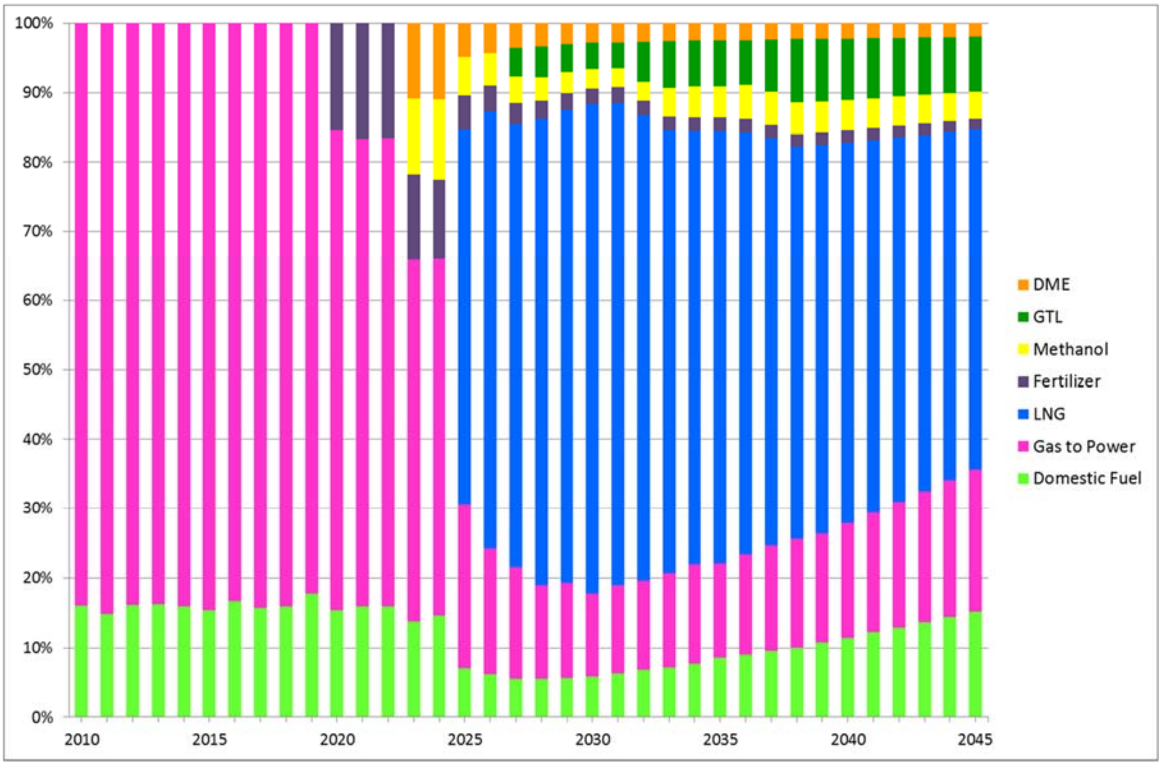
Category	Gas Fields	Proven-Reserve P90 P1	Probable-Resource P50 P1+P2
Land/ Shallow Water	Songosongo	0.88	2.5
	Mnazi-bay	0.262	5
	Mkuranga	-	0.2
	Nyuni	0.045	0.07
	Ruvuma	-	0.178
	Ruvu	-	2.17
	Sub-total	**1.187**	**10.118**
Deep Water	Block 2	-	25.4
	Block 1,3 & 4	-	21.73
	Sub-total	**-**	**47.13**
Total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

Source: Tanzania Petroleum Development Corporation



Source: Natural Gas Utilization Master Plan

Figure 8.3.2-8 Gas Consumption Outlook: Base Case (NGUMP)



Source: Draft Natural Gas Utilization Master Plan

Figure 8.3.2-9 Gas Consumption Share: Base Case (NGUMP)

Table 8.3.2-8 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 8.3.2-9 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%

Source: Task Force Team for PSMP

Generation expansion plans which correspond to five scenarios from Scenario-1 to 5 are formulated using WASP.

(2) Items to be considered in generation expansion plans

1) General

Generation mix is to be established so as not to depend too much on single energy source. Generation mix should be well balanced to maintain the security of electricity supply. Gas fired power: Availability of gas to power is the key for considering the share of gas fired power in generation mix. In Draft NGUMP, it is assumed that gas fired power accounts for 40% of energy generation in 2040 as a condition of estimating total gas demand.

2) Coal fired power

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

3) 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. 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 3,600MW.

4) Renewable energy etc.

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[31] of US$54/MWh (United

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

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[32]. 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) Results

Optimum solutions obtained from WASP for each scenario are shown in Table 8.3.2-10. Scenario-2 is most recommended through the evaluation of scenarios from the view point of total generation cost for 25years (from 2015 to 2040) which includes capital cost, operation and maintenance cost and fuel cost, energy balance and environment.

Table 8.3.2-10 Results of scenario comparison

Scenarios	Features	Cost* (million$)	Cost	Energy Balance	Environment	Order
Scenario-1	Gas:50%, Coal:25%, Hydro:20% Renewable etc.:5%	45,838	3	3	1	2
Scenario-2	Gas:40%, Coal:35%, Hydro:20% Renewable etc.:5%	45,099	1	1	2	1
Scenario-3	Gas:35%, Coal:40%, Hydro:20% Renewable etc.:5%	46,941	5	1	3	3
Scenario-4	Gas:25%, Coal:50%, Hydro:20% Renewable etc.:5%	45,411	2	3	5	4
Scenario-5	Gas:50%, Coal:35%, Hydro:10% Renewable etc.:5%	46,638	4	5	4	5

[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 different by type of fuel.

32 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.

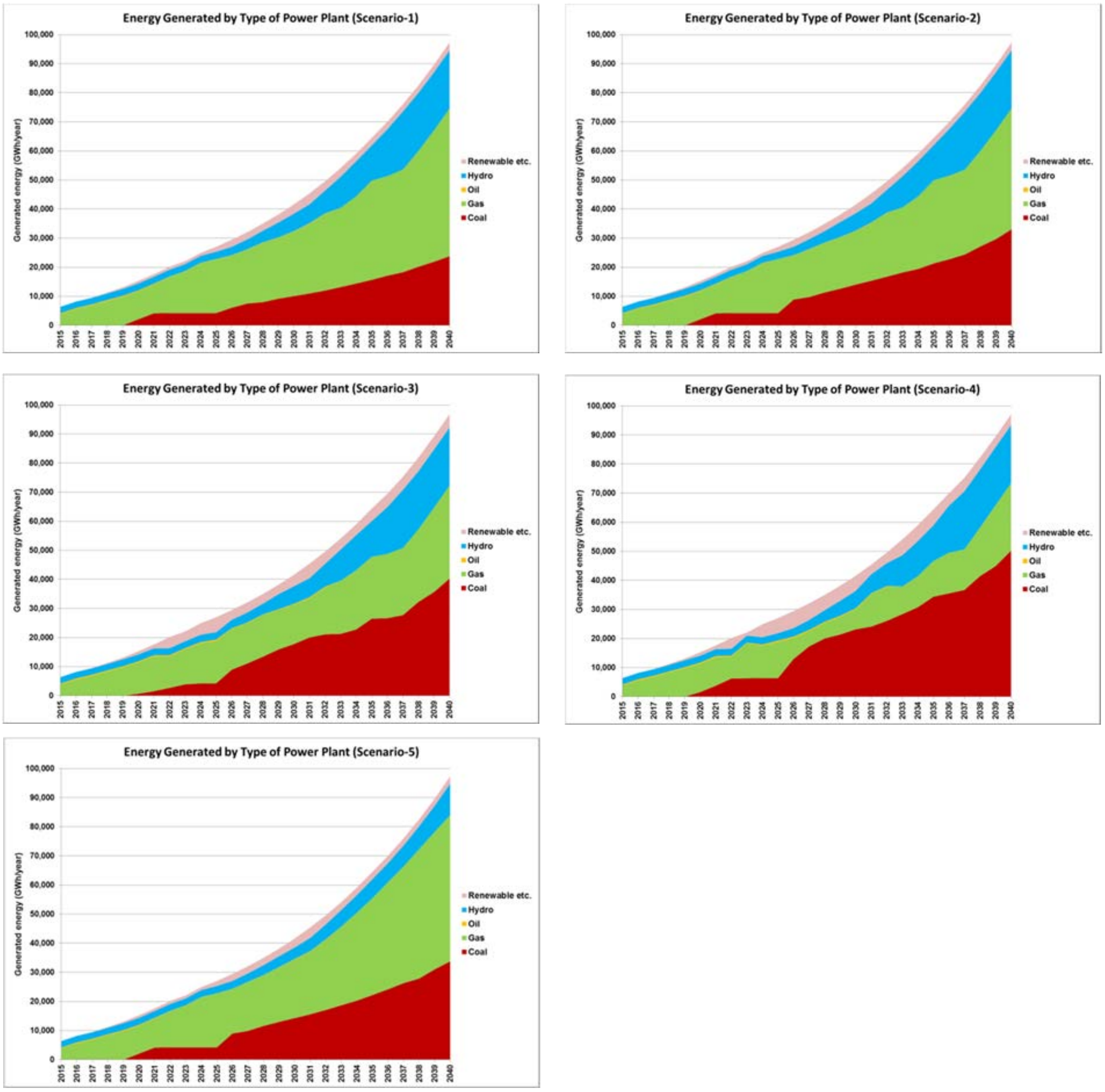


Figure 8.3.2-10 Energy generated

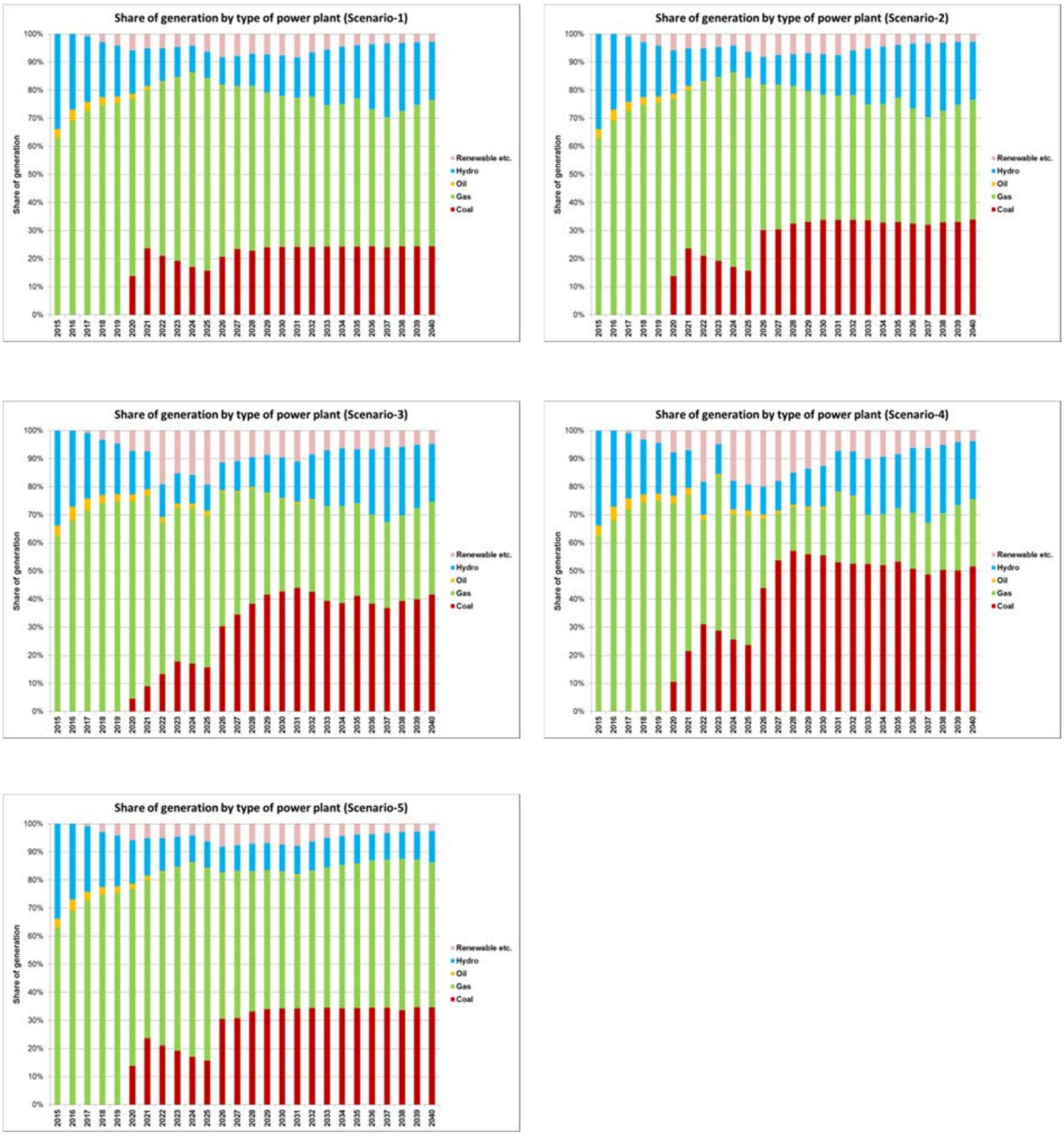


Figure 8.3.2-11 Share of energy generated

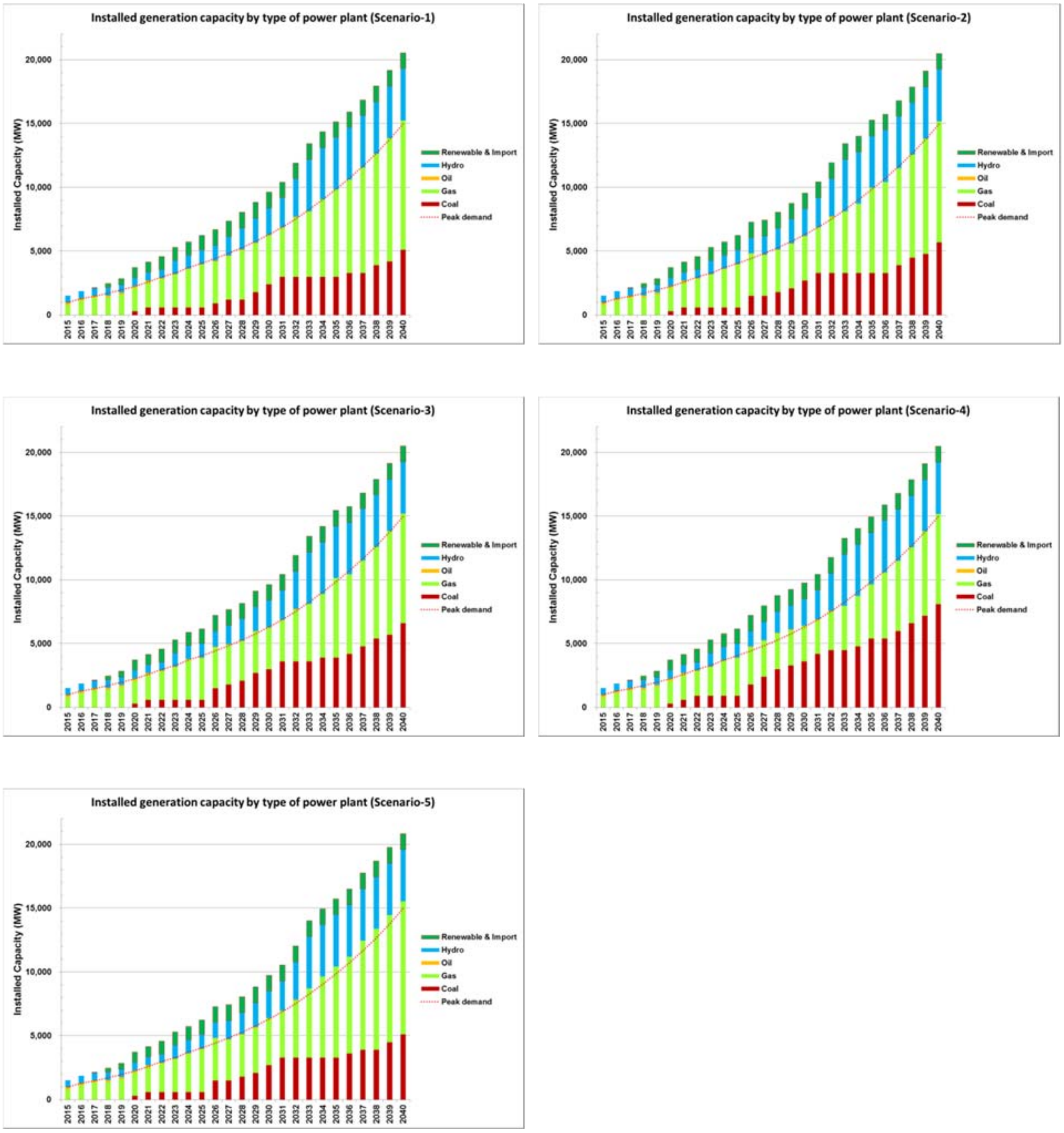


Figure 8.3.2-12 Generation capacity

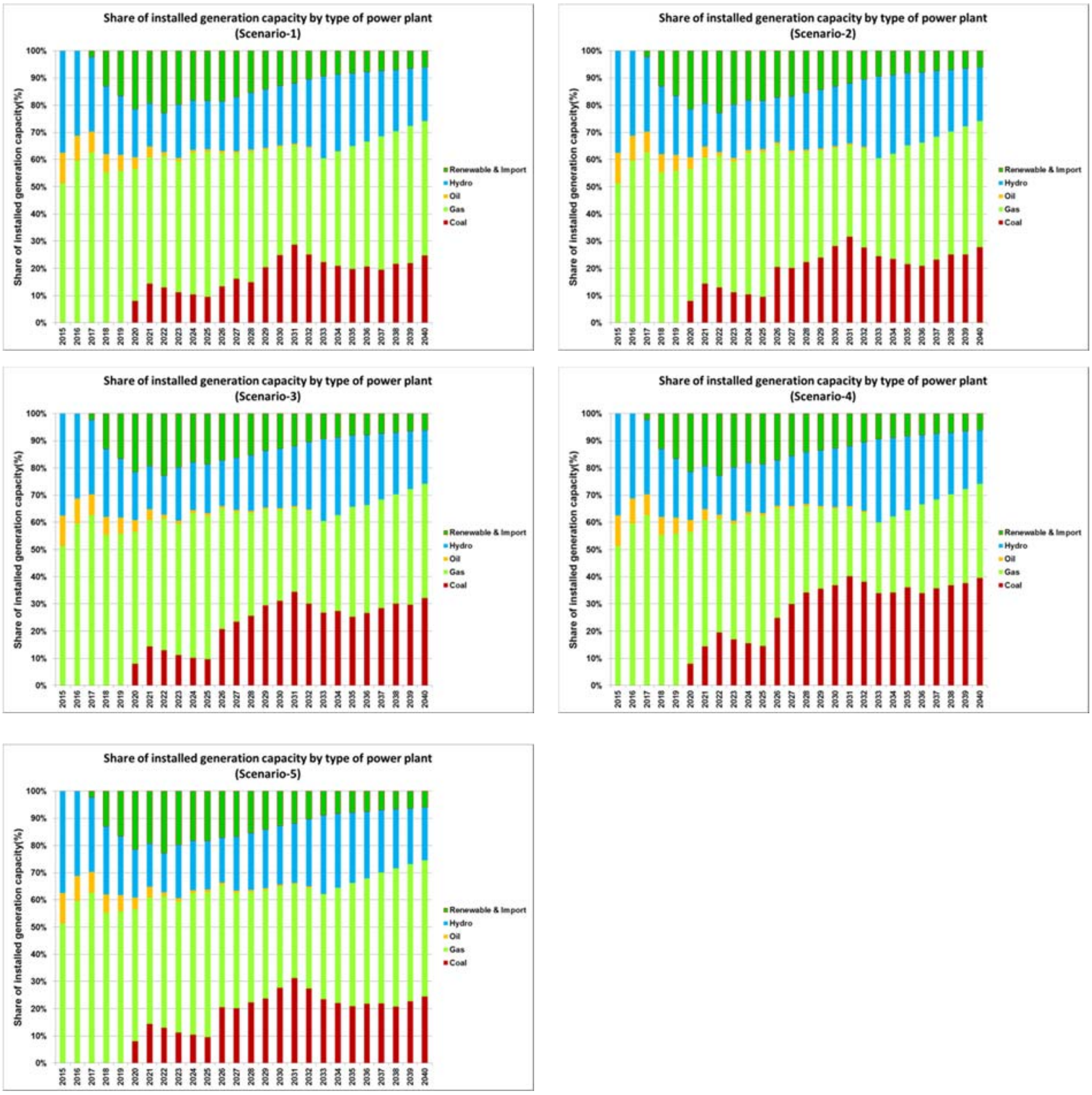
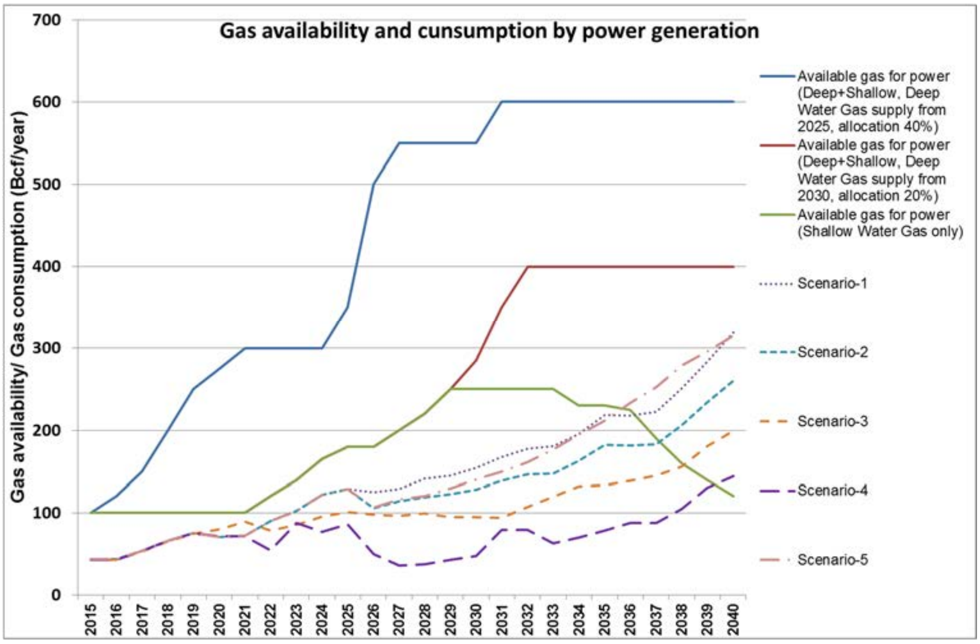


Figure 8.3.2-13 Share of generation capacity

(4) Observations

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. 8.3.2- compares the capability of gas supply and demand by power for five scenarios. With accelerated production from shallow water gas fields, no serious shortage of gas to power will be anticipated as shown in Fig. 8.3.2-14.

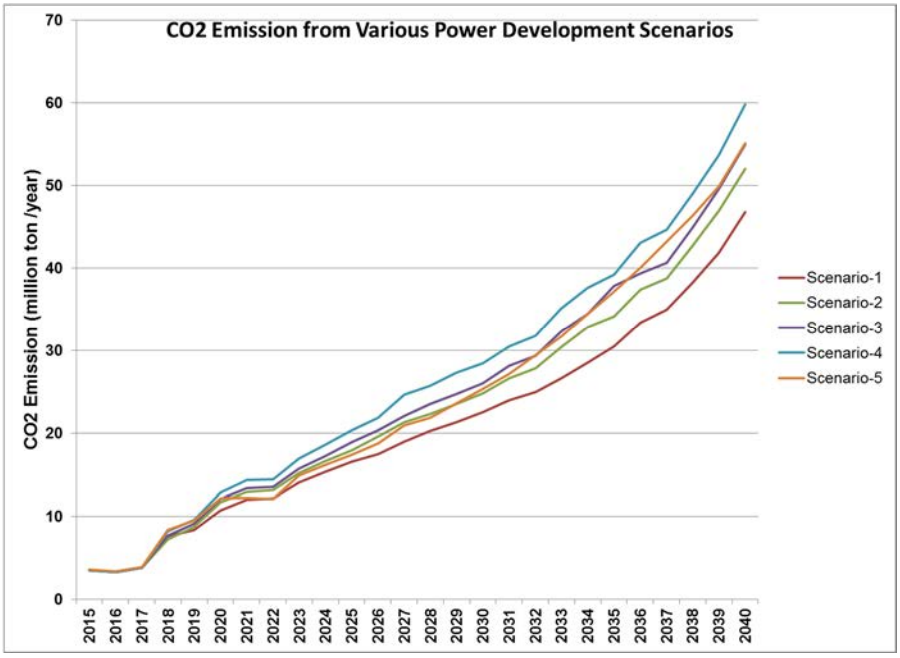


Source: Made by JICA Study Team based on the information from TPDC

Figure 8.3.2-14 Natural gas demand and supply for power sector

2) Carbon dioxide emission

Fig. 8.3.2-15 shows the CO_2 emission from five 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-1, Scenario-4 generates 28% more CO_2 than Scenario-1 in 2040.



Source: JICA Study Team

Figure 8.3.2-15 CO_2 emission in five power development scenarios

8.3.3 Optimal power development plan

Least cost generation plan of Scenario-2 which was calculated by WASP is shown in Table 8.3.3-1. Power development plan of Scenario-2 which includes the location and name of ongoing/planned projects is shown in Table 8.3.3-2.

Table 8.3.3-1 Least cost generation expansion plan (Scenario-2)

Year	Fixed expansion		Variable expansion												LOLP%
			Simple cycle GT			Combined cycle			Coal			GeoTh	Hydro		
	Plant	MW	SGT1	SGT2	SGT3	CGT1	CGT2	CGT3	SBCL	ASBC	USCL	GEO1	DAM		Target
			70MW	120MW	310MW	110MW	185MW	470MW	150MW	300MW	700MW	50MW	Site Name	(MW)	=1.37%
2015	Kinyerezi-I	150													0.262
2016						330									0.161
2017	Kinyerezi-II	240				110									0.198
	Singida Wind (50MW)	50													
2018	Import from Ethiopia (1st stage)	200													0.032
	Kinyerezi-I (Extension)	185													
	Singida Wind (75MW)	75													
2019	Rusmo (Hydro)	30				220									0.057
	Makambako Wind (100MW)	100													
	Dodoma solar (50MW)	50													
2020	Singida Wind (75MW) Extension	75				220			300						0.049
	Singida Wind (100MW)	100													
	Kishapu-Shinyanga Solar	150													
2021	Singida Wind (75MW) Extension	50				110			300						0.133
2022	Import from Ethiopia(2nd stage)	200				110	185								0.089
2023						330									0.068
2024						110	370								0.064
2025						440						100	Malagarasi Stg-III	44.7	0.023
2026										900		100	Iringa-Ibosa	36	0.005
													Iringa-Nginayo	52	
2027													Kakono	87	0.095
2028						110				300			Mnyera - Ruaha	60	0.133
													Songwe Manolo	88	
2029						220				300			Mnyera - Mnyera	137	0.089
													Mnyera - Kwanini	144	
2030										600			Mnyera - Pumbwe	123	0.068
													Mnyera - Taveta	84	
2031							185						Mnyera - Kisingo	120	0.064
2032								940					Lower Kihansi Exp.	120	0.023
													Mpanga	160	
													Masigira	118	
2033								470					Rumakali	222	0.012
													Ruhudji	358	
2034						110		470					Kikonge	300	0.019
													Songwe Sofre	80	
2035								1,410							0.009
2036								470					Stieglers Gorge Ph-1	1,048	0.012
													Upper Kihansi	47	
2037								470		600			Stieglers Gorge Ph-2	1,048	0.034
2038								470		600					0.043
2039								940		300					0.052
2040								470		900					0.041
Total addition (Number of units)			0	0	0	22	4	13	4	17	0	4	21		
Total addition (MW)		1,655	0	0	0	2,420	740	6,110	600	5,100	0	200	4,477		

Source: JICA Study Team

Table 8.3.3-2 Optimal generation expansion plan (Scenario-2)

	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)						**997**	**1,275**	**1,483**	**1,722**	**1,970**	**2,241**	**2,601**	**2,985**	**3,281**	**3,723**	**4,051**	**4,426**	**4,835**	**5,284**	**5,776**	**6,314**	**6,905**	**7,550**	**8,256**	**9,028**	**9,867**	**10,724**	**11,656**	**12,668**	**13,768**	**14,963**
Power supply capacity (MW)						**1,455**	**1,343**	**1,578**	**2,138**	**2,764**	**3,995**	**4,345**	**4,682**	**4,982**	**5,440**	**5,905**	**6,953**	**6,926**	**7,578**	**8,334**	**9,141**	**9,976**	**11,314**	**12,301**	**13,261**	**14,521**	**16,086**	**18,019**	**18,849**	**20,089**	**20,559**
Generation capacity without solar,wind and import (MW)						**1,455**	**1,343**	**1,528**	**1,813**	**2,289**	**3,195**	**3,495**	**3,632**	**3,932**	**4,390**	**4,855**	**5,903**	**5,876**	**6,528**	**7,284**	**8,091**	**8,926**	**10,264**	**11,251**	**12,211**	**13,471**	**15,036**	**16,969**	**17,799**	**19,039**	**19,509**
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	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												
Ongoing	Kinyerezi I	TANESCO	2015	GT	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	Retire					
	Kinyerezi I Extension	TANESCO	2017	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	2018	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 Candidate	Somanga Fungu-1	IPP	2019	GT	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-2	IPP	2020	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
	Kinyerezi III(Ph1) 1-3	PPP	2019	GT	246					246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246	246
	Kinyerezi III(Ph2) 1-2	PPP	2020	C/C	123						123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123
	Kinyerezi IV 1-2	PPP	2020	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	2023	C/C	300									300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Somanga (PPP)	PPP	2024	C/C	300										300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Somanga	TANESCO	2022	C/C	240								240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240
	Bagamoyo(Zinga)	IPP	2024	C/C	200										200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
	Future CGT1(1-10)			CGT1	110 *											440	440	440	550	770	770	990	990	990	1100	1100	1100	1100	1100	1100	1100
	Future CGT3(1-13)			CGT3	470 *																		940	1410	1880	3290	3760	4230	4700	5640	6110
	Mchuchuma 1-4		2020	SBCL	150 *						350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
	Mbeya Ph-1 + Exp(+2)		2021	SBCL/ASUB	150 *							300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	900	900	900	900
	Ngaka 1-3			SBCL	200 *												600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
	Ngaka (Exp)+3			ASUB	300 *																	600	600	600	600	600	600	600	600	900	900
	Kiwira 1-2			SBCL	200 *														400	400	400	400	400	400	400	400	400	400	400	400	400
	Kiwira (Exp)+1			ASUB	300 *																								300	300	300
	Mchuchuma(Exp)+3			ASUB	300 *																600	600	600	600	600	600	600	600	900	900	900
	Rukwa 1+Exp(+1)			ASUB	300 *												300	300	300	600	600	600	600	600	600	600	600	600	600	600	600
Thermal generation capacity subtotal (MW)						**889**	**777**	**962**	**1,220**	**1,676**	**2,582**	**2,882**	**3,019**	**3,319**	**3,777**	**4,097**	**4,957**	**4,843**	**5,347**	**5,822**	**6,422**	**7,137**	**8,077**	**8,484**	**9,064**	**10,324**	**10,794**	**11,679**	**12,509**	**13,749**	**14,219**
	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	2018	Dam	27				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		2032	Dam	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
Variable Hydro Candidate	Malagarasi Stage-III	TANESCO	2025	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
	Mpanga		2032	Dam	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		2033	Dam	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		2036	Dam	1048																						1048	1048	1048	1048	1048
	Stieglers Gorge Ph-2		2037	Dam	1048																							1048	1048	1048	1048
	Upper Kihansi		2036	Dam	47																						47	47	47	47	47
Hydro subtotal						**566**	**566**	**566**	**593**	**613**	**613**	**613**	**613**	**613**	**613**	**658**	**746**	**833**	**981**	**1,262**	**1,469**	**1,589**	**1,987**	**2,567**	**2,947**	**2,947**	**4,042**	**5,090**	**5,090**	**5,090**	**5,090**
Total generation capacity (MW)						**1,455**	**1,343**	**1,578**	**2,138**	**2,764**	**3,995**	**4,345**	**4,682**	**4,982**	**5,440**	**5,905**	**6,953**	**6,926**	**7,578**	**8,334**	**9,141**	**9,976**	**11,314**	**12,301**	**13,261**	**14,521**	**16,086**	**18,019**	**18,849**	**20,089**	**20,559**
Reserve capacity (with rated hydro capacity)						458	68	95	416	794	1,754	1,744	1,697	1,702	1,717	1,854	2,527	2,091	2,294	2,558	2,827	3,071	3,764	4,045	4,232	4,654	5,362	6,363	6,181	6,321	5,596
Reserve margin (with rated hydro capacity)						45.9%	5%	6.4%	24.2%	40.3%	78.3%	67.1%	56.8%	51.9%	46.1%	45.8%	57.1%	43.2%	43.4%	44.3%	44.8%	44.5%	49.9%	49.0%	46.9%	47.2%	50.0%	54.6%	48.8%	45.9%	37.4%

Note: * means installed capacity per unit

8.3.4 Priority project of power development plan

The power source development plans currently in progress in PSMP 2012 are all IPP and PPP projects for which the IPP owners and PPP partners have already been decided. Accordingly, opportunities are extremely limited for participation in existing new projects. However, as was also described in 8.3.4 Optimum power development plan, these projects are behind schedule mainly due to funding constraints, etc. If the demand for power continues to steadily increase in Tanzania from now on, there is a risk that supply shortages will occur, so it is necessary to promptly develop power sources.

Against this background, review was conducted on the possibility of Japanese cooperation being provided for new thermal power development projects.

(1) Fuel

When reviewing new thermal power development projects in Tanzania, it is expected that coal and natural gas will be used as primary energy sources.

Concerning use of coal, since the main coal deposits are situated inland and are not accessible to major infrastructure and railways, etc., power generation facilities are limited to colliery facilities. Moreover, it is necessary to advance development in line with the development of coal mines, so there is a risk that fuel supply shortages will arise in the case where it is planned to develop new coal-fired thermal power in addition to the facilities being planned in line with the current development of coal mines. Therefore, it is desirable to plan new coal-fired thermal power development projects after a certain degree of progress has been made in coalmine development.

Concerning use of natural gas, currently the Mnazi Bay gas field is being developed in southern Tanzania, and a new pipeline is currently being constructed to Dar es Salaam. This pipeline, which follows the Tanzanian coast, is scheduled for completion in 2015. Therefore, because the stable supply of fuel will become possible following completion of the pipeline, examination is being conducted into the development of new gas-fired thermal power stations.

(2) Generation type

Gas-fired thermal power stations comprise power stations with gas turbines that can be converted for aircraft use, and large-capacity gas turbine thermal power stations. Gas turbines that can be converted for aircraft use are small, light, and compact; they require little time from start to full load, and they can start and stop rapidly. Moreover, they can be easily modified for simple cycle or combined cycle systems as well as expansion or addition of units.

On comparing simple cycle and combined cycle systems, a difference of around 10% can be expected in terms of thermal efficiency. Accordingly, combined cycle gas turbines based on the aircraft conversion type will be adopted here.

(3) Candidate sites

The necessary conditions for sites when constructing combined cycle gas turbine thermal power stations are as follows:

- It is possible to secure a cooling source (seawater or freshwater) for cooling steam following work in the steam turbine.

- A stable supply of fuel is available.
- Transmission facilities for delivering the generated power to consumer areas are established.

TANESCO implemented a field survey for selecting candidate sites for new gas-fired thermal power stations from the end of October to the start of November, 2014. Within that, nine candidate sites for future development were selected. Since these are located in sparsely populated areas, it should be possible to secure the necessary site areas.

Table 8.3.4-1 Candidate sites for newly gas-fired thermal power station

District	Site Name	Coordinates (Easting & Northing)			Distance (to site - km)	
		Zone	X	Y	From BVS	From Sea
Mkuranga (BVS 13)	Site 1	-37	545072.04	9202457.05	18	4
	Site 2	-37	547567.85	9206259.91	23	4.6
	Site 3	-37	536504.23	9181334.59	25	1.7
Kilwa - Somanga (BVS Somanga)	Site 1	-37	529343.25	9066947.77	0.4	4
	Site 2	-37	530361.75	9066236.19	1.2	2.5
Lindi (BVS 03)	Site 1	-37	585970.59	8907107.29	35	0.6
	Site 2	-37	579510	8901078.7	27	0.37
Mtwara (BVS 01)	Site 1	-37	623142.7	8869147.26	13	0.8
	Site 2	-37	622974.56	8870502.97	20	4

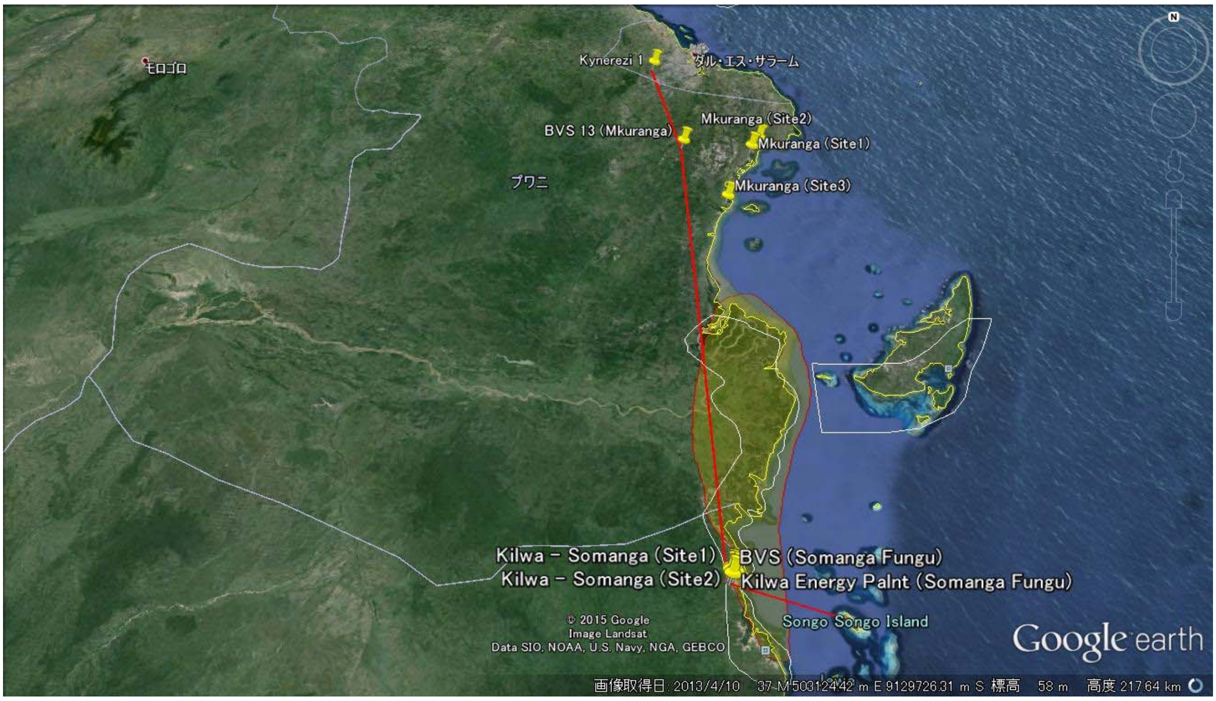
BVS: Block Valve Station

Source: TANESCO

The above candidate sites have been selected along the route of the coastal pipeline, not too far from valve stations. Moreover, since they are in coastal areas, it will be possible to use seawater for cooling. Transmission facilities in the coastal areas are planned for construction in the future, although there are plans to construct a 400kV transmission line between Somanga Fungu and Kinyerezi in a prior project. According to TANESCO, the NSSF has decided to make a loan of 150 million USD, and TANESCO is currently coordinating with the NSSF towards conclusion of the loan agreement. When the transmission line between Somanga Fungu and Kinyerezi is finished, it will be possible to connect Mkuranga at the midway point to the transmission line. Accordingly, out of the above nine candidate sites, those in Lindi and Mtwara are omitted, and the review has been narrowed down to five sites in Mkuranga and Kilwa - Somanga.

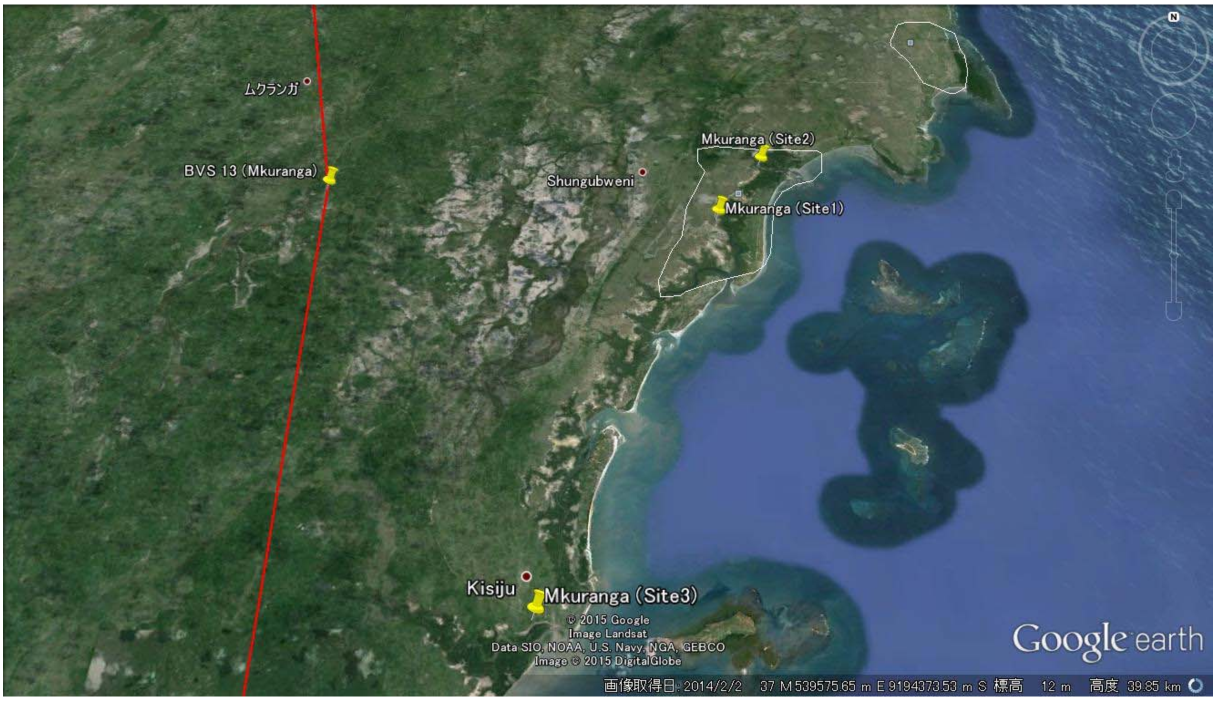
Next, conditions are ascertained in Mkuranga and Kilwa - Somanga. Figure 8.3.4-1 shows the candidate sites for gas-fired thermal power stations (overall). Figure 8.3.4-2 shows the sites in Mkuranga, and Figure 8.3.4-3 shows those in Kilwa – Somanga. According to these figures and Table 8.3.4-1, the sites in Kilwa - Somanga are closer to the coast and valve stations than those in Mkuranga. However, land in the Kilwa - Somanga area comprises a massive wetland and also contains designated sanctuaries under the Ramsar Convention (the yellow colored parts in Figures 8.3.4-1 and 8.3.4-3). Coastal areas in Mkuranga also contain coral and mangrove forests, although these have not been designated as sanctuaries. Therefore, when advancing development of the Kilwa – Somanga area, it is expected that a lot of time will be required to implement the EIA and secure environmental authorization.

In consideration of the above points, the site of the new gas-fired thermal power station will be located in Mkuranga. There are three candidate sites in Mkuranga, and it will be desirable to decide on one upon conducting a detailed survey.



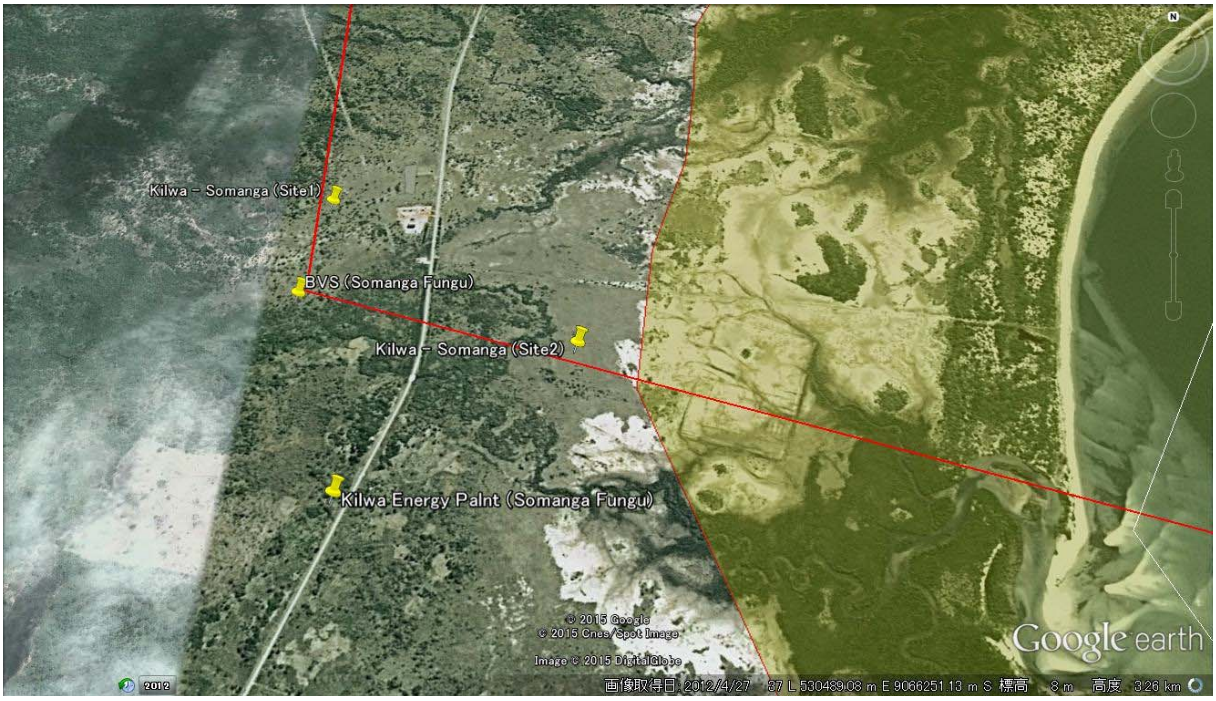
Source: Made by JICA Team

Figure 8.3.4-1 Candidate sites for gas-fired thermal power station (overview)



Source: Made by JICA Team

Figure 8.3.4-2 Candidate sites for gas-fired thermal power station (Mkuranga region)



Source: Made by JICA Team

Figure 8.3.4-3 Candidate sites for gas-fired thermal power station (Kilwa – Somanga region)

(4) Need for detailed field survey

As a result of the basic survey conducted here, Mkuranga has been selected as the candidate area for construction of the new gas-fired thermal power station. In advancing the project, upon estimating the rough scale of the generating facilities, it will be necessary to compare and assess each candidate site from the technical and economic viewpoints and then select the ideal construction site.

8.3.5 Issues and Recommendations in Realization of Power Source Development Plans

8.3.5.1 Thermal Power Generation Facilities

The issues to be addressed in advancing power source development are described below.

(1) Issues concerning infrastructure development

Gas-fired thermal power stations in the Dar es Salaam zone (Songas, Ubungo-1, 2, Tegeta), which utilize gas supplied from Songo Songo gas field located 200 kilometers south of Dar es Salaam, operate together with an industrial natural gas supply network, however, frequently the gas supply is deficient and this lowers the utilization rate. In the south of the country, Mnazi Bay gas field has been developed and a pipeline is being constructed to supply gas from the gas fields on land and in the shallow sea. Moreover, a giant gas field has been discovered in deep offshore waters (depths of 1,150~2,500 meters) and it is anticipated that this will become an important supply source in future. In order to actualize gas-fired thermal power development plans on schedule, the development of these gas fields and construction of gas pipelines must be advanced without delay.

Concerning coal-fired thermal power, it is largely planned to produce coal around Lake Malawi in the southwest of Tanzania and generate power at mine-mouth power station. Thermal power stations require cooling sources in order to condense steam. In cases where water from lakes and rivers is used for this purpose, it is necessary to obtain water upon first making sure that no impact is had on intake for hydropower generation and intended uses of water for other activities. In cases where seawater is used for cooling, it is necessary to locate facilities on the coast, but in this case it is important to development infrastructure (railway, etc.) for transporting the coal to be used as fuel.

(2) Issues concerning environmental and social consideration and global environmental problems

Thermal power generation, which uses fossil fuels, entails great air pollution and environmental load in line with combustion, and there are growing concerns over the effects of this on not only local environmental contamination but also global warming.

Concerning particulates, nitrogen oxide, and sulfur oxide, since the World Bank Group International Finance Corporation (IFC) has established guidelines (2008) for atmospheric discharges from thermal power stations in its Environmental, Health, and Safety Guidelines (EHS), it will be necessary to pay attention to the values in these when conducting design.

As for coal-fired thermal power, President Obama of the United States announced the President's Climate Action Plan in June 2013, in which he (1) announced the end of American government support for new coal-fired thermal power stations overseas, and (2) called on other countries and multilateral development banks to adopt a similar approach. In line with this, the World Bank Group announced a tough policy of limiting loans for new coal-fired thermal power stations to cases where no other economic alternatives to coal exist.

It is necessary to pay close attention to international trends in line with this heightening interest in global environmental problems. One means of addressing global warming is to increase the efficiency of thermal power stations. In gas-fired thermal power stations, this can be done by introducing larger gas turbines with higher temperatures, while in coal-fired thermal power stations, it can be done by introducing supercritical (SC) and ultra-supercritical (USC) systems, etc. In the case of Tanzania, because the power network is still fragile, it is difficult to construct large-capacity thermal power stations. Therefore, it is considered effective to introduce small-capacity aero-derivative gas turbines, advanced subcritical pressure (Advanced Sub-C) coal-fired thermal power stations which improve subcritical pressure (Sub-C), and so on.

Moreover, when constructing large-scale thermal power stations, since a large site area is needed, it is necessary to consider impacts on the natural environment and social environment such as resettlement of residents, cultural heritage, effects on protected areas and ecosystems, and so on. Particularly in coastal areas, since coral and mangroves have been confirmed and the area around Mtwara is designated as a marine protected area, it is necessary to conduct field survey and give appropriate consideration when selecting sites.

(3) Issues concerning transmission lines

Because power systems in Tanzania are fragile, it is urgently required to reinforce transmission systems. At the same time, it is important to install transmission lines to new locations and to bolster substations and so on. In order to realize the stable operation of power systems, it is necessary to satisfy three technical constraints, i.e. power flow, fault current, and stability. In the case where facilities are concentrated in certain locations due to site limitations, power flow and voltage must be appropriately maintained without imparting excessive load on transmission lines and transformers, etc.

(4) Issues concerning O&M

Because thermal power generation facilities deteriorate over time, operation and maintenance steadily becomes more important. In order to continue reliable operation over the long run, it is necessary to conduct operation and maintenance based on a long-term plan. As a result of investigating the existing gas-fired thermal power stations of TANESCO, it was found that periodic inspections are not implemented at appropriate intervals and there is a shortage of spare parts due to insufficient maintenance budget. Inspections are not periodically implemented, and the current practice can be described as breakdown maintenance, whereby problems are fixed after failures occur. Because it is important for power generation facilities to always display their intended performance and maintain stable supply, it is necessary to establish ongoing and appropriate maintenance in tandem the development of power sources.

In order to establish ongoing and appropriate maintenance and improve O&M skills in Tanzania, possible methods are to conduct guidance via counterparts training in Japan and to provide maintenance know-how as a package when developing new power sources. Moreover, in order to make judgments for extending the service life of plants, an effective method is to jointly conduct diagnoses of individual deteriorated items of equipment together with the counterparts and provide technical support to ensure that the know-how is embedded on the local side.

8.3.5.2 Hydro Power Generation Facilities

In order to develop the planned hydro power projects based on the optimum power generation development plan 2015-2040, the following are recommended.

(1) Steady Implementation of Studies:
In order to start construction work of the planned hydro power projects without delay, required technical and environmental studies should be steadily implemented taking into consideration the appropriate lead time for preparation.

(2) Optimization of Generation Plans:
In order to further improve economic efficiency of the planned hydro power projects, the power generation plan for each project should be optimized when the required technical studies above have been stepped-up, and precision of planning and design have been improved.

(3) Improvement of System for Study and Construction:
In order to simultaneously prepare for commencement of construction and to manage

construction work of a large number of planned hydro power projects, a sufficient number of staff to work on the related tasks including studies, permission processes, bidding and contract processes and supervision of construction should be secured.

(4) Identification of New Power Development Options:
In order to continuously develop economically viable hydro power projects, studies on potential projects should be implemented and candidates for future power development options should be identified.

(5) Improvement of System for Operation and Maintenance:
In order to supply electric power as planned, a sufficient number of staff to work on operation and maintenance should be secured in concert with increasing hydro power plant.

(6) Complete Implementation of Appropriate Maintenance:
In order to supply electric power as planned, existing and newly constructed hydro power plant should be appropriately maintained and forced outage rates should be decreased.

(1) Steady Implementation of Studies

Under the optimum power generation development plan 2015-2040, a total of 22 planned large and medium-scale hydro power projects are to be developed. However, of those 22 planned projects only 6 planned projects have completed the feasibility studies during last decade, and the current status of the remaining 16 planned projects is still at pre-feasibility study or preliminary study level (see Table 8.3.4-3).

Therefore, the technical studies should be stepped-up and the precision of planning and design should be improved in a well-planned manner. Specifically pre-feasibility study, feasibility study and detailed design including tender documents should be steadily implemented in concert with planned commencement year of operation.

For most planned hydro power projects, the technical studies have been carried out in recent years. It is considered that these projects were planned to be adapted to current land use and environmental regulations.

However, it is considered that further mitigation of environmental and social impact will be required in future, and the technical studies and power generation plans will have to be changed due to the readjustment of waterways and the demands of environmental flow. In addition, there is concern that it will take much time to obtain Environmental and Social Impact Assessment (ESIA) approval from the National Environment Management Council (NEMC), and the start of construction will be delayed.

Especially, Steiglers Gorge Project, which is located within the Selous Game Reserve, which is registered as a World Heritage Site, and further mitigation of environmental and social impact will be required.

On the other hand, only 11 planned projects have completed ESIA studies during last decade (see Table 8.3.4-3). Therefore, ESIA studies should be implemented in parallel with step up and/or update of technical studies.

(2) Optimization of Generation Plans

In the previous study reports on planned large and medium-scale hydro power projects, except for Upper Kihansi Project and Mnyera River Projects (Ruaha, Mnyera, Kwanini, Pumbwe, Taveta, Kisingo), the setting methods for development scale such as installed capacity and plant discharge were not indicated. For Mnyera River Projects, the development scales were set so that the plant factor of each project was 55%. In other words, there is a possibility that the power generation plans for many planned projects are not optimized in terms of economic efficiency.

Therefore, the power generation plans for each project should be optimized with reconsideration of minimizing the average generation cost during service life and/or maximizing the benefit compared to alternative thermal power plant, when the required technical studies above are stepped-up and the precision of planning and design are improved.

(3) Improvement of System for Study and Construction

In order to achieve the optimum power generation development plan 2015-2040, a large number of planned hydro power projects have to be studied and constructed at the same time (see Figure 8.3.5-1). Therefore, TANESCO and other developers will require a sufficient number of staff to work on the related tasks including studies, permission processes, bidding and contract processes and supervision of construction.

It should be taken into consideration that TANESCO has not constructed a hydro power plant since the commencement of commercial operation in 2000 of Khihansi hydro power plant. In addition, Rufiji Basin Development Authority (RUBADA) has not yet experienced construction of a hydro power plant.

For these reasons, in order for TANESCO and RUBADA to work on the related tasks including studies, permission processes, bidding and contract processes and supervision of construction, it is necessary to improve the skills of their engineers and staff. In addition to this, it is necessary to increase the number of engineers and staff of TANESCO and RUBADA. Therefore, appropriate responses including the following should be considered and the system for study and construction should be improved.

- Setting up a professional team or department for hydro power development, which consistently carries out studies/investigations, permission and contract processes, and supervision of construction
- Implementation of OJT (On the Job Training) through the development of the planned projects for which construction work will start early such as the Rusumo Project
- Implementation of personnel rotation between hydro power operation and maintenance department and hydro power construction department
- Increasing the number of hydro power engineers through mid-career recruitment and/or new recruitment

	River Basin	Planned Projects	Installed Capacity (MW)	Operation Start Year
1	Lake Victoria	Rusumo	90.0	2019
2		Kakono	87.0	2027
3	Lake Tanganyika	Malagarasi Stage III	44.7	2026
4	Lake Nyasa	Rumakali	222.0	2033
5		Masigira	118.0	2032
6		Kikonge	300.0	2034
7		Songwe Manolo (Lower)	177.9	2028
8		Songwe Sofre (Middle)	158.9	2034
9	Rufiji	Ruhudji	358.0	2033
10		Mnyera - Ruaha	60.3	2028
11		Mnyera - Mnyera	137.4	2029
12		Mnyera - Kwanini	143.9	2029
13		Mnyera - Pumbwe	122.9	2030
14		Mnyera - Taveta	83.9	2030
15		Mnyera - Kisingo	119.8	2031
16		Mpanga	160.0	2032
17		Lower Kihansi Expansion	120.0	2032
18		Upper Kihansi	47.0	2036
19		Iringa - Ibosa	36.0	2026
20		Iringa - Nginayo	52.0	2026
21		Steiglers Gorge Phase 1	1,048.0	2036
22		Steiglers Gorge Phase 2	1,048.0	2037
Total			4,735.7	

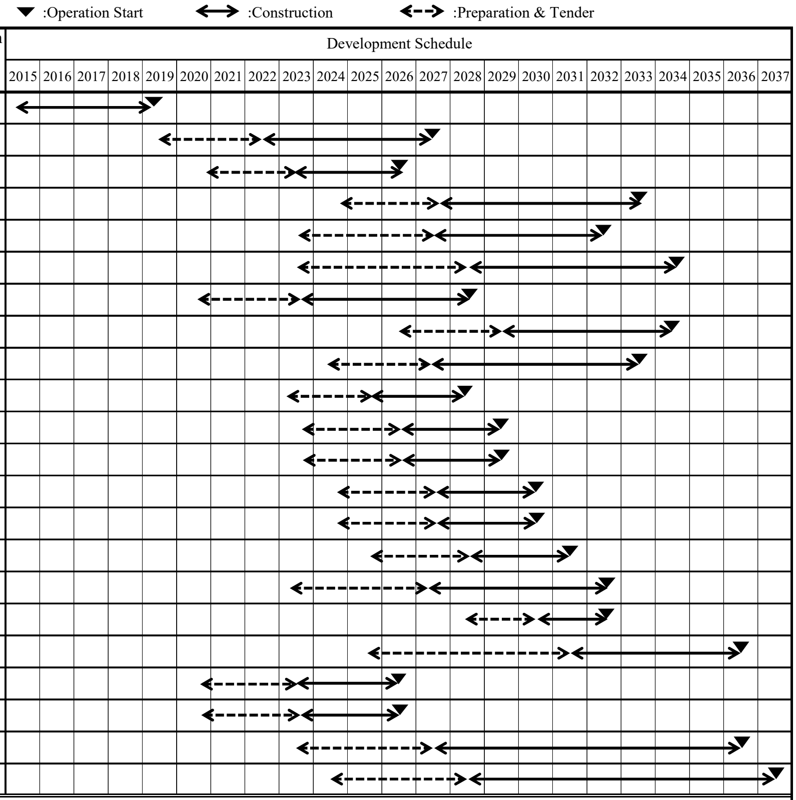


Figure 8.3.5-1 Development Schedule of Planned Large and Medium-Scale Hydro Power Projects under Optimum Power Generation Plan

(4) Identification of New Power Development Options

Under the optimum power generation development plan 2015-2040, all existing planned hydro power projects except for the Songwe Bipugu (Upper) Project, which was excluded from power development options as described in Section 8.3.4, are planned to be developed by 2036 (see Figure 8.3.5-1). In order to update the power system master plan in future, it is necessary to identify new power development options which could be developed after 2036.

Hydro power potential in Tanzania is estimated as 38,000MW[33]. Based on the previous studies including hydro power potential studies[34], economically viable hydro power projects should be identified and the precision of surveys/investigations should be improved.

(5) Improvement of System for Operation and Maintenance

Only 6 operating large and medium-scale hydro power plans are interconnected to the National Grid in Tanzania as of the end of 2014. Under the optimum power generation development plan 2015-2040, an additional 22 large and medium-scale hydro power projects are planned to be developed by 2037 (see Figure 8.3.5-1). This means that the number of hydro power plants will be increased to about 4

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

[34] Rufiji Basin Hydropower Master Plan (April 1984, Norconsult)

times the current number in the next 20 years. Hydro power plants operated by TANESCO are planned to increase rapidly from 7 plants in 2014 to 17 plants in 2035.
Most hydro power plants in Tanzania are manned plants and employ not only operation staff but also maintenance staff work at powerhouses.
For these reasons, in order for TANESCO and RUBADA to work on operation, maintenance and repair, it is necessary to improve the skills of their engineers and staff. In addition to this, it is necessary to increase the number of engineers and staff of TANESCO and RUBADA. More specifically, outsourcing of maintenance and repair work currently conducted by TANESCO' staff should be considered.
In addition to these points, measures for hardware such as (i) introduction of unmanned operation of plant, and (ii) introduction of equipment which allows for labor-saving should be considered.
As just outlined, the measures for both human resources and hardware should be considered and the system for operation and maintenance should be improved.

(6) Complete Implementation of Appropriate Maintenance

Forced outage duration time for existing hydro power plants operated by TANESCO is currently much too long as shown in Table 8.3.5-1 (see Section S-3-2 of Supplement S-2). Not only for existing plants but also plants to be built in future, forced outage, which causes degradation of power supply capability and destabilization of the power system, should be avoided.
Therefore, efforts to decrease forced outage should be made through complete implementation of appropriate maintenance for equipment and facilities of hydro power plants.
In addition, some exiting hydro power plants have no record of forced outage duration time. This indicates that some managers and staff of the maintenance department and hydro power plants have a low awareness of the importance of maintaining a stable power supply. A management cycle, comprised of recording forced outage duration time and causes, analyzing historical trends and implementing countermeasures, should be built.

Table 8.3.5-1 Forced Outage Rates for Existing Hydro Power Plants

Item				Hydro Power Plant					
				Hale	Nyumba Ya Mungu	Kidatu	Mtera	New Pangani Falls	Kihansi
Plant Characteristics	Installation Year			1967	1968	1975	1988	1995	2000
	Number of units			2	2	4	2	2	3
Forced Outage Duration Time	Whole Plant (Days-Unit)	Year	1999	N/A	N/A	8.3	N/A	N/A	N/A
			2000	N/A	N/A	22.9	N/A	N/A	N/A
			2001	N/A	N/A	8.3	N/A	N/A	71.5
			2002	N/A	N/A	5.9	N/A	N/A	N/A
			2003	N/A	N/A	10.7	N/A	N/A	0.5
			2004	N/A	N/A	11.8	N/A	N/A	5.0
			2005	N/A	N/A	4.3	N/A	N/A	4.5
			2006	367.6	28.3	15.4	N/A	3.0	N/A
			2007	370.2	209.5	36.9	N/A	1.6	10.7
			2008	389.4	359.4	10.6	N/A	5.9	10.7
			2009	N/A	N/A	10.3	N/A	N/A	30.2
			2010	N/A	N/A	109.0	N/A	N/A	81.3
			2011	N/A	N/A	32.6	N/A	N/A	33.8
			2012	N/A	N/A	148.0	N/A	N/A	25.2
			2013	708.1	295.3	30.5	N/A	74.5	17.0
		Average		458.8	223.1	31.0	N/A	21.3	26.4
				152.1					
	Per Unit (Days)	Average		229.4	111.6	7.8	N/A	10.6	8.8
				229.4	111.6	9.1			
				73.6					
Forced Outage Rate per Unit (time per year)				62.9%	30.6%	2.1%	N/A	2.9%	2.4%
				62.9%	30.6%	2.5%			
				20.2%					

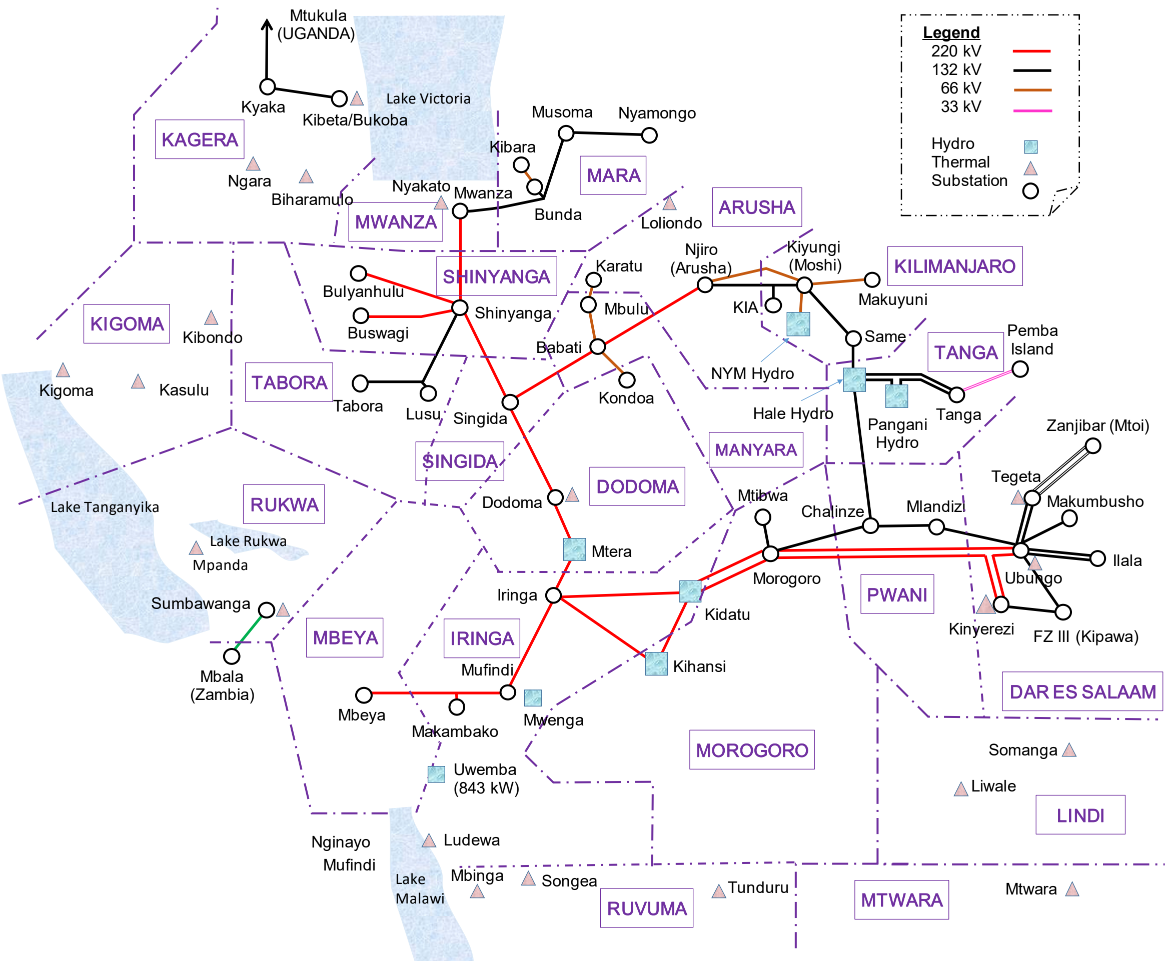
Source: Made by JICA Study Team with reference to "Annual Report of each Hydro Power Plant (1999 - 2012, TANESCO)"

Chapter 9 System Planning

9.1 Present Condition of Transmission and Substation Facilities

9.1.1 Present national transmission network

Figure 9.1.1-1 shows National Power Transmission Network Diagram of Tanzania as of November 2016.



Source: Study team based on TANESCO data

Figure 9.1.1-1 National Power Transmission Network Diagram of Tanzania

The Tanzania power transmission network is consisting of 220 kV as the maximum voltage, with 132 kV and 66 kV following.

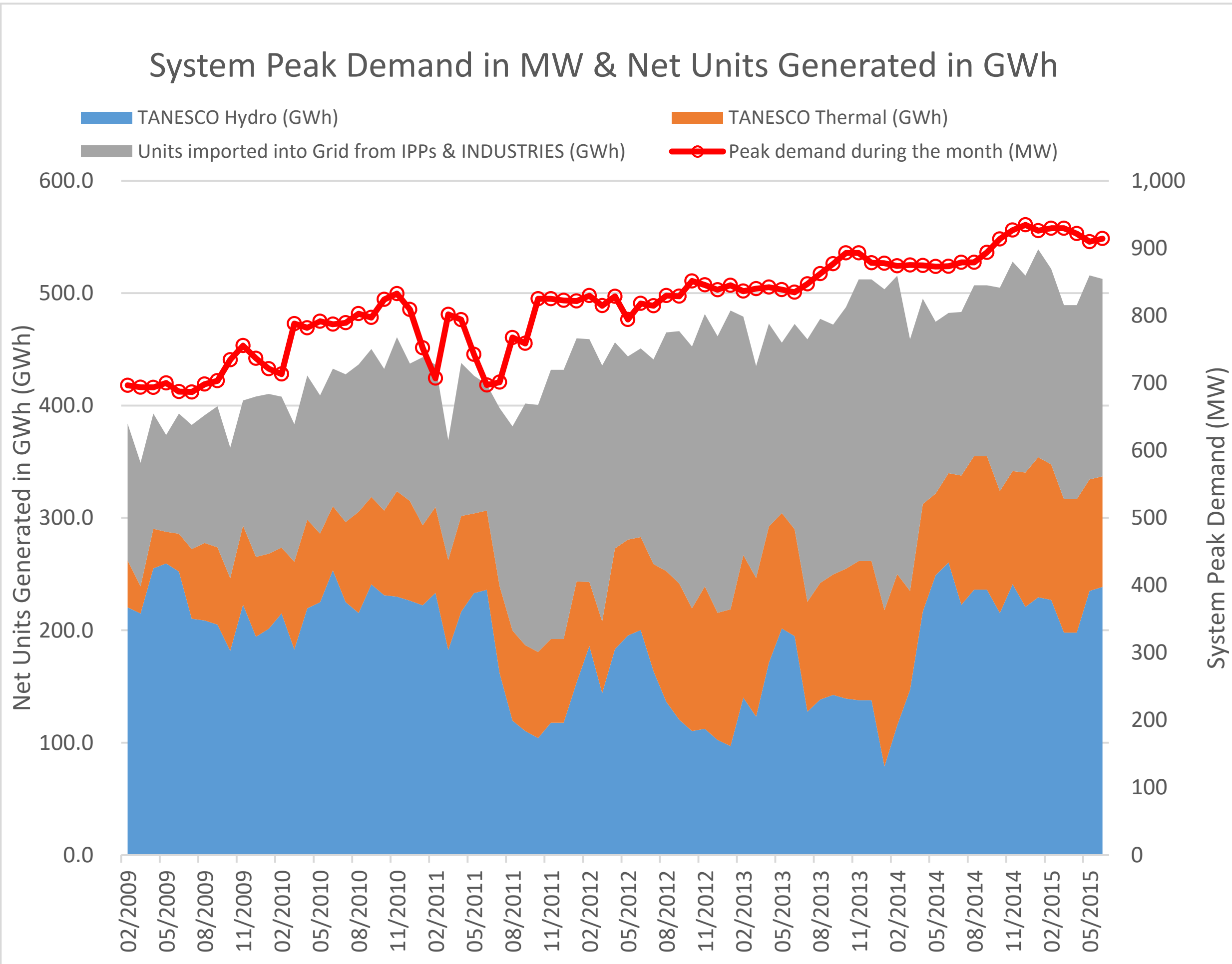
Three large-scale Hydro power plants (HPP) are located in the center of the country, they are Kidatu HPP (4 x 51 MW), Mtera HPP (2 x 40 MW) and Kihansi HPP (3 x 60 MW). The 3 HPPs supply the power through 220 kV transmission lines to three direction, i.e. the east direction of Dar es Salaam (DSM) which is the biggest power demand area in the country, the northwest direction of Shinyanga, Singida, etc. in which several mines are located, and the west direction of Mbeya region which is the biggest city in the west area of the country. Recently, the power by the 3 HPPs supplies mainly to northwest and west regions, since the power generation by thermal power plants in DSM has been increasing gradually.

The power system in DSM is comprising of 132 kV network, which is radial type system from Ubungo 132 kV busbar. In order to raise the reliability of the power system in DSM, ring circuit system by 132 kV has been planned and the associated transmission line projects are being carried out at present.

There are other 5 HPP other than 3 HPP mentioned above in the country. The 5 HPPs are connected to national network system as well. On the other hand, there are 24 Thermal power plants (TPP), including Kinyerezi I TPP (150 MW) commissioned in 2016, in the whole country. Among them, 6 TPPs only are connected to the national network and other 18 TPPs are operated in their own isolated systems, located mainly in west and south area, as shown in Figure 9.1.1-1.

Tanzania borders on 8 countries. As of 2015, the following power exchange between countries has been conducted.

・ Uganda by 132 kV (Kagera region)
・ Zambia by 66 kV (Sumbawanga region)



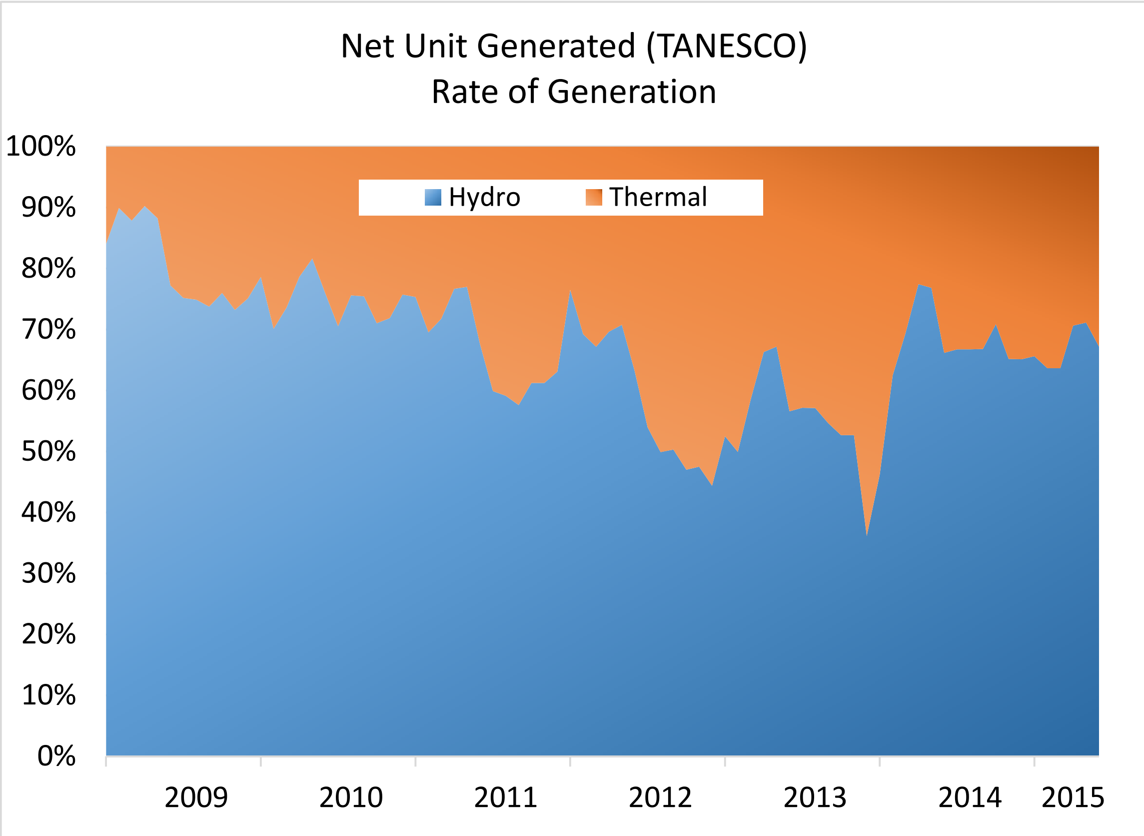
Source: Study team based on TANESCO data

Figure 9.1.1-2 System peak demand (MW) and Generated power by Unit (GWh)

Figure 9.1.1-2 shows System peak demand in MW and Net units generated in GWh from Februay 2009 to May 2015. The peak demand in December 2014 was 935 MW, while 755 MW in November 2009. Thus, the average rate of the growth is 4.7% per year for the five years.

The procured power from IPP and industries varies in accordance with the power generation by TANESCO's HPP.

The rate of TANESCO's HPP and TPP in a month from January 2009 to June 2015 is shown in Figure 9.1.1-3. The peak generation of HPPs in each year is in April. The percentage of HPP is gradually decreased year by year from 2009 to 2013. However, it recovered in 2014.



Source: Study team based on TANESCO data

Figure 9.1.1-3 Rate of Power Generation by TANESCO's HPP and TPP

The power factor data is shown in Table 9.1.1-1. These data was recorded by Study team at 3 substations in DSM in 2013 and 2014. The average of the data is almost lag 0.9. In order to reduce the loss of the system, the power factor should be close to 1.0 as possible as it can. Power capacitors could be effective for improvement of the power factor. On the other hand, there is also one of the solution from customer's side. For instance, an incentive (like less tariff according to the power factor value) is given to customers if the customers improve the power factor by themselves.

Table 9.1.1-1 Measurement of Power Factor

S/S Name	Date	Time	Feeder Name	Voltage (kV)	Current (A)	Active Power (MW)	Reactive Power (Mvar)	Power Factor	Average Power Factor
Ubungo	March 04, 2013	14:20	Ubungo Gas Plant (105 MW)	220		88	34	0.93	
			Makumbusho	132		50	30	0.86	
			Mlandizi	132		44	-15	0.95	
			Ilala 2	132		53	37	0.82	
			Ilala 1	132		42	25	0.86	
			Factory Zone 3	132		22	14	0.84	
Makumbusho	March 08, 2013	11:00	132/33 kV T2 Secondary	33		29.18	15.43	0.88	
			F2 (Oyster Bay)	33		9.42	5.43	0.87	
			F3 (Industry)	33		7.53	3.69	0.90	
			33/11 kV T4 Secondary	11		4.79	2.10	0.92	
Ilala	March 18, 2013	11:27	Tanzania Oxigen Ltd. (TOL)	33	290	14.6	7.9	0.88	
			132/33 kV T1 Secondary	33	1,127	53.4	26.7	0.89	0.89972
			132/33 kV T2 Secondary	33	780	42.5	18.7	0.92	↓
			132/33 kV T5 Secondary	33	800	42.0	19.0	0.91	**0.90**
			33/11 kV T4 Secondary	11	590	10.0	4.8	0.90	
			33/11 kV T5 Secondary	11	600	10.0	4.8	0.90	
	March 27, 2013	11:05	132/33 kV T1 Secondary	33	985	47.6	26.7	0.87	
			132/33 kV T2 Secondary	33	590	32.0	14.5	0.91	
			132/33 kV T5 Secondary	33	800	31.0	14.5	0.91	
			33/11 kV T4 Secondary	11	560	9.5	4.6	0.90	
			33/11 kV T5 Secondary	11	560	9.5	4.7	0.90	
	August 29, 2014	11:16	132/33 kV T1 Secondary	33		56.8	16.7	0.96	
			132/33 kV T2 Secondary	33	710	38.0	11.0	0.96	
			132/33 kV T5 Secondary	33	710	38.0	11.0	0.96	
			33/11 kV T4 Secondary	11	590	10.0	4.9	0.90	
			33/11 kV T5 Secondary	11	590	10.0	4.8	0.90	

Source: Measured by Study team in TANESCO substations

9.1.2 Existing Transmission Lines

List of existing transmission lines 220 – 66 kV as of November 2016 is shown on the Table 9.1.2-1.

Table 9.1.2-1 List of Existing Transmission Line as of November 2016

Rated Voltage (kV)	from	to	Route Length (km)	No. of Towers	No. of Circuits	Conductor Code Name	Conductor Aluminum Sectional Area (mm^2)	Year Commi-ssioned	Current Rating*1 (Amps)	Full Rating (MVA)	Normal Rating*2 (MVA)
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 Above Table	No. of Lines Above Table	Remarks
220kV	2,745	22	
132kV	1,626	24	(2 x submarine cables included)
66kV	580	8	
Total:	4,950	54	

Source: Study team based on TANESCO data

The main features of ACSR conductor and XLPE cable on each voltage are shown in Table 9.1.2-2.

Table 9.1.2-2 ACSR conductor and XLPE cable properties on each voltage

Voltage	Conductors	Code	Cross Section (mm^2)	*Capacity (MVA)	Remarks
220 kV	ACSR	Bluejay	565	333	
		Bison	350	207	
		Pheasant	644	362	
		Rail	483	303	
132 kV	ACSR	Wolf	150	74	
		Hawk	241	121	
		Tiger	130	66	
	XLPE	—	300/400	143	Submarine cables
		—	95	52	
66 kV	ACSR	Wolf	150	37	
		Rabbit	50	18	

*Capacity is 80% of the full rating of the conductor. (TANESCO standard)

Source: Study team based on TANESCO data

As shown in Table 9.1.2-2, ACSR Hawk sectional size adopted on 132kV transmission lines is 240mm^2, which was fair enough when the lines were built. However, it is rather small transmission capacity at the moment in these days. Although on 220kV transmission lines, only single conductor is so far adopted, in the future plan a multiple conductor will be deployed such as Twin, Quadruple bundle phase conductor.

9.1.3 Existing Substation Equipment

There are 49 substations with 66 kV above voltages in the national network as of 2015, as shown in Figure 9.1.1-1. Transformers and Reactive power compensators in the network are summarized with voltage and capacity basis in Table 9.1.3-1 and 9.1.3-2, respectively. (Note; the data are not completed since there are equipment with no data in substations.)

Table 9.1.3-1 List of Transformers

Primary Voltage (kV)	Secondary Voltage (kV)	Tertiary Voltage (kV)	Unit Capacity (MVA)	Units	Total Capacity (MVA)	Remarks
220	132	33	45	1	45	
			60	6	360	
			90	1	90	
			150	2	300	
		—	60	2	120	
	66	—	30	2	60	Babati
	33	33	35	2	70	Tertiary winding : Shunt reactors
	33	—	10	1	10	
			15	2	30	
			20	2	40	
			22.5	2	45	
			22.5	2	45	For Shunt reactors
			30	5	150	
	11	—	45	2	90	3 x 15 MVA single phase transformer
		—	60	4	240	For 51 MW Generators
		—	71	3	213	For generators
	6.6	—	15	1	15	Bulyanhulu

Primary Voltage (kV)	Secondary Voltage (kV)	Tertiary Voltage (kV)	Unit Capacity (MVA)	Units	Total Capacity (MVA)	Remarks
132	66	33	15	1	15	
	66	—	15	1	15	
		—	20	1	20	
	33	11	120	2	240	For generators
	33	—	5	2	10	
			10	9	90	
			15	7	105	
			20	6	120	
			30	2	60	
			45	3	135	
			50	2	100	
			60	4	240	
			90	3	270	
	11	—	40	2	80	
			56	3	168	For generators
			60	2	120	
			65	4	260	For generators
	6.6	—	45	1	45	
66	33	11	8.4	5	50.4	
	33	—	5	5	25	
			10	2	20	
	11	—	5	2	10	
33	33	—	20	2	40	Voltage regulating transformer
	11	—	5	1	5	For generators
			12.5	2	25	
11	11	—	2	2	4	For phase shifting
Total Number and Capacity				**121**	**4,195.4**	

Source: Study team based on TANESCO data

Table 9.1.3-2 List of Reactive Power Compensators

Equipment	Voltage (kV)	Capacity (Mvar)	Units	Total Capacity (Mvar)
Static var Compensator	220	**-35 to +30**	2	—
Fixed Series Compensator	220	91	1	**91**
Shunt Reactor	220	15	2	30
		60	7	420
		20	5	100
		10	1	10
	132	5	1	5
	33	10	10	100
	11	35	1	35
	Total Number and Capacity		**27**	**700**
Power Capacitor	33	2.5	2	5
		5	8	40
		10	6	60
		18.3	4	73.2
	Total Number and Capacity		**20**	**178.2**

Source: Study team based on TANESCO data

9.1.4 Comments on Existing Transmission Facilities

(1) Heavy Concentration in Ubungo premise

In Ubungo premise, there are so many facilities congested, Thermal plants, 220, 132, 33 & 11 kV Transmission, Substation, Grid Control Center and TANESCO headquarter. Hence, No. 2 or No. 3 Ubungo substation(s) should be considered to avoid too much concentration and for a risk hedge.

(2) Configuration of Transmission lines

There are 16 km of the transmission towers with double circuit in the present network, i.e. it is only 0.3% in the network. This results in shutdown directly in the case of a fault of the line, i.e. no flexible operation, no alternative operation and so on. Hence, the transmission towers with double circuit should be considered for future plan from the power stability of the system point of view.

(3) Design Criteria

Up to now, as most of Power Grid Systems have been built by the several countries' aids, no standardization is employed by TANESCO. That results in a difficulty in maintenance & operation work. It is advisable for TANESCO to equip a design codes/standards on each transmission voltage.

(4) Management System of Drawings and Documents

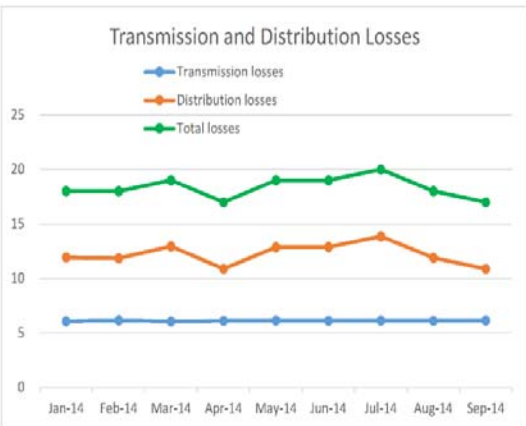
At present, it is very difficult to trace drawings and documents for the operating equipment, such as specifications, maintenance manuals, the maintenance records and other information of main equipment. These drawings and documents are mandatory for the preparation of repairing works, replacement works, expansion works or other required works for the present equipment and/or system. Hence, TANESCO should settle the suitable management system or the filing system of the drawings and documents to keep the data latest in all the times.

(5) Future Scheme

In addition to existing 220kV systems, 400kV systems are forthcoming. TANESCO should be well prepared for establishment and organization (maintenance & operation) of 400 kV system.

(6) Transmission and Distribution Loss

Figure 9.1.4-1 shows monthly Trans-mission and Distribution losses during January to September 2014. (Source: Report of the Controller and Auditor Generation the Financial Statements of TANESCO for the year ended 31 December 2013, hereinafter as the Report) Total losses was 17% to 19%, comprising of approx. 6% of Transmission losses and approx.



Source: Report of the Controller and Auditor Generation the Financial Statements of TANESCO for the year ended 31 December 2013)

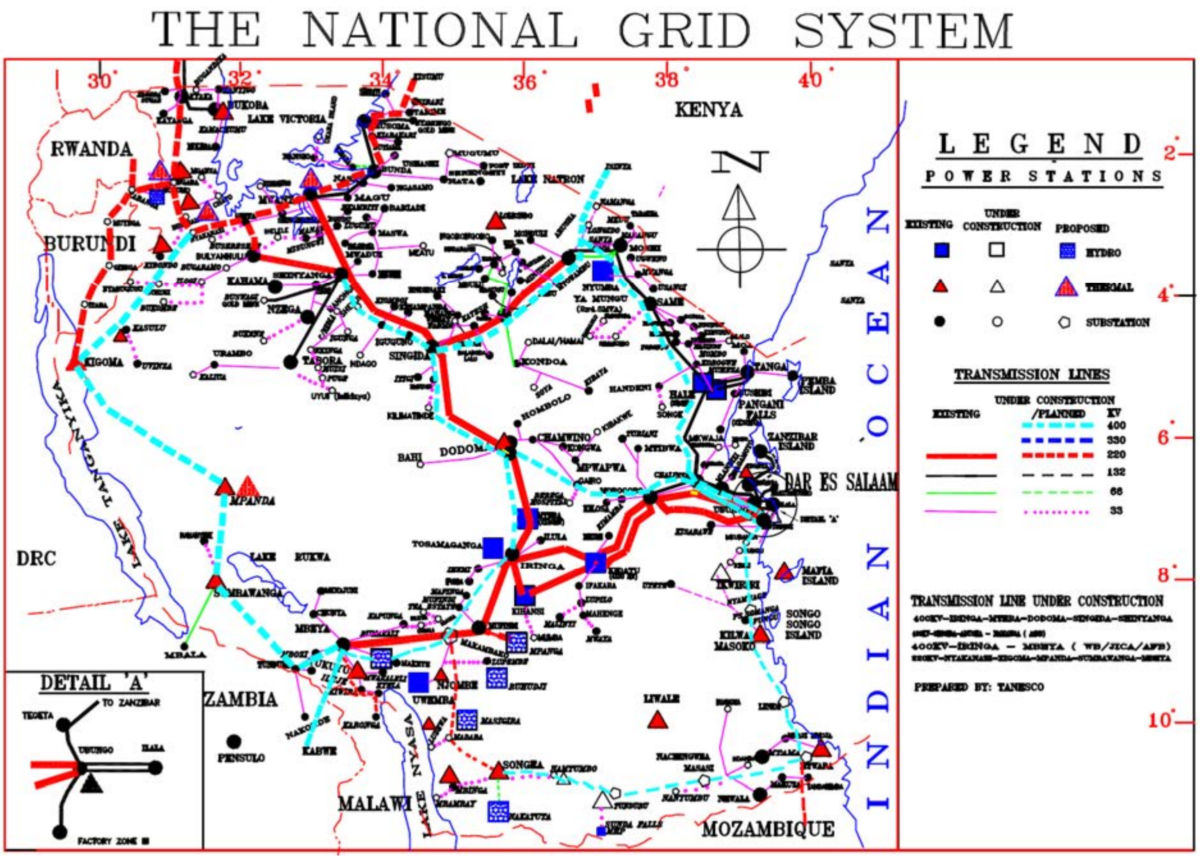
Figure 9.1.4-1 Transmission and Distribution Loss during January to September 2014

11% to 14% of Distribution losses. The value of 17% to 19% is relatively high, comparing other countries. For reference, the total losses in 2013 in Indonesia was 10.1% (Transmission losses: 2.33% and Distribution losses: 7.77%). The losses are consisting of technical and non-technical ones. For technical losses, there are several countermeasures such as raising voltage, no overloading, etc. However, according to the Report, a total of 161,877 customers countrywide were inspected and out of which 4,749 customers had metering discrepancies. Thus, a total of TSH 12,913 million was established as revenue loss. In this connection, TANESCO continued to carry out a massive campaign against energy theft, called as "Kampeni Kamata Wezi wa Umeme (KAWEU)" in Dar es Salaam region and then rolled-out to all the remaining regions.

9.2 On-going / Under Planning Development Plan

9.2.1 Future Development of National Grid Systems

The National Grid System with future development as of 2015 is shown in Figure 9.2.1-1, which is made by TANESCO.



Source: TANESCO

Figure 9.2.1-1 The National Grid System with Future Development

The maximum transmission voltage will be raised to 400 kV from 220 kV for the whole national network as shown in Figure 9.2.1-1.

Power exchange interconnection with neighboring countries is also considered as follows;-

- Through 400 kV

Kenya and Zambia (ZTK project), Mozambique

- Through 220 kV

  Uganda, Malawi, Rwanda and Burundi (through Rusumo Hydro power station)

Since the interconnection between countries has several advantages such as flexibility of network operation, exchanging power in case of emergency, etc., the discussion between countries is being continued including standardization of the specification of the transmission lines and substations.

9.2.2 Transmission Line Projects in progress

Table 9.2.2-1 shows the transmission line projects in progress in the country as of November 2016.

Table 9.2.2-1 Transmission Line Projects in Progress

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Commis-sioned	Current Rating*1 (Amps)	Full Rating (MVA)	Normal Rating*2 (MVA)
						Code Name	No. of Cond. per Phase	Alum. Sectional Area (mm2)				
132	FZ III	FZ II	TEDAP	7.4	1	Rail	1	483	2016	993	227	182
132	FZ II	Mbagala	TEDAP	16.2	1	Rail	1	483	2016	993	227	182
132	Mbagala	Kurasini	TEDAP	15.1	1	Rail	1	483	2016	993	227	182
132	Kurasini	Ubungo	TEDAP	13	1	Rail	1	483	2016	993	227	182
132	Ilala	New City Centre	Over head line	1.3	1	AAAC	1	281	2016	683	156	125
			Under ground cable	1.5	1	XLPE Alum	1	1,000	2016	935	0	0
132	New City Centre	Makumbusho		8	1	XLPE Alum	1	1,000	2016	935	214	171
400	Iringa	Dodoma	Backbone Project	237	2	Bluejay	2	564	2016	1,092	3,026	2,421
400	Dodoma	Singida	Backbone Project	210	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	Makambako	Madaba		162	1	Bluejay	2	564	2016	1,092	832	666
220	Madaba	Songea		171	1	Bluejay	2	564	2016	1,092	832	666
132	Morogoro	Mtibwa	MCC, F/S completed	88	1	Hawk	1	242	2016	659	151	121
400	Kinyerezi	Chalinze	Contract before Aug. 2015	138	2	Bluejay	4	564	2017	1,092	6,052	4,842
400	Chalinze	Segera	Ditto	175	1	Bluejay	4	564	2017	1,092	3,026	2,421
400	Segera	Arusha	Ditto	366	1	Bluejay	4	564	2017	1,092	3,026	2,421
220	Wind Project	Singida	Ditto	10	1	Bluejay	2	564	2017	1,092	832	666
220	Shinyanga	Geita	Ditto	240	2	Bluejay	1	564	2017	1,092	832	666
220	Kibaha-Pai	Bagamoyo (Zinga)	Ditto	45	1	Bluejay	1	564	2017	1,092	416	333
220	Bagamoyo (Zinga)	Kibaha-Pai	Ditto	45	1	Bluejay	1	564	2017	1,092	416	333
220	Segera	Tanga	Ditto	76	2	Bluejay	2	564	2017	1,092	1,664	1,332

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

Source: TANESCO

Note;

1) TEDAP (Tanzania's Energy Development and Access Expansion Project) is the projects under World Bank assistance.
2) New City Centre (NCC) substation and associated transmission line projects are under Finland assistance.

In Dar es Salaam city, 132 kV system is going to form ring circuits by 132 kV transmission lines, as the present system is formed by radial system from Ubungo substation, as mentioned in 9.1.1. New 132 kV transmission lines are being constructed as indicated in Table 9.2.2-1, the following ring circuits will be formed. Consequently, reliable power supply system will be expected to be reliable power supply.

- 132 kV Southwest ring;

  Ubungo - FZ III (Kipawa) - FZ II (Gongolamboto) - Mbagala - Kurasini - Ubungo

- Southeast ring;

  Ubungo - Ilala - New City Centre - Makumbusho - Ubungo

In addition, the following 400 and 220 kV transmission line projects have already been started;-

- 400 kV Backbone transmission line project (BTLP) (funded by World Bank)
  Iringa - Dodoma - Singida - Shinyanga
- 400 kV Zambia - Tanzania - Kenya (ZTK) transmission line project (co-operative funded by JICA and others)
  Isinya (Kenya) - Arusha – Singida
  (400 kV Mbeya to Nakonde (Zambia) is under planned.)
- 400/220 kV Kinyerezi to Arusha line project
  400 kV; Kinyerezi – Chalinze – Segera – Arusha lines
  220 kV; Bagamoyo and Tanga

It is noted that 220 kV interconnection between Tanzania and Malawi is also under planning via Mbeya/Kyela substations.

9.2.3 Development Plan

In accordance with Clause 8.3 optimal power development plan, optimum power grid system is studied.

(1) Development plan to be considered

1) Items to be considered

The following items shall be considered for future development plans.

- Capacity of equipment/facilities
  - Transmission lines
    Purpose: Study of capacity to deliver for substations to be connected and number of circuits
    a. Voltage level (Standard voltage: 400 kV, 220 kV and 132 kV)
    b. Standard conductors
    c. Number of conductors per phase (Single, Twin, Quadruple and Octuple bundle)
    d. Permissible capacity (Normal capacity and emergency capacity)
  - Transformers
    Purpose: Study of unit capacity and number of Transformers
    Unit capacity and number of Transformers shall be decided by the demand growth, and an additional transformer for future increased demand is basically not required in minimum 5 years.

- Coefficient of equipment/facilities
  Purpose: Study of the operating voltage (voltage drop), losses and Stability of the system
  - Transmission lines
    a. Distance

b. Resistance
c. Reactance
d. Susceptance

- Transformers
  a. Impedance (Reactance)

➢ Reliability of transmission lines

a. Whether or not, necessary power can be transmitted in normal operation without problem? (Not only capacity but also from voltage level point of view, conductor size and number of circuits to be studied)
b. Whether or not, each generator can be operated in normal operation within the range of Steady-state stability?
c. Whether or not, the loss of the generator power is less than 5% of the nationwide system demand in case of failure of one transmission line for the power plant? (Redundant system to be considered as necessary)
d. Whether or not, the power can be transmitted, in case of one of the redundant lines shut-down by failure, by the remaining line within the emergency capacity of the line?
e. Whether or not, the power can be transmitted, in case of one of the redundant lines shut-down by failure, by the remaining line within permissible voltage drop? (Application of reactive power compensators to be studied as necessary)

2) Confirmation of Health of Power System

In the preceding section, items to be considered for future development of transmission system are described. In particular the health of a power system is confirmed using the software PSS®E as a power system analysis as the description below. The criteria used in the study are based on PSMP2012.

➢ Health at Normal Operating Conditions (N-0)

Power Flow Analysis is carried out for the state where the transmission infrastructure is entirely available, and it is confirmed whether overload is not occurred in the transmission lines or the transformers, and voltage is not deviated from the acceptable range.

a. Overload

It is confirmed whether power flow (MVA) of each transmission line is within transmission capacity (80% of the maximum capacity). Moreover, it is confirmed whether power flow (MVA) of each transformer is within transformer rated capacity.

b. Voltage

It is confirmed all the bus voltage is within the acceptable range (95% - 105%) at the normal system conditions.

In this stage, if there is a deviation from criterion on overload or voltage, the countermeasures have to be studied.

- Health at Contingency Operation Conditions (N-1)

  It is confirmed whether one single component failure in the system does not make overload of transmission line(s) or transformer(s), or does not make the deviation(s) of voltage from the acceptable range. The N-1 analysis function of PSS®E is used for this confirmation.

  a. Overload

     It is confirmed whether power flow (MVA) of each transmission line is within emergency transmission capacity (120% of the normal capacity). Moreover, it is confirmed whether power flow (MVA) of each transformer is within transformer rated capacity.

  b. Voltage

     It is confirmed whether all the bus voltage is within the acceptable range (90% - 110%) at the contingency system conditions.

     In this stage, if there is a deviation from criterion on overload or voltage, the countermeasures have to be studied.

- Short Circuit Study

  A short circuit study is performed to confirm whether fault currents at all buses in the grid are well below the practical switchgear ratings at each voltage level.

(2) Specification of Transmission lines

Table 9.2.3-1 shows the conductors which are adopted in the TANESCO projects in progress or planned. Hence, these conductors are considered as standard specifications for future projects. As shown in the table, 400 and 220 kV transmission lines utilize multiple conductor per phase.

Table 9.2.3-1 Specifications of Conductors

Parameter	400kV			220KV
Conductor	ACSR	ACSR	ACSR	ACSR
Code Name	Bluejay	Bluejay	Bluejay	Bluejay
Size (MCM/mm2)	1,113/564	1,113/564	1,113/564	1,113/564
No. of Circuit & Type	2-cct Vert.	2-cct Vert.	2-cct Vert.	2-cct Vert.
No. of Cond. Per phase	8	4	2	2
Current/conductor (Amp)	1,092	1,092	1,092	1,092
①Full Rating(MVA)	6,052	3,026	1,513	832
②Normal Rating (MVA) = ① x 80%	4,842	2,421	1,210	666
③Emergency Rating (MVA) = ② x 120%	5,810	2,905	1,453	799

Source: Study team based on TANESCO data

(3) Specifications of Substations

Substations should be basically designed by their demand, in consideration of the equipment procured in the market. The following specifications are the standard model for the future plan.

- Busbar configuration
  a. 400 kV
  Busbar configuration of 400 kV Arusha substation (ZTK project) should be of one and half busbar system, which is as same as the one in Isinya substation of ZTK project in Kenya, from the reliability point of view. For other 400 kV substation, double busbar system with bypass circuit should be of standard, which the circuit breaker can be maintained without shutdown. However, one and half busbar system could be applied when the capacity of the substation increases and busbar material (equivalent to the breaking capacity of the Bus coupler circuit breaker) cannot be purchased in the market.
  b. 220 kV
  Standard system should be Double busbar configuration.

- Transformers
  a. 400/220 kV: Maximum capacity rating is 1,000 MVA. In addition, 500 MVA and 250 MVA ratings can be also standard capacity.
  b. 220/132 kV: Maximum capacity is 400 MVA. In addition, 200 MVA and 100 MVA transformers can be also standard capacity.
- Circuit Breakers (CB)
  a. Rated current: CB should have enough capacity for the maximum current of the circuit.
  b. Rated interrupting current
     - ✓ 400 kV ：40 kA
     - ✓ 220 kV ：40 kA
     - ✓ 132 kV ：31.5 kA

  The results of the short circuit calculation in which all the future development plan until 2040 have been reflected is shown in Table 9.2.3-2 (next page).

- Reactive power compensators
  The capacity should be selected by the results of the System analysis. The capacity and the year required in the grid are indicated on Table 9.2.3-8 to 12 in next section “(4) Development Plan”.

Table 9.2.3-2 Short Circuit Fault Current at Substation bus in 2040

Name of Substation Bus **400 kV**	Fault Current (kA)	Name of Substation Bus **220 kV**	Fault Current (kA)	Name of Substation Bus **220 kV**	Fault Current (kA)
Arusha	5.8	Arusha	8.3	Ruhugji	6.1
Bagamoyo	13.8	Babati	4.1	Rumakali	5.8
Chalinze	18.8	Bagamoyo	23.0	Rusmo	4.2
Dodoma	7.9	Bulyanhulu	4.9	Segera	8.7
Future CGT1	11.5	Bunda	4.0	Shinyanga	11.3
Future CGT3-1	29.1	Buswagi	4.4	Singida	8.5
Future CGT3-2	29.1	Chalinze	9.0	Songea	5.8
Future CGT3-3	25.3	Dodoma	7.2	Songwe	4.6
Future CGT3-4	25.0	Geita	5.5	South Dar es Sallam	21.0
Iringa	10.0	Geothermal	8.4	Southeast Dar es Sallam	16.7
Isinya	3.8	Ibosa	3.6	Tabora	9.0
Kigoma	4.4	Iringa	12.3	Tanga	5.2
Kinyerezi	23.6	Kibaha-branch1	7.0	Tavera3	6.9
Kisada	13.9	Kibaha-branch2	12.3	Ubungo	25.4
Kiwira	11.5	Kidatu	5.7	Uyole	16.0
Lindi	14.8	Kigoma	4.4	West Dar es Salaam	25.6
Madaba	14.1	Kihansi	5.3	Zinga	16.8
Masasi	8.0	Kikonge	5.8		
Mbeya	14.2	Kinyerezi	32.8		
Mkuranga	20.1	Kisingo	6.5		
Mnyera	6.9	Kwanini	7.7		
Mozambique	8.3	Kyaka	2.8		
Mpanda	6.6	Lusu	7.6		
Mpanda-Tabora SwS	6.2	Madaba	12.0		
Mtwara	12.7	Makanbako	5.0		
Mwanza	5.6	Masigira	4.1		
Ngaka	11.4	Mbeya	20.7		
Nyakanazi	3.6	Mbeya	13.3		
Rukwa	8.4	Mkuranga	20.9		
Segera	8.7	Mlandizi	11.2		
Shinyanga	6.7	Mnyera2	11.1		
Singida	7.2	Morogoro	6.1		
Somanga Fungu	36.1	Mpanda	3.0		
Somanga Fungu-Kinyerezi SwS1	20.0	Mtera	4.5		
Somanga Fungu-Kinyerezi SwS2	20.1	Mtwara	8.3		
Somanga Fungu-Kinyerezi SwS3	23.7	Mufindi	4.4		
Somanga Fungu-Mkuranga SwS	20.3	Musoma	3.3		
Songea	11.5	Njiro	8.2		
Stiegler's Gorge	11.9	North Dar es Salaam	20.8		
Sumbawanga	8.8	Nyakanazi	6.2		
Sumbawanga-Mpanda SwS	7.2	Nyamongo	2.6		
Tabora	6.2	Pumbwe	7.7		
Tunduru	6.8	Ruaha2	6.2		

Source: Study team

(4) Development Plan

As the result of the study including the system impact analysis, the development plan of Transmission lines and Substation is shown in the tables every 5 years period.

- The plan of Transmission lines

Table 9.2.3-3 Development plan of Transmission Lines from 2016 to 2020

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating (Amps)	Full Rating (MVA)	Normal Rating (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
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
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
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	Kin-Som SwS1	Kin-Som SwS2		53	2	Bluejay	8	564	2019	1,092	12,105	9,684
400	Kin-Som SwS2	Kin-Som SwS3		53	2	Bluejay	8	564	2019	1,092	12,105	9,684
400	Kin-Som SwS3	Somanga Fungu P/S	210 MW	53	2	Bluejay	8	564	2019	1,092	12,105	9,684
400	Kinyerezi	Kin-Som SwS1		53	2	Bluejay	8	564	2019	1,092	12,105	9,684
220	Arusha	Njiro (Arusha existing)		5	2	Bluejay	4	564	2019	1,092	3,329	2,663
220	Geita	Nyakanazi		130	1	Bluejay	2	564	2019	1,092	832	666
220	Nyakanazi	Rusumo Falls P/S	30 MW	97	1	Bluejay	2	564	2019	1,092	832	666
220	Rusumo Falls P/S	Kyaka	30 MW	150	1	Bluejay	2	564	2019	1,092	832	666
220	Shinyanga	Geita		240	1	Bluejay	4	564	2019	1,092	1,664	1,332
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	Kinyerezi	Chalinze		138	2	Bluejay	4	564	2020	1,092	6,052	4,842
400	Muchuchuma P/S	Madaba	Total 1,500 MW	15	2	Bluejay	2	564	2020	1,092	3,026	2,421
400	Segera	Arusha		366	1	Bluejay	4	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		Bluejay	4	564	2020	1,092	0	0
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	Lusu	Tabora		139	1	Bluejay	1	564	2020	1,092	416	333
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	1	Hawk	2	242	2020	659	301	241
132	Morogoro	Mtibwa		88	1	Hawk	1	242	2020	659	151	121
66	Babati	Mbulu		85	2	Wolf	2	150	2020	406	186	149

Source: Study team

Table 9.2.3-4 Development plan of Transmission Lines from 2021 to 2025

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating (Amps)	Full Rating (MVA)	Normal Rating (MVA)
						Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				
400	Kisada	Iringa		106	2	Bluejay	8	564	2021	1,092	12,105	9,684
400	Kisada	Mbeya		186	2	Bluejay	8	564	2021	1,092	12,105	9,684
400	Lindi	Somanga Fungu		216	2	Bluejay	8	564	2021	1,092	12,105	9,684
400	Mtwara	Namialo(Mozambique)	up to Mozambique border	51	2	Bluejay	2	564	2021	1,092	3,026	2,421
400	Mtwara P/S	Lindi	400 MW	74	2	Bluejay	4	564	2021	1,092	6,052	4,842
220	Mbeya	Mbeya Coal P/S	300MW in 2021	100	2	Bluejay	4	564	2021	1,092	3,329	2,663
400	Somanga Fungu P/S	Somanga P/S(PPP)	300MW	20	2	Bluejay	2	564	2022	1,092	3,026	2,421
400	Kinyerezi	Mkuranga P/S	300 MW	70	2	Bluejay	8	564	2024	1,092	12,105	9,684
220	Zinga P/S	Bagamoyo	200 MW	15	1	Bluejay	2	564	2024	1,092	832	666
400	Chalinze	Bagamoyo		102	2	Bluejay	8	564	2025	1,092	12,105	9,684
400	Kigoma	Mpanda		290	2	Bluejay	8	564	2025	1,092	12,105	9,684
400	Mpanda	Mpa-Sum SwS		119	2	Bluejay	8	564	2025	1,092	12,105	9,684
400	Mpa-Sum SwS	Sumbawanga		119	2	Bluejay	8	564	2025	1,092	12,105	9,684
400	Mtwara	Future CGT1 P/S	1,100MW	50	2	Bluejay	2	564	2025	1,092	3,026	2,421
400	Nyakanazi	Kigoma		317	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
400	Sumbawanga	Mbeya		300	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	Malagarasi P/S(Stage III)	Kigoma	44.7 MW	74	1	Hawk	1	242	2025	659	151	121
66	Mbulu	Karatu		65	2	Wolf	2	150	2025	406	186	149

Source: Study team

Table 9.2.3-5 Development plan of Transmission Lines from 2026 to 2030

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating (Amps)	Full Rating (MVA)	Normal Rating (MVA)
						Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				
400	Kisada	Madaba		243	2	Bluejay	8	564	2026	1,092	12,105	9,684
400	Madaba	Songea		171	2	Bluejay	2	564	2026	1,092	3,026	2,421
400	Masasi	Lindi		141	2	Bluejay	4	564	2026	1,092	6,052	4,842
400	Ngaka P/S	Songea	600MW in 2026	37	2	Bluejay	2	564	2026	1,092	3,026	2,421
400	Songea	Tunduru		230	2	Bluejay	4	564	2026	1,092	6,052	4,842
400	Sumbawanga	Rukwa P/S	300MW in 2026	46	2	Bluejay	8	564	2026	1,092	12,105	9,684
400	Tunduru	Masasi		194	2	Bluejay	4	564	2026	1,092	6,052	4,842
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	(36+52+120) MW	81	1	Bluejay	2	564	2026	1,092	832	666
220	Ibosa P/S (Hydro)	Nginayo P/S (Hydro)	52MW	10	1	Bluejay	1	564	2026	1,092	416	333
132	Kakono P/S (Hydro)	Kyaka	87 MW	39	1	Hawk	1	242	2027	659	151	121
400	Kiwira P/S	Mbeya	400MW in 2028	110	2	Bluejay	8	564	2028	1,092	12,105	9,684
400	Mnyera S/S (new)	Kisada	(668.2+358) MW	180	2	Bluejay	4	564	2028	1,092	6,052	4,842
220	Mbeya	Kyela		106	1	Bluejay	2	564	2028	1,092	832	666
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	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	Geita	Nyakanazi		130	1	Bluejay	2	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	2	242	2030	659	603	482

Source: Study team

Table 9.2.3-6 Development plan of Transmission Lines from 2030 to 2035

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating (Amps)	Full Rating (MVA)	Normal Rating (MVA)
						Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				
220	Taveta 3 P/S (Hydro)	Kisingo P/S (Hydro)	119.8MW	15	1	Bluejay	2	564	2031	1,092	832	666
400	Mkuranga	Mku-Som SwS		92	2	Bluejay	8	564	2032	1,092	12,105	9,684
400	Mku-Som SwS	Somanga Fungu S/S		92	2	Bluejay	8	564	2032	1,092	12,105	9,684
400	Somanga Fungu S/S	Future CGT3-1	4x470 MW	20	2	Bluejay	4	564	2032	1,092	6,052	4,842
220	Ibosa P/S (Hydro)	Lower Kihansi P/S (Hydro)	120MW	55	1	Bluejay	1	564	2032	1,092	416	333
220	Masigira P/S (Hydro)	Madaba	118 MW	73	1	Bluejay	2	564	2032	1,092	832	666
220	Mufindi	Mpanga P/S (Hydro)	160 MW	65	1	Bluejay	2	564	2032	1,092	832	666
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	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	2	Bluejay	4	564	2035	1,092	6,052	4,842
400	Segera	Arusha		366	2	Bluejay	4	564	2035	1,092	6,052	4,842
400	Somanga Fungu S/S	Future CGT3-2	3x470 MW	20	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
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	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	Shinyanga	Geita		240	1	Bluejay	4	564	2035	1,092	1,664	1,332
220	Singida	Babati		150	2	Bluejay	1	564	2035	1,092	832	666
132	Kinyerezi	FZ-II		5	1	Hawk	2	242	2035	659	301	241
132	Kyaka	Kibeta/Bukoba		54	2	Hawk	2	242	2035	659	603	482
66	Babati	Kondoa		85	2	Wolf	2	150	2035	406	186	149

Source: Study team

Table 9.2.3-7 Development plan of Transmission Lines from 2036 to 2040

Rated Voltage (kV)	from	to	Remarks	Route Length (km)	No. of Circuit	Conductor			Year to be Com-missioned	Current Rating (Amps)	Full Rating (MVA)	Normal Rating (MVA)
						Code Name	No. of Cond. per Phase	Aluminum Sectional Area (mm2)				
400	Somanga Fungu	Future CGT3-3	3x470 MW	20	2	Bluejay	4	564	2036	1,092	6,052	4,842
400	Stiegler's Gorge	Chalinze	2 x 1,048 MW	195	2	Bluejay	8	564	2036	1,092	12,105	9,684
220	Kihansi P/S (Hydro)	Upper Kihansi P/S (Hydro)	47MW	10	1	Bluejay	1	564	2036	1,092	416	333
400	Somanga Fungu S/S	Future CGT3-4	3x470 MW	20	2	Bluejay	4	564	2039	1,092	6,052	4,842
400	Chalinze	Dodoma		336	1	Bluejay	2	564	2040	1,092	1,513	1,210
220	Kinyerezi	West DSM		20	1	Bluejay	4	564	2040	1,092	1,664	1,332
220	Lusu	Tabora		139	1	Bluejay	1	564	2040	1,092	416	333
220	Nyakanazi	Rusumo Falls P/S		97	1	Bluejay	2	564	2040	1,092	832	666
220	Rusumo Falls P/S	Kyaka		150	1	Bluejay	2	564	2040	1,092	832	666
220	Shinyanga	Buswagi		108	2	Bluejay	1	564	2040	1,092	832	666
220	Shinyanga	Mwanza		140	2	Bluejay	1	564	2040	1,092	832	666
220	Shinyanga	Lusu		64	1	Bluejay	1	564	2040	1,092	416	333
220	Singida	Shinyanga		200	2	Bluejay	1	564	2040	1,092	832	666

Source: Study team

➢ The plan of Substations

Table 9.2.3-8 Development plan of Substations from 2016 to 2020

Name of Substations	Year	Switchgear Bus Config.: **1-1/2**; One & Half, **DB**; Double Bus, **SB**; Single Bus													Transformer (in MVA)				Reactor (MVA)	STAT-COM (MVA)
		400 kV					220 kV				132 kV				Voltage	Rating	Q'ty	Total MVA		
		Bus Config.	Bay	Line	TR	BC	Bus Config.	Line	TR	BC	Bus Config.	Line	TR	BC	(kV)	(MVA)				
Dodoma	2016	DB		4	3	1	DB		2						400/220	250	2	500	200	
Iringa	2016	DB		2	2	1	DB		2						400/220	250	2	500	100	
Kinyerezi	2016						DB	2												
Morogoro	2016						DB				DB	1						0		
Mtibwa	2016										SB	1			220/132	45	2	90		
Shinyanga	2016	DB		2	2	1	DB		2						400/220	315	2	630	100	
Singida	2016	DB		4		1	DB		4										200	
Kinyerezi	2017							1												
Singida	2017	DB					DB	1												
Kinyerezi	2018							1												
Madaba	2018						DB	2		1										
Makambako	2018						SB	1												
Songea	2018						DB	1		1										
Arusha	2019	1-1/2	4	4	2		DB	4	2	1					400/220	375	2	750	190	
Dodoma	2019	DB					DB	1												
Geita	2019						DB	2		1										
Kin-Som SwS-1	2019	DB		4		1													60	
Kin-Som SwS-2	2019	DB		4		1													60	
Kin-Som SwS-3	2019	DB		4		1													60	
Kinyerezi	2019	1-1/2	7	3	6		DB		5										30	
Kyaka	2019						DB	1	1	1	SB		1		220/132	100	1	100		
Makambako	2019										SB	1								
Nyakanazi	2019	DB					DB	2		1										
Shinyanga	2019						DB	1												
Singida	2019	DB		2			DB												140	
Somanga Fungu	2019	1-1/2	3	4	1		DB		1	1					400/220	125	1	125	30	
Arusha	2020	1-1/2	1	1	1														95	50
Bagamoyo	2020						DB	2	2	1					220/33	90	2	180		
Bunda	2020						DB	2	1	1	SB		1		220/132	100	1	100		
Chalinze	2020	1-1/2	4	4	3		DB		3	1	DB	1	2	1	400/220	150	2	300	190	50
Dodoma	2020	DB			1		DB													50
Iringa	2020	DB		2	1		DB												100	50
Kin-Som SwS-1	2020	DB			1															50
Kin-Som SwS-2	2020	DB			1															50
Kin-Som SwS-3	2020	DB			1															50
Kinyerezi	2020	1-1/2	2	4			DB	2	1										70	
Lusu	2020						DB	1	1	1	SB		1		220/132	100	1	100		
Madaba	2020	DB		2		1														
Mlandizi	2020										SB	2								
Morogoro	2020						DB		2		DB	1	2		220/132	150	2	300		
Mtibwa	2020										SB	1								
Musoma	2020						DB	2	1	1	SB		1		220/132	100	1	100		
Mwanza	2020						DB	2		1										
Mwanza	2020						SB	1												
Nyakanazi	2020						DB		1										50	
Nyamongo	2020						DB	2	1	1	SB		1		220/132	100	1	100		
Segera	2020	1-1/2	2	2	2		DB								400/220	150	1	150	140	50
Shinyanga	2020	DB			1		DB	2												50
Singida	2020	DB			3		DB		2						400/220	250	2	500		50
Somanga Fungu	2020	1-1/2			1		DB		1											50
Tabora	2020						DB	1	1	1	SB		1		220/132	100	1	100		
Tanga	2020						DB	2		1										

Source: Study team

Table 9.2.3-9 Development plan of Substations from 2021 to 2025

Name of Substations	Year	Switchgear Bus Config.: **1-1/2**; One & Half, **DB**; Double Bus, **SB**; Single Bus													Transformer (in MVA)				Reactor (MVA)	STAT-COM (MVA)
		400 kV					220 kV				132 kV				Voltage (kV)	Rating (MVA)	Q'ty	Total MVA		
		Bus Config.	Bay	Line	TR	BC	Bus Config.	Line	TR	BC	Bus Config.	Line	TR	BC						
Kisada	2021	1-1/2	4	4															220	
Lindi	2021	DB		4	1	1	DB		1	1					400/220	125	1	125	170	
Madaba	2021																			
Mbeya	2021	DB		2	2	1	DB	3	2	1					400/220	500	2	1,000	120	
Mtwara	2021	DB		4	1	1	DB		1	1					400/220	125	1	125	60	
Mtwara	2021						DB		1		SB		1		220/132	100	1	100		
Somanga Fungu	2021	1-1/2	1	2															130	
Shinyanga	2022	DB			1		DB		1						400/220	1,000	2	2,000		
Somanga Fungu	2022	1-1/2	1	2																
Mtwara	2023	DB		1																
Bagamoyo	2024						DB	1												
Kinyerezi	2024	1-1/2		2			DB								400/220	500	5	2500	40	
Mkuranga	2024	DB		3	1	1	DB		1	1					400/220	500	1	500	40	
Bagamoyo	2025	DB		2	2	1	DB	2	1						400/220	500	1	500	60	50
Chalinze	2025	1-1/2	1	2			DB		1		DB		1		220/132	90	1	90	60	
Geothermal A	2025						SB	1	1	1										
Kigoma	2025	DB		4	3	1	DB		1	1					400/220	150	1	150	475	50
Kigoma	2025						DB		1						220/132	55	1	55		
Kinyerezi	2025						DB	2												
Kisada	2025	1-1/2			1										400/220	500	1	500		50
Lindi	2025	DB			1															50
Mbeya	2025	DB		2	2		DB	1											190	50
Mkuranga	2025						DB	2												
Mpanda	2025	DB		4	2	1	DB		1	1									250	50
Mpa-Sum SwS	2025	DB		4	1	1													140	50
Mtwara	2025	DB		2	1														20	50
Mwanza	2025	DB		2	3	1	DB		2						400/220	500	2	1,000	90	50
Mwanza	2025						SB		2		SB		2		220/132	200	2	400		
Nyakanazi	2025	DB		2	3	1	DB		2						400/220	250	2	500	200	50
Shinyanga	2025	DB		2			DB												90	
Singida	2025						DB		2						220/132	100	2	200		
Sumbawanga	2025	DB		4	2	1	DB		2	1					400/220	125	2	250	260	50

Source: Study team

Table 9.2.3-10 Development plan of Substations from 2026 to 2030

Name of Substations	Year	Switchgear Bus Config.: **1-1/2**; One & Half, **DB**; Double Bus, **SB**; Single Bus													Transformer (in MVA)				Reactor (MVA)	STAT-COM (MVA)
		400 kV					220 kV				132 kV				Voltage (kV)	Rating (MVA)	Q'ty	Total MVA		
		Bus Config.	Bay	Line	TR	BC	Bus Config.	Line	TR	BC	Bus Config.	Line	TR	BC						
Geothermal A	2026						SB	1												
Kisada	2026	1-1/2		2											400/220	500	1	500	150	
Lindi	2026	DB		2															70	
Lusu	2026						DB		1		SB		1		220/132	100	1	100		
Madaba	2026	DB		4	3		DB		2						400/220	125	2	250	230	50
Masasi	2026	DB		4	1	1	DB		1	1					400/220	125	1	125	170	
Nyamongo	2026						DB		1		SB		1		220/132	100	1	100		
Songea	2026	DB		6	1	1	DB								400/220	125	1	125	220	
Sumbawanga	2026	DB		2																
Tabora	2026						DB		1		SB		1		220/132	100	1	100		
Tunduru	2026	DB		4	1	1	DB		1	1					400/220	125	1	125	220	
Kyaka	2027						DB				SB	1								
Kisada	2028	1-1/2	1	2											400/220	500	1	500	90	
Kyela	2028						DB	1	1	1	DB	2	1	1	220/132	200	1	200		
Mbeya	2028	DB		2			DB	1											70	
Mnyera	2028	DB		2	2	1	DB	1	2	1					400/220	500	2	1,000	90	
Musoma	2028						DB		1		SB		1		220/132	100	1	100		
Songwe A S/S	2028										SB	2	1							
Bagamoyo	2029	DB			1		DB		1						400/220	500	1	500		
Arusha	2030	1-1/2			1				1						400/220	250	1	250		
Bagamoyo	2030	DB					DB	2												
Bunda	2030						DB		1		SB		1		220/132	100	1	100		
Geita	2030						DB	1												
Kyaka	2030						DB		1		SB		1		220/132	100	1	100		
Lindi	2030	DB			1		DB		1						400/220	125	1	125		
Masasi	2030	DB			1		DB													50
Mkuranga	2030	DB			2		DB		2						400/220	500	2	1,000		
Mlandizi	2030						DB	2	2	1	DB		2	1	220/132	100	2	200		
Mnyera	2030						DB	1	1											
Mpanda	2030	DB		2											400/220	125	1	125	90	
Mpa-Tab SwS	2030	DB		4	1	1	DB		1										180	50
Mtwara	2030	DB			1		DB		1						400/220	125	1	125		
Mtwara	2030						DB		1		SB		1		220/132	100	1	100		
Nyakanazi	2030	DB					DB	1												
Shinyanga	2030	DB		2			DB												130	
Somanga Fungu	2030	1-1/2	1		1		DB		1						400/220	125	1	125		
Songea	2030	DB			1				1											50
Tabora	2030	DB		4	3	1	DB		2						400/220	400	2	800	220	50
Tunduru	2030	DB			1		DB													50

Source: Study team

Table 9.2.3-11 Development plan of Substations from 2031 to 2035

Name of Substations	Year	Switchgear Bus Config.: **1-1/2**; One & Half, **DB**; Double Bus, **SB**; Single Bus													Transformer (in MVA)				Reactor (MVA)	STAT-COM (MVA)
		400 kV					220 kV				132 kV				Voltage	Rating	Q'ty	Total MVA		
		Bus Config.	Bay	Line	TR	BC	Bus Config.	Line	TR	BC	Bus Config.	Line	TR	BC	(kV)	(MVA)				
Mnyera	2031																			
Tanga	2031						DB		1		SB		1		220/132	100	1	100		
Arusha	2032	1-1/2	1		1				1						400/220	250	1	250		
Lusu	2032						DB		1		SB		1		220/132	100	1	100		
Madaba	2032						DB	1												
Mkuranga	2032	DB		2															60	
Mku-Som SwS	2032	DB		4	1															
Mufindi	2032						SB	1												
Somanga Fungu	2032	1-1/2	2	4															60	
Mbeya	2033	DB					DB	1												
Mnyera	2033	DB			1		DB	1							400/220	500	1	500		
Mwanza	2033	DB			1		DB		1						400/220	500	1	500		
Mwanza	2033						SB		1		SB		1		220/132	200	1	200		
Nyamongo	2033						DB		1		SB		1		220/132	100	1	100		
Tabora	2033						DB		1		SB		1		220/132	100	1	100		
Chalinze	2034	1-1/2					DB		1		DB		1							
Madaba	2034						DB	1												
Nyakanazi	2034	DB			1		DB		1						400/220	250	1	250		
Shinyanga	2034						DB		2						220/132	200	2	400		
Songwe A S/S	2034										SB	1								
Songwe B S/S	2034										SB	1	1							
Arusha	2035	1-1/2	1	2	1														190	140
Bulyanhulu	2035						DB	2												
Bunda	2035						DB	2												
Chalinze	2035	1-1/2	2	4			DB				DB								270	
Geita	2035						DB	1												
Kigoma	2035	DB					DB		1						400/220	150	1	150		
Kinyerezi	2035	1-1/2			1		DB	2	1											
Kyaka	2035						DB				SB	2								
Mkuranga	2035	DB			3		DB		1						400/220	500	1	500		225
Morogoro	2035						DB		1		DB		1		220/132	150	1	150		
Mpanda	2035	DB			1		DB		1						400/220	125	1	125		
Mtibwa	2035										SB		1						60	
Mtwara	2035	DB					DB		1		SB		1		220/132	100	1	100		
Musoma	2035						DB	2												
Mwanza	2035	DB			1		DB	1												25
Nyamongo	2035						DB	2												
Segera	2035	1-1/2	3	4	2		DB								400/220	150	1	150	280	50
Shinyanga	2035	DB			2		DB	3	1											55
Singida	2035						DB		2											
Somanga Fungu	2035	1-1/2	2	4															180	
Sumbawanga	2035	DB			1		DB		1						400/220	125	2	250		
Tabora	2035	DB			1															25

Source: Study team

Table 9.2.3-12 Development plan of Substations from 2036 to 2040

Name of Substations	Year	Switchgear Bus Config.: **1-1/2**; One & Half, **DB**; Double Bus, **SB**; Single Bus													Transformer (in MVA)				Reactor (MVA)	STAT-COM (MVA)
		400 kV					220 kV				132 kV				Voltage (kV)	Rating (MVA)	Q'ty	Total MVA		
		Bus Config.	Bay	Line	TR	BC	Bus Config.	Line	TR	BC	Bus Config.	Line	TR	BC						
Chalinze	2036	1-1/2	1	2			DB				DB								120	
Lusu	2036						DB		1		SB		1		220/132	100	1	100		
Masasi	2036	DB			1		DB		1						400/220	125	1	125		
Musoma	2036						DB		1		SB		1		220/132	100	1	100		
Somanga Fungu	2036	1-1/2	1	2																
Songea	2036	DB			1		DB								400/220	125	1	125		
Tanga	2036						DB		1		SB		1		220/132	100	1	100		
Tunduru	2036	DB			1		DB		1						400/220	125	1	125		
Arusha	2037	1-1/2	1		1				1						400/220	250	1	250		
Kyaka	2037						DB		1		SB		1		220/132	100	1	100		
Mbeya	2037	DB			1		DB		1						400/220	500	1	500		
Mwanza	2037						SB		1		SB		1		220/132	200	1	200		
Nyamongo	2037						DB		1		SB		1		220/132	100	1	100		
Tabora	2037						DB		1		SB		1		220/132	100	1	100		
Shinyanga	2038						DB		1						220/132	200	1	200		
Chalinze	2039	1-1/2	1		1		DB		1		DB									
Nyakanazi	2039	DB			1		DB		1						400/220	250	1	250		
Somanga Fungu	2039	1-1/2	1	2																
Arusha	2040	1-1/2	1		3															355
Bagamoyo	2040	DB			1		DB								400/220	500	1	500		60
Buzwagi	2040						DB	2												
Chalinze	2040	1-1/2	2	1	4		DB		1		DB		1						75	580
Dodoma	2040	DB		2	4		DB												150	480
Kigoma	2040	DB			1															
Kin-Som SwS-1	2040	DB			5															655
Kin-Som SwS-2	2040	DB			2															240
Kin-Som SwS-3	2040	DB			1															135
Kinyerezi	2040	1-1/2	2		5		DB	1												550
Kisada	2040	1-1/2	2		4															485
Kyaka	2040						DB	1			SB									
Lindi	2040	DB			1															15
Lusu	2040						DB	1												
Mbeya	2040	DB			2															290
Mkuranga	2040	DB			2															275
Mku-Som SwS	2040	DB			4															520
Mlandizi	2040						DB		1		DB		1		220/132	100	1	100		
Mnyera	2040	DB			1															40
Mpanda	2040	DB			3															330
Mpa-Sum SwS	2040	DB			4															585
Mpa-Tab SwS	2040	DB			1		DB		1											115
Mtwara	2040	DB			1															30
Mwanza	2040	DB			2		SB	2												230
Nyakanazi	2040	DB			2		DB	1												175
Segera	2040	1-1/2	1		2		DB													220
Shinyanga	2040	DB			3		DB	7												430
Singida	2040	DB			2		DB		2											280
Somanga Fungu	2040	1-1/2			1															90
Songea	2040	DB			1				1											50
Sumbawanga	2040	DB			5															635
Tabora	2040	DB			5		DB	1	1						400/220	400	1	400		455

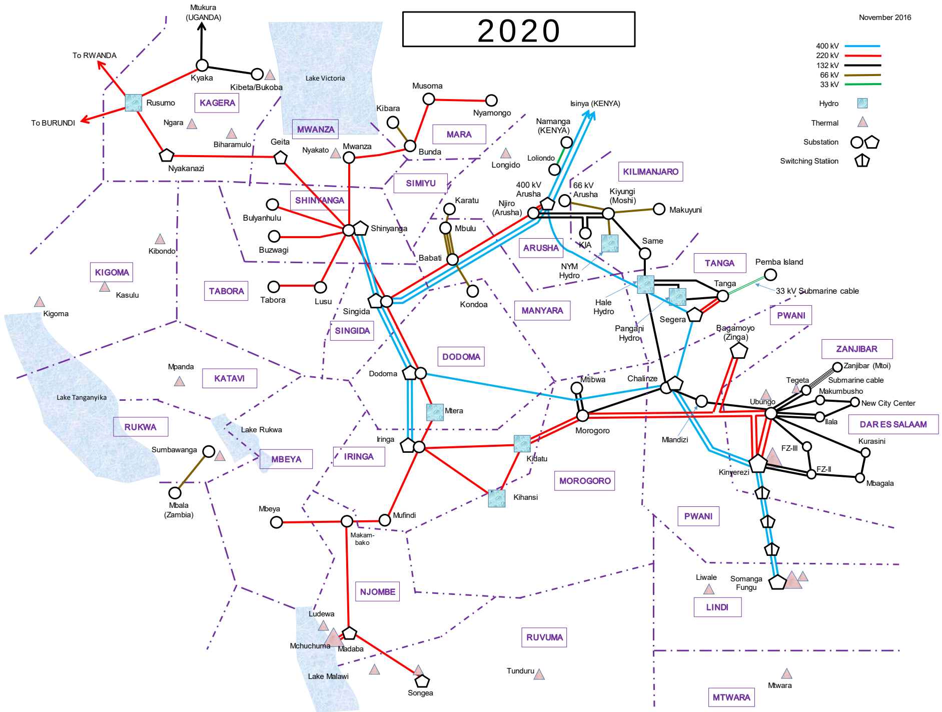
Source: Study team

9.2.4 National Grid System based on System Analysis

(1) National Grid System

National Grid Systems are shown in Figures 9.2.4-1 to 10 every 5 years period from 2020 to 2040.

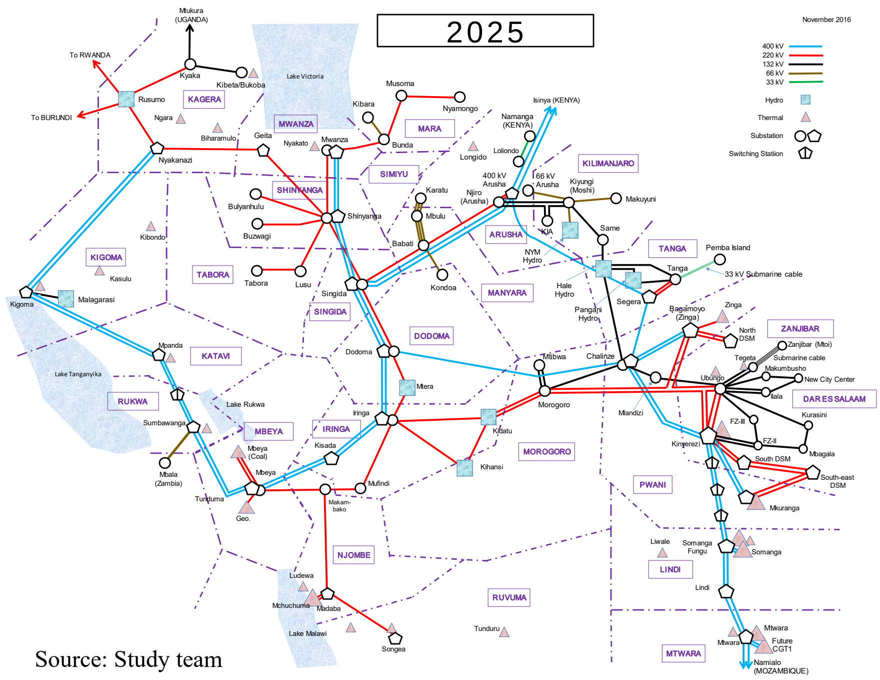
- Year 2020



Source: Study team

Figure 9.2.4-1 National Grid System in year 2020

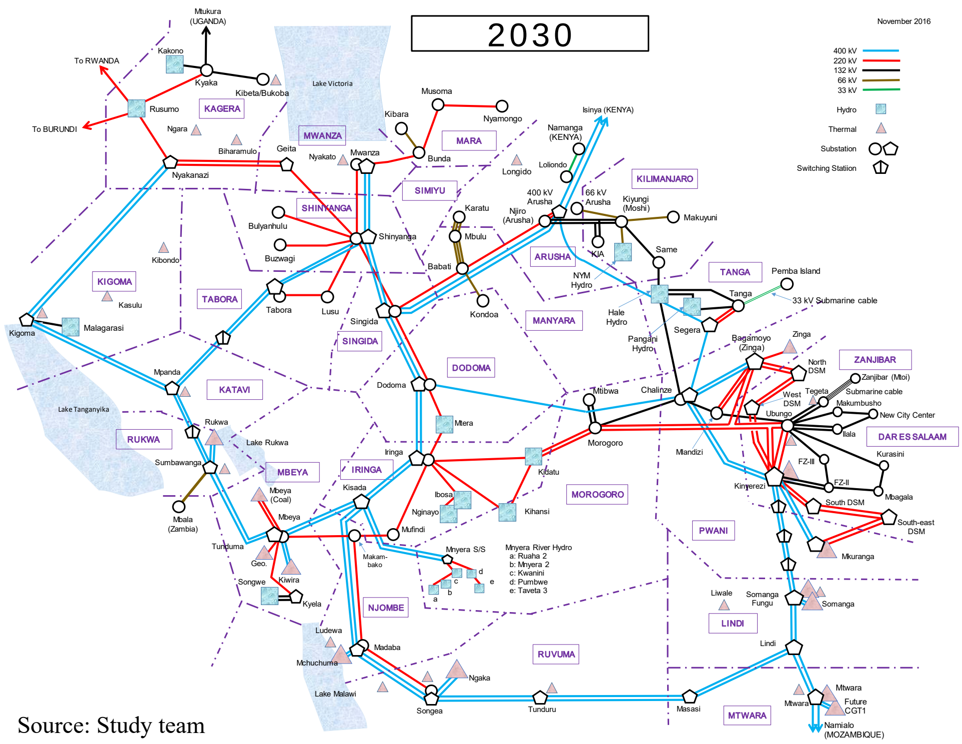
- Year 2025



Source: Study team

Figure 9.2.4-2 National Grid System in year 2025

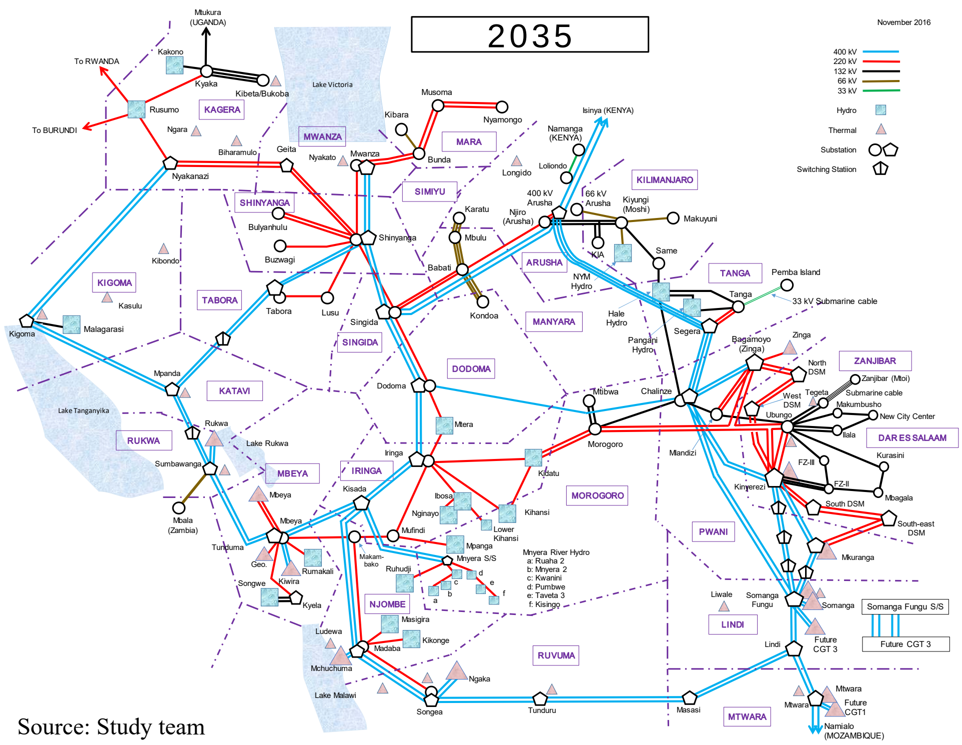
➢ Year 2030



Source: Study team

Figure 9.2.4-3 National Grid System in year 2030

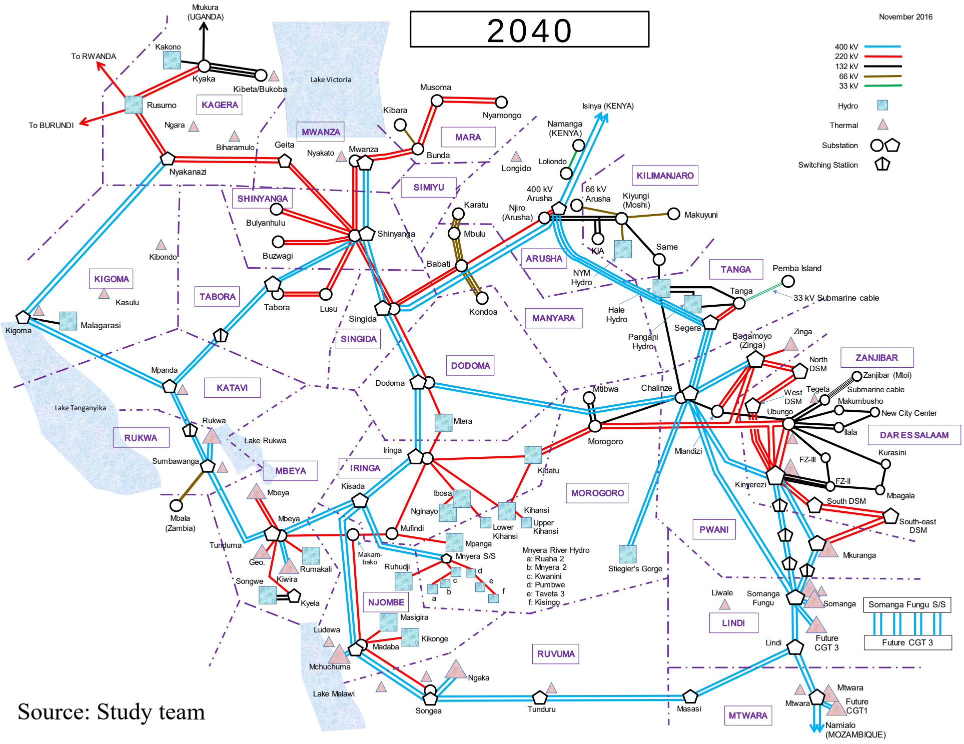
➢ Year 2035



Source: Study team

Figure 9.2.4-4 National Grid System in year 2035

➢ Year 2040



Source: Study team

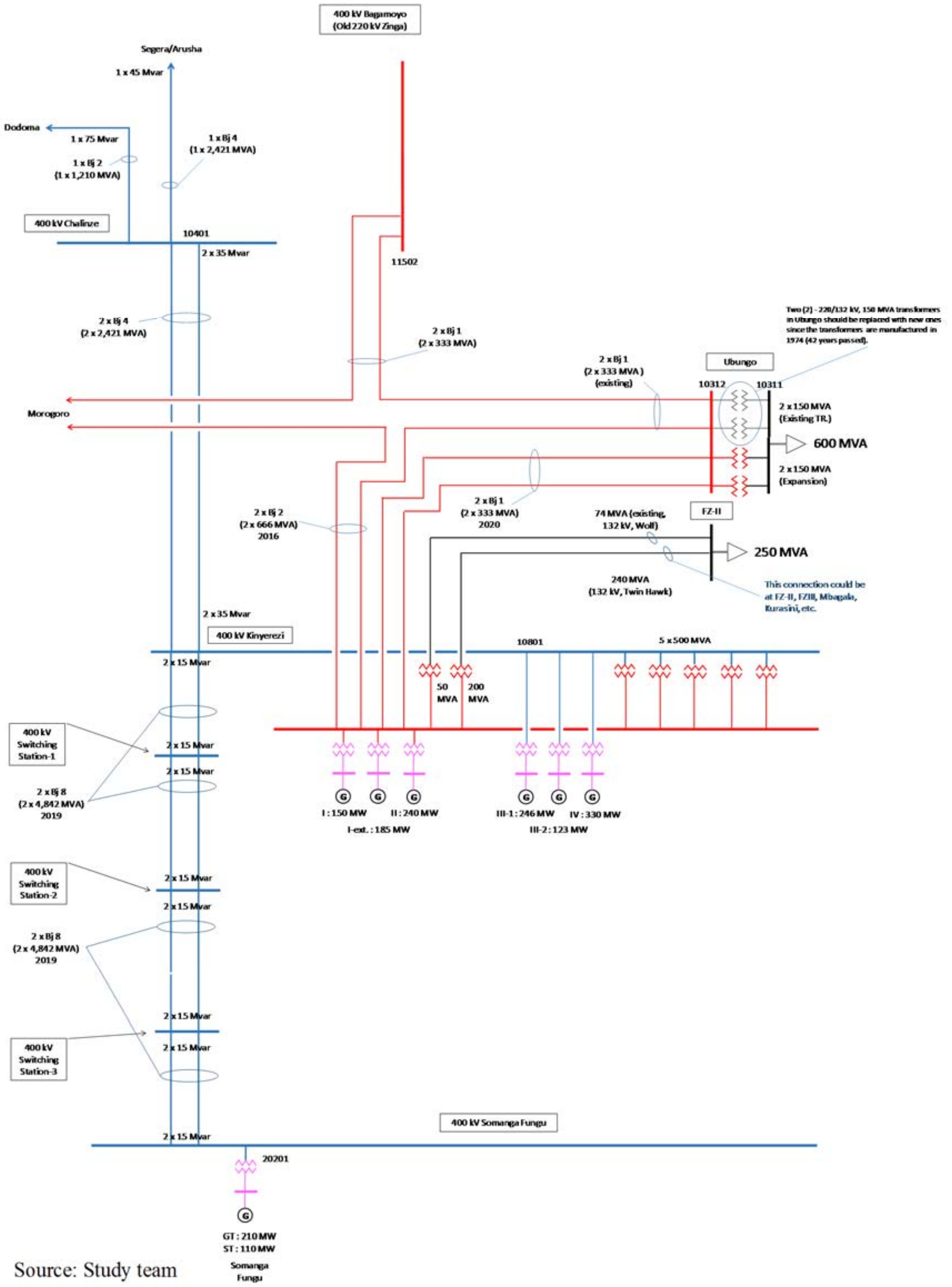
Figure 9.2.4-5 National Grid System in year 2040

(2) Grid System around Dar es Salaam (DSM)

The formulation of Dar es Salaam master plan (DSMP) is scheduled, as soon as the update of the National power system master plan (PSMP) has been completed. Since DSM is the biggest demand in the country, much power should be provided to DSM from the generation area, such as Gas power plants in Mtwara, Coal power plants in southwest regions etc. Therefore, the peripheral transmission network of DSM has been studied for PSMP tentatively. This peripheral transmission network of DSM may change in accordance with the result of DSMP. Hence, PSMP may be changed based on the result of DSMP.

The tentative peripheral transmission network per 5 years period are shown as below.

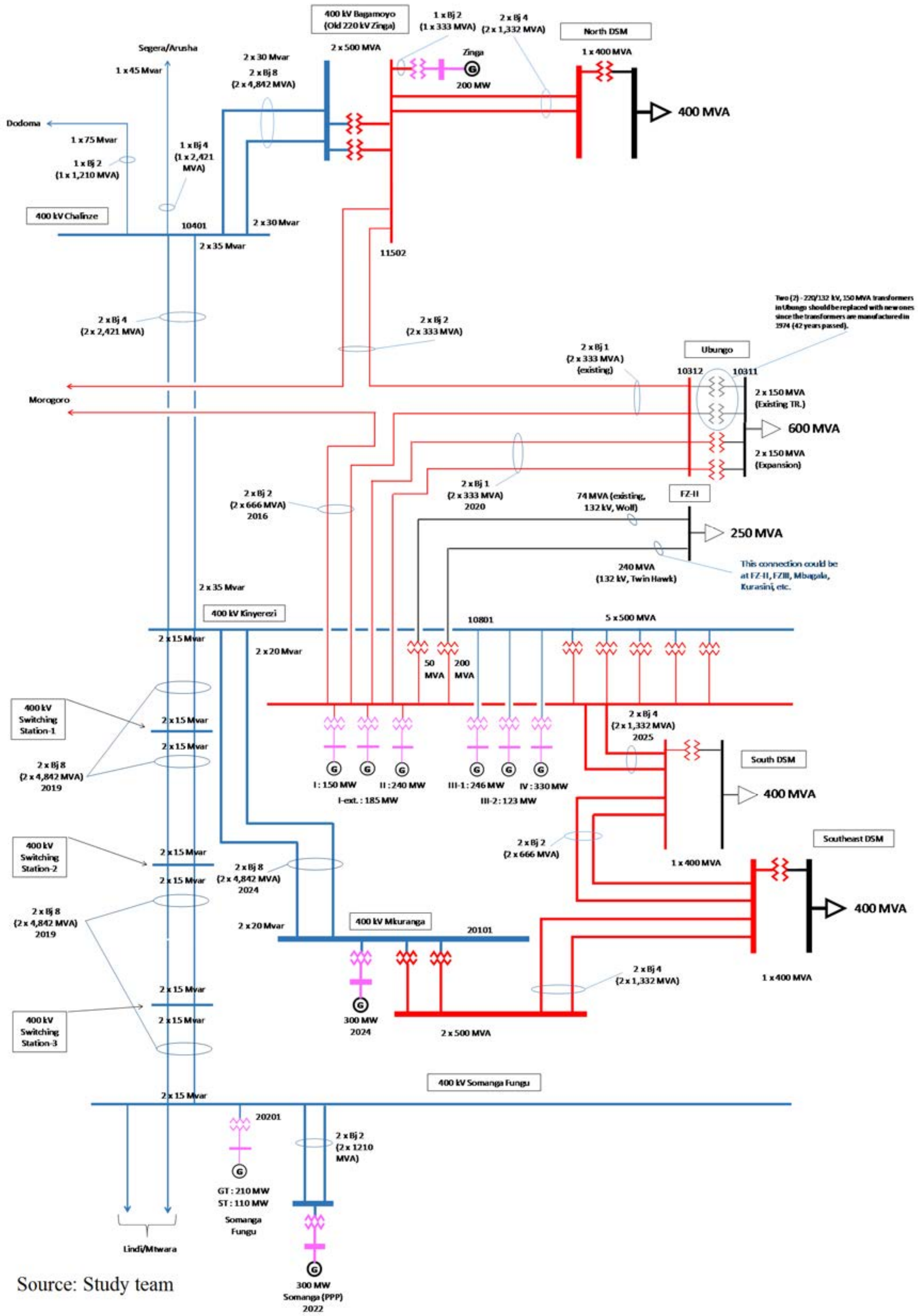
➢ Year 2020



Source: Study team

Figure 9.2.4-6 Tentative Peripheral Transmission Network of DSM in year 2020

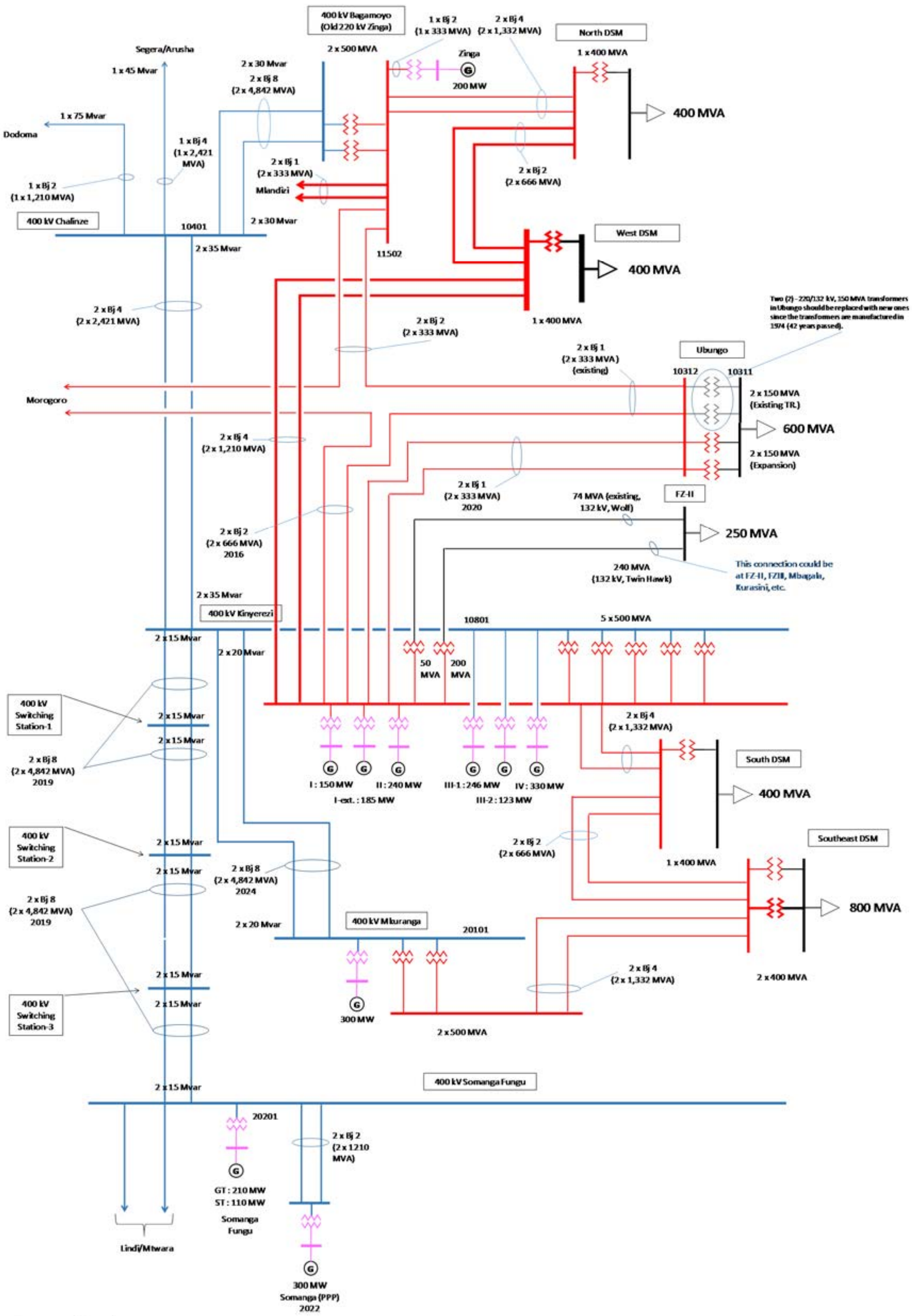
➢ Year 2025



Source: Study team

Figure 9.2.4-7 Tentative Peripheral Transmission Network of DSM in year 2025

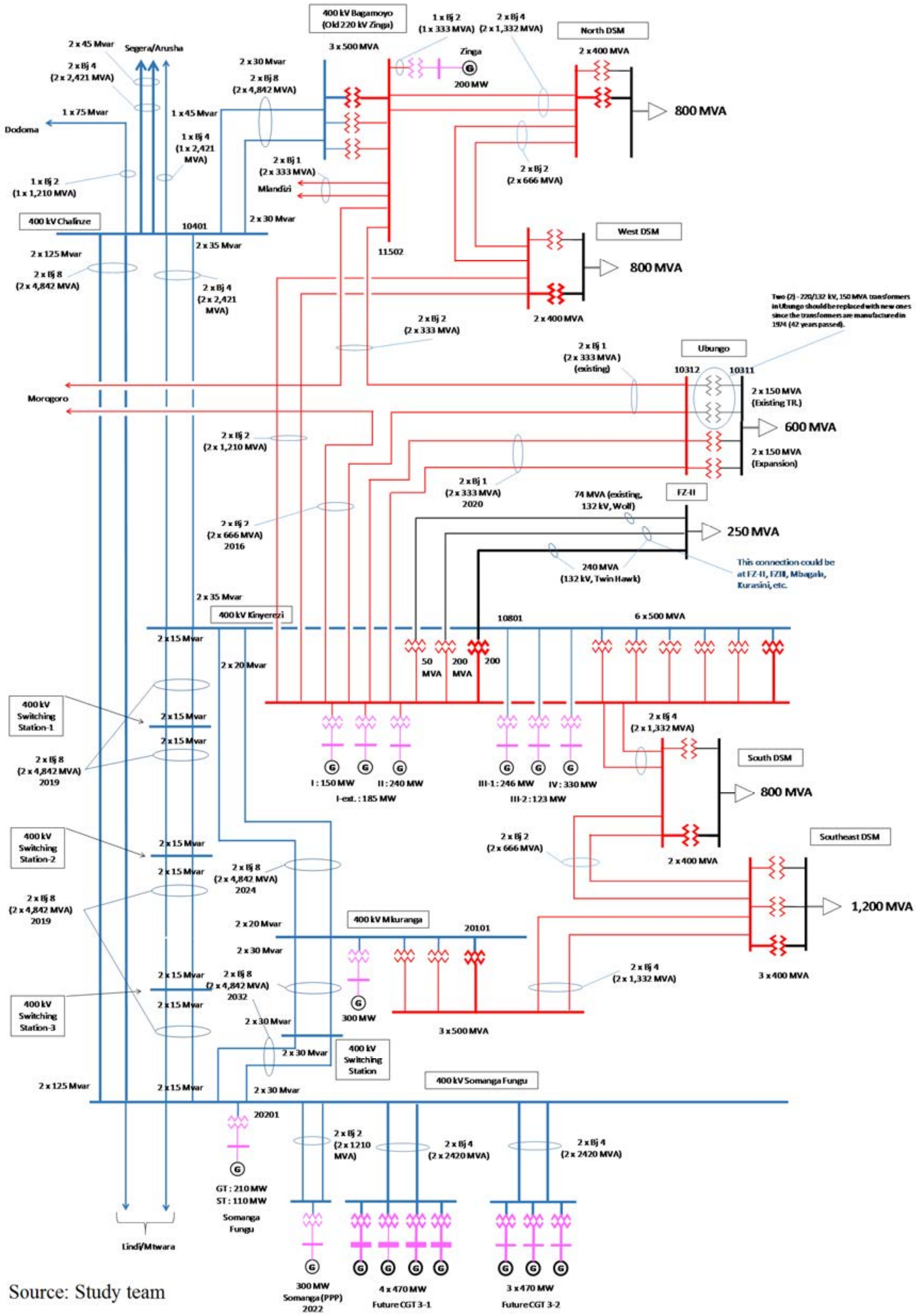
➢ Year 2030



Source: Study team

Figure 9.2.4-8 Tentative Peripheral Transmission Network of DSM in year 2030

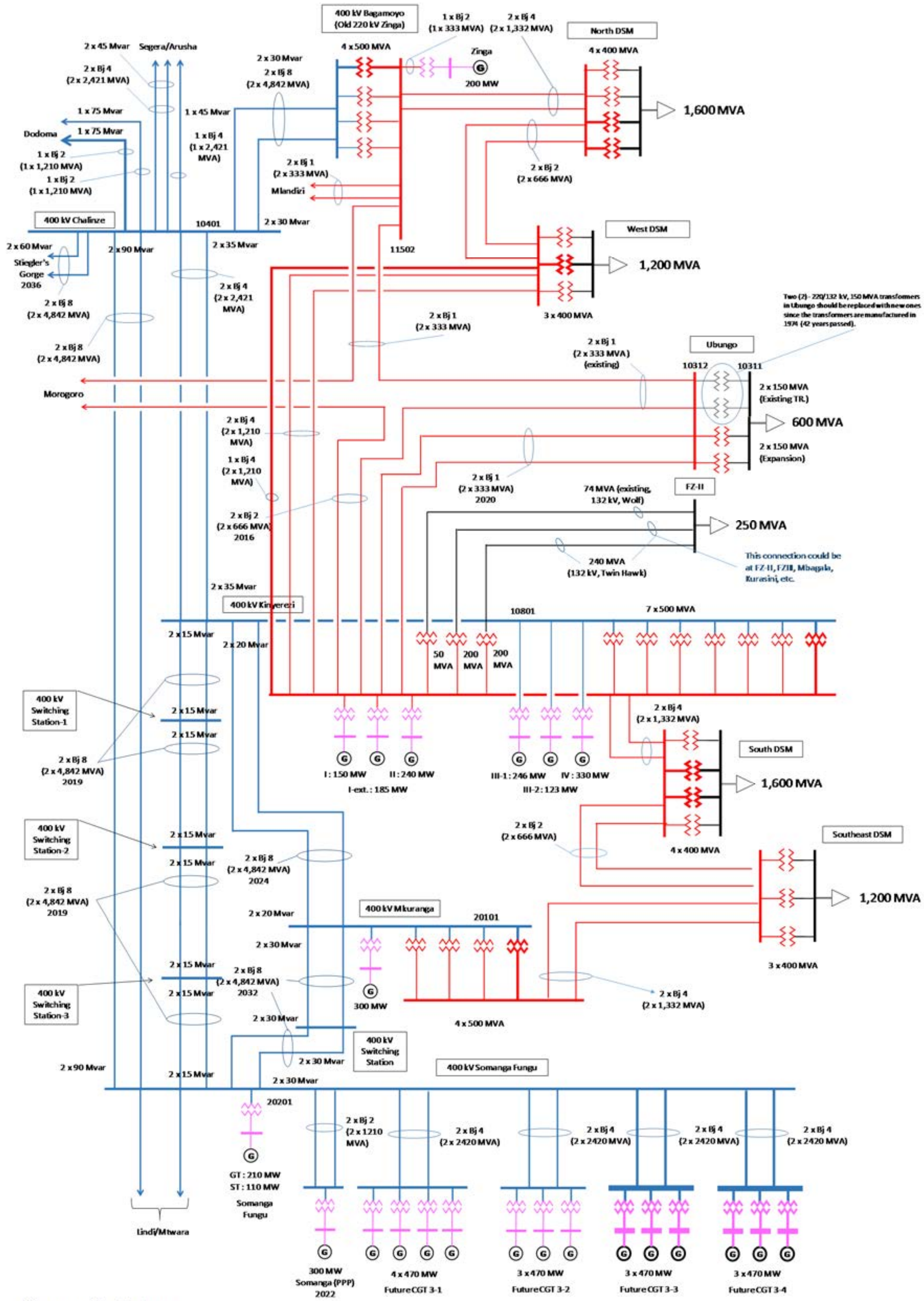
➢ Year 2035



Source: Study team

Figure 9.2.4-9 Tentative Peripheral Transmission Network of DSM in year 2035

➢ Year 2040



Source: Study team

Figure 9.2.4-10 Tentative Peripheral Transmission Network of DSM in year 2040

9.2.5 Issues and Recommendations for Transmission line and Substation development

(1) Feasibility study for Project implementation

Since the development of the Power system may or may not proceed as planned in the Master Plan due to various conditions, the system parameters may subject to change at the time of the implementation of the individual project. In order to obtain the reliable system, the specifications of the transmission lines (such as voltage, the number of conductors/circuits, etc.) and reactive compensation equipment should carefully be designed in the feasibility studies of the projects, considering the circumstances of the system as well as future expansion program.

(2) Study of Ultra-high voltage transmission lines and DC transmission system

In the Master plan, 400 kV is the maximum transmission voltage, considering the power interconnection between the eastern African counties. However, in case of heavy power flow in long transmission lines, the specification of transmission line may be changed such as application of higher 700 kV class voltage or DC voltage transmission system in order possibly to reduce the number of conductors and the number of circuits. Thus, the Master plan should be reviewed periodically by TANESCO while checking the power system conditions, time to time.

(3) Environmental and Social considerations

When constructing High voltage transmission lines, since a long site area is needed, it is necessary to consider impacts on the natural environment and social environment such as resettlement of residents, cultural heritage, effects on protected areas and ecosystems, and so on. Particularly in coastal areas, since mangroves have been confirmed, it is necessary to conduct survey carefully and give appropriate consideration when selecting routes.

(4) Necessity of skilled engineers for Projects

In accordance with the Master plan, large-scale power plants and their high voltage transmission lines/substations (or switching stations) should be constructed at the same time. Hence, TANESCO should have enough numbers of skilled engineers who can design the projects and manage the construction properly.

(5) Operation and Maintenance

Because the construction of 400 kV transmission line projects such as Backbone Transmission lines, TZK project and others have been already started in Tanzania and also additional transmission line projects have been planned, it is necessary to conduct operation and maintenance based on a long-term plan. Suitable management system should be developed for operation and maintenance of the transmission lines and substations. And also spare parts and maintenance tools/equipment should be prepared for proper maintenance and the organization of maintenance should be built inside TANESCO as well.

Since there are many existing transmission lines and substations being operated for a long time, it is recommended to adopt a maintenance recording system (history of the equipment/facilities) and a lifetime diagnosis system in order to know the time of replacement of equipment/facilities.

(6) Grid Operation System

While the National Grid Control Center (NGCC) installed beside Ubungo substation has been operated, it is predicted that it will become difficult to operate the grid of whole country at the only one control center for supply-demand control, frequency control, voltage control and system manipulation during emergency situation in the situations where large-scale power plans and renewable energy power plants will be interconnected successively to the grid and simultaneously ultra-high voltage system will spread nationwide. Therefore, by building of a hierarchical structure of NGCC and Regional Grid Control Centers (RGCCs) together with a communication network among control centers, power stations and substations, it can be realized that NGCC will responsible for the start-up, shutdown and automatic frequency control (AFC) of the large-scale generators including economic load dispatching control and for the operation of backbone transmission lines, on the other hand RGCCs will responsible for operation of voltage control and regional transmission lines in their own area in coordination with NGCC. In order to establish the system mentioned above, the detail engineering design of both hardware and software is indispensable by the experienced experts excelling in power system operation. In this sense the support is strongly desired from a grown country where the wide area power grid is well operated.

(7) Distribution planning

PSMP formulated the plan of transmission lines and their related substations, but the plan of distribution substations, local transmission lines for their interconnection and distribution lines are not included. In order to supply the electricity to end users, the formulation of distribution network development plan and its implementation is essential. JICA Study Team will study and formulate the distribution network plan for Dar es Salaam, however, TANESCO shall prepare plans for other regions. It is recommended that the distribution network development for every region should be implemented along with the PSMP to attain the early improvement of the electrification whole over the country.

Chapter 10 Environmental and Social Consideration

10.1 Relevant legal framework on Environmental and Social Consideration in Tanzania

10.1.1 Legal Framework

Tanzania has legislation related to environmental and social consideration. Most of them are aimed at regulating use and management of natural resources, have evolved along sector lines governing specific environmental field.

Tanzania's overarching environmental legislation is the Environmental Management Act 2004 (EMA), which provides a framework for sustainable management of the environment and repeals all earlier laws and provisions that are inconsistent with it on environmental matters. The Act is a comprehensive management act that includes provisions for institutional roles and responsibilities with regard to environmental management; principle for management; impact and risk assessments; strategic environmental assessment; prevention and control of pollution; waste management; environmental quality standards; public participation; compliance and enforcement; implementation of international instruments on environment; state of the environment reporting; implementation of the National Environment Policy; establishment of the national environmental trust fund; and to provide for other related matters.

	Laws/regulations	Description
1	Marine Parks and Reserves Act, 1994	An Act to provide for the establishment, management and monitoring of Marine Parks and Reserves for the purpose of to protect, conserve, and restore the species and genetic diversity of living and non-living marine resources and-the ecosystem processes of marine and coastal areas; to stimulate the rational development of underutilized natural resources; to manage marine and coastal areas so as to promote sustainability of existing resource use, and the recovery of areas and resources that have been over exploited or otherwise damaged; to ensure that villages and other local resident users in the vicinity of, or dependent on, a marine park or marine reserve are involved in all phases of the planning, development and management of that marine park or marine reserve, share in the benefits of the operation of the protected area, and have priority in the resource use and economic opportunity afforded by the establishment of the marine park or reserve; and to establish a Park and Marine reserves unit, and to repeal certain provisions of existing legislation with related matters;
2	The Forest Act, 2002	An Act to provide for the Management of forests, to repeal certain laws relating to forests; provide for undertaking Environmental Impact Assessments of the required certain development projects; provide for establishment of forest management plan for all types of forest for the purpose of its best endeavours to achieve the sustainable management of the forest reserve over the periods of time; and designates Community Forest Reserves, Mangrove Forest Reserves and encourages community-based management and for related matters.
3	The Wildlife Management Act No 5 of 2009,	An Act to make better provisions for the conservation, management, protection and sustainable utilisation of wildlife and wildlife products; to repeal the Wildlife Conversation Act Cap. 283; provides for establishment and management of Wildlife Management Area and benefit sharing; provides for management plans, environmental impact assessment, wildlife impact assessment and environmental audit and monitoring; and to provide for other related matters.

	Laws/regulations	Description
4	The Water Resources Management Act No. 11 of 2009	An Act to provide for the institutional and legal framework for sustainable management and development of water Resources; to outline principal for Water Resources management; to provide for prevention and control of water pollution; to provide for participation of stakeholders and general public in implementation of the National Water Policy, repeal of the Water Utilization (Control and Regulations) Act and to provide for related matters.

10.1.2 Multi-lateral Environmental Agreements (MEAs)

Tanzania has ratified various Multilateral Environmental Agreements (MEAs) in order to join the international community efforts in addressing global environmental issues such as climate change, ozone depletion, desertification, and hazardous chemicals and wastes. Through this international cooperation, the country has been implementing a number of projects/programs to address environmental issues and poverty reduction and subsequently contributing to sustainable development. Table 10.1.2-1 below shows the treaties and conventions on environment that Tanzania is a party.

Table 10.1.2-1 Treaties and conventions on environment that Tanzania is a party

#	Category	Treaties and Conventions	Year ratified/acceded
1	Ecosystem/pest	The convention on the African Migratory Locust, Kano	1962
2	Wetland	The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (the Ramsar Convention)	1971
3	Heritage	The convention concerning the Protection of World Cultural and Natural Heritage, Paris	1972
4	Marine environment	The convention on the Prevention of Marine Pollution by Dumping of Wastes and other matters, London	1972
5	Ecosystem/ endangered	The convention on International Trade in Endangered species of Wild Fauna and Flora (CITES), Washington	1973
6	Marine environment	The convention on the Prevention of Marine Pollution from ships (MARPOL)	1973
7	Marine environment	The United Nations Convention on Law of the Sea, Montego Bay	1982
8	Marine environment	Convention on Development and Protection of Coastal and Marine Environment for the Eastern Africa Region	1985
9	Hazardous waste	Bamako convention on the Ban of the Import into Africa and the control of Transboundary Movements of Hazardous Wastes within Africa	1990
10	Ozone layer	The Vienna Convention on the Protection of Ozone Layer	1993
11	Ozone layer	Montreal Protocol on Substances that Deplete the Ozone Layer	1993
12	Hazardous waste	The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal - adopted on 22 March 1989 and it entered into force in April 1997	1993
13	Ecosystem	The Convention on Preservation of Fauna and Flora in their Natural state, London	1993
14	Climate Change	United Nations Framework Convention on Climate Change - adopted in 1992	1996
15	Ecosystem/ biodiversity	United Nations Convention on Biological Diversity - adopted in May 1992	1996
16	Desertification	United Nations Convention to Combat Desertification - adopted in June 1994	1997
17	Hazardous chemicals	Rotterdam Convention of Prior Informed Consent Chemicals	1998
18	Hazardous chemicals/PCB	Stockholm Convention on Persistent Organic Pollutants (POPs) - adopted in 2001 and entered into force in 2004	2002
19	Lake	Convention on Sustainable Management of Lake Tanganyika	2004

10.1.3 Institutional Framework

The Environmental Management Act (EMA) 2004 sets up the institutional framework for environmental management in the country. It confers the tasks of overall coordination of environmental management in the country and provision of the central support functions to the Ministry Responsible for Environment, which is the Vice President's Office. The National Environmental Policy, 1997 and the Environmental Management Act, 2004, guide functions by providing a policy and legislative framework for coordinating implementation of policies and laws on environmental and natural resources management in the country. The Act confers the role of management of specific natural resources or environmental services, such as agriculture, fisheries, forestry, wildlife, mining, water, and waste management to various Ministries, the Local Government Authorities and departments. These functions are to a large extent directly operational and in addition to EMA they are also guided by sector specific policies and legislations. Figure 10.1.3-1 provides Institutional Arrangement under Environmental Management Act.

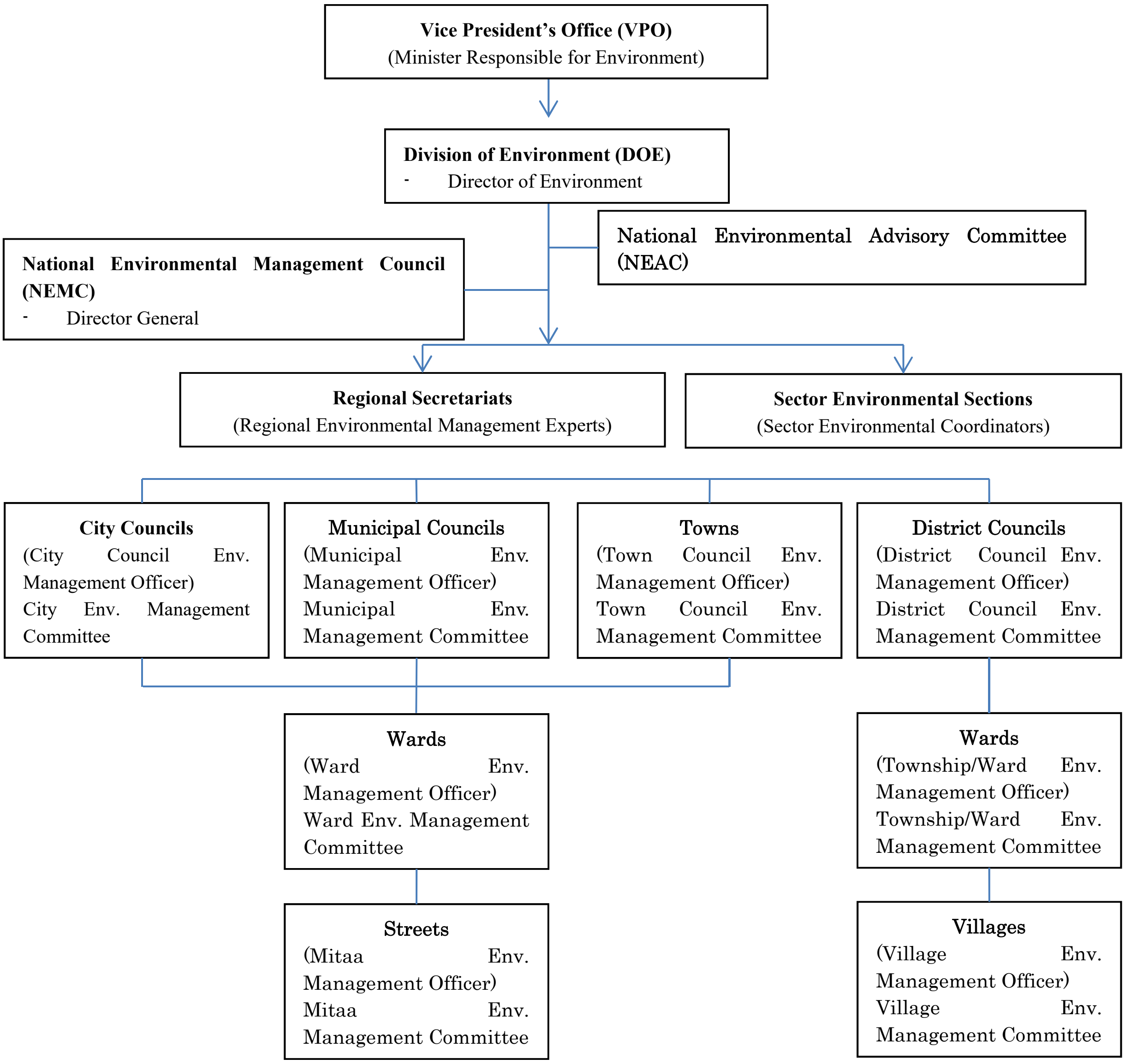


Figure 10.1.3-1 Institutional framework on Environmental Management in Tanzania
(DOE-VPO, 2012)

- **National Environmental Advisory Committee (NEAC)**

  The committee is created to advise the Minister for environment (the Vice President"s Office-VPO in this instance) or any sector ministry on any environmental matter which may be referred to it.

- **Minister Responsible for Environment**

  The Minister can articulate policy guidelines, make regulations, guidelines, can designate any institution to perform any function or do any activity within a specified time. The Minister can make rules for preparation of periodic environmental plans at sector level, can make regulations prescribing the procedure and manner in which Environmental Action Plans may be prepared, adopted and implemented.

- **Director of Environment, Vice President's office**

  The Director of Environment coordinates environmental activities, advices the government on the law and international environmental agreements on the environment, monitor and assess activities of relevant agencies, prepares and issue State of Environment Report.

- **National Environmental Management Council (NEMC)**

  The function of the Council among others include carries out environmental audits, surveys, researches; reviews and recommend for approval of Environmental Impact Assessment; enforce compliance of the National Environmental Quality Standards; initiates procedure for the prevention of accidents which may cause environmental degradation; undertakes programs to enhance environmental education; publishes and disseminate manuals relating to environmental management; renders advise and technical support to entities engaged in natural resources and environmental management; and performs any other functions assigned to it by the Minister responsible for environment.

- **Sector Ministries**

  Each sector ministry carries out its functions and duties in connection with the environment according to EMA and any other law provided that such law does not conflict with EMA. Involvement of Sector Ministries in environmental management is through a sector environment sections (SEs) which have been established in each ministry to ensure that ministries comply with the EMA. So far, since the enactment of EMA, Sector Environmental sections have been established in almost all sector ministries and Sector Environmental coordinators have either been designated or employed in such ministries.

- **Regional Secretariat**

  The Regional Secretariat is composed of a Regional Environmental Management Expert (REME) charged with the responsibility to advise the Local Government Authorities of that particular administrative region on matters relating to implementation and enforcement of EMA. The REME links the region with the Director of Environment. Since the enactment of EMA, several

Regional Secretariats have either designated or employed Regional Environmental Management Experts.

- **Local Government**

  Local Government Authorities are classified into two categories. Urban authorities are responsible for the administration and development of urban areas ranging from townships, municipalities and cities. Rural Authorities commonly known as District Councils form the second category. All Local Government Authorities are mandated to play two main functions of administration, law and order; and economic and development planning in their respective areas of jurisdiction. Implementation of various sustainable development initiatives is implemented at this level, particularly for rural areas. EMA has vested to the Local Government Authorities the function of environmental management. It has created officers and has also designated to some committees certain environmental functions.

10.1.4 Environmental Impact Assessment (EIA)

EIA in Tanzania is guided by the National Environmental Policy (1997) and Environmental Management Act (EMA) 2004. The EMA 2004 specifies detailed measures for protecting ecological process, the sustainable utilization of ecosystems, and environmental protection, and is organized into following parts:

Part I: Preliminary provisions
Part II: general principles
Part III: Administrative and institutional arrangements
Part IV: Environmental Planning
Part V: Environmental Management
Part VI: Environmental Impact Assessment (EIA)
Part VII: Strategic Environmental Assessment (SEA)
Part VIII: Pollution prevention and control
Part IX: Waste management
Part X: Environmental quality standards
Part XI: Environmental restoration, easements and conservation orders
Part XII: Analysis and records
Part XIII: Environmental Information
Part XIV: Public participation in environmental decision-making
Part XV: International arrangements
Part XVI: Compliance and enforcement
Part XVII: Environmental Appeals Tribunal
Part XVIII: National Environmental Trust Fund
Part XIX: Financial provisions
Part XX: General and transitional provisions

In addition to the Act, the EIA practice is also guided by the Environmental Impact Assessment and Audit Regulations of 2005, EIA and Audit procedures and guidelines that were prepared by the Vice President's Office. The EIA and Audit Regulations is the operational tool of EMA, it has 12 parts setting out detailed steps for conducting EIA in Tanzania as follows:

Part I: Preliminary provisions
Part II: General prohibition
Part III: Project registration and screening
Part IV: The Environmental Impact Assessment
Part V: The Environmental Impact Statement
Part VI: Review process of Environmental Impact Statement
Part VII: Decision of the Minister
Part VIII: Access to Environmental Impact Statements and Information
Part IX: Period of validity
Part X: Environmental Audit
Part XI: Monitoring
Part XII: General provisions

For the energy sector, the following projects as per EIA Regulations require EIA (First Schedule):

- Production and distribution of electricity, gas, steam, and geothermal energy
- Storage of natural gas
- Thermal power development
- Hydroelectric power
- Development of other large scale renewable and non-renewable sources of energy

An activity listed in the First Schedule of the EIA and Audit Regulations cannot proceed without obtaining the necessary license from the relevant licensing authority (line ministry). The licensing authority, however, will not issue a license without having first received an EIA Certificate from the NEMC. The Developer must commence with his/her authorized development within three years.

The EMA 2004 makes a provision of the EIA to be conducted at the national, sectoral or local government levels. Currently, all EIA projects are still being administrated at the national level. Figure 10.1.4-1 shows the EIA administration at the national level.

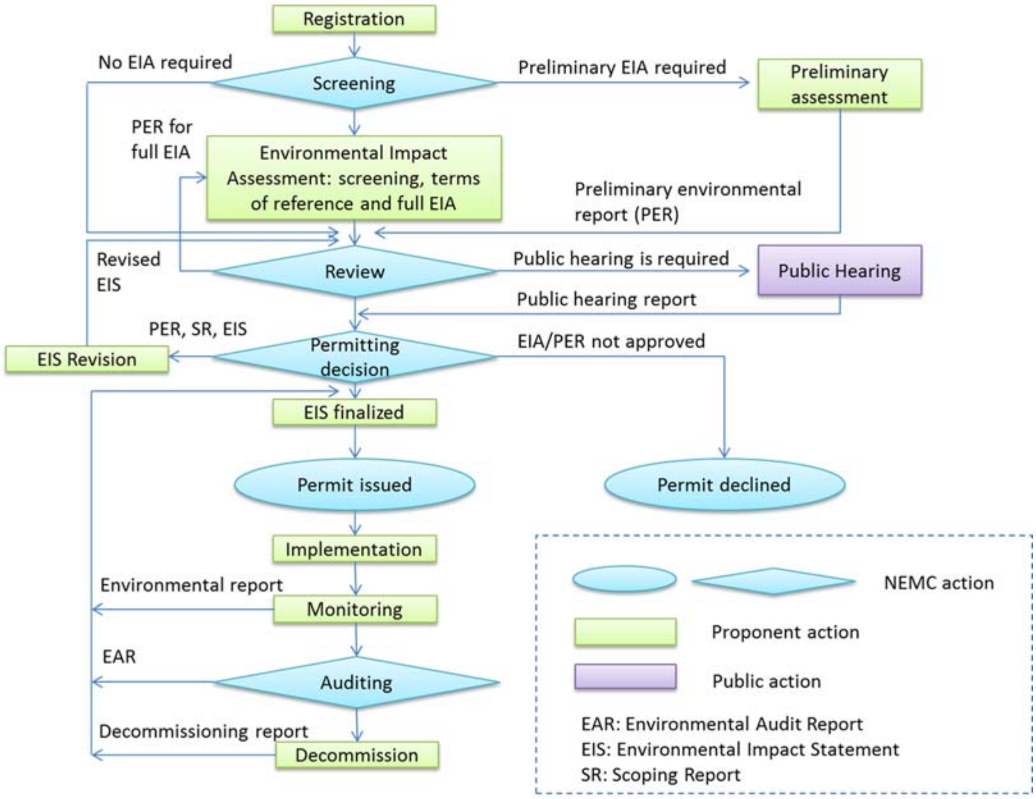


Figure 10.1.4-1 EIA Administration (Energy Sector EIA guideline, MEM, 2012)

10.1.5 Strategic Environmental Assessment (SEA)

(1) Definition and Objectives of SEA

The Strategic Environmental Assessment Regulations (2008) defines SEA as "a systematic process for evaluating the environmental, including health, consequences of proposed legislation, policy, plan, strategy or programme initiatives in order to ensure that they are fully included and appropriately addressed at the earliest appropriate stage of decision on par with economic and social considerations, which comprises the determination of the scope of an environmental report and its preparation, the carrying out of public participation and consultations and the taking into account of the report".

According to SEA Regulations objectives of SEA are:

a) to ensure that environmental concerns are taken in the policies, Bills, regulations, plans, strategies or programmes;
b) to enable the public to contribute to the consideration of environmental concerns in the preparations of policies, Bills, regulations, plans, strategies or programmes;
c) to establish clear, transparent and effective procedures for formulation of policies, Bills, regulations, plans, strategies or programmes; and to integrate environmental concerns into measures and instruments designed to further sustainable development.

(2) Legal and Regulatory Requirements of SEA

The legal and regulatory requirements of SEA are provided in Section 104 and 105 of EMA. Section 104 requires that when preparing a Bill that is likely to have effect on the management, conservation and enhancement of the environment; or sustainable development of natural resources, SEA should be undertaken and submitted to the Minister responsible for environment. Moreover, the Act requires that when promulgating regulations, public policies, programmes and development plans that may have effects on the environment, SEA should be conducted.

Furthermore, Section 105 of the Act requires that where a mineral or petroleum resource is identified and before specific details are planned or a hydro-electric power station is planned or a major water project is planned, the Ministry responsible for mining, energy or water should carry out a SEA.

(3) Principles of SEA

The principles upon which SEA is based include:

a) sustainable use of natural resources;
b) enhancement of protection and conservation of biodiversity;
c) inter-linkage of human settlement and cultural issues;
d) integration of socio-economic and environmental factors.
e) protection and conservation of natural physical surroundings of scenic beauty as well as protection and conservation of built environment of historic or cultural significance; and
f) Public and stakeholder engagement.

(4) Authority Responsible to Undertake SEA

Regulation 8(1) of the SEA Regulations requires Sector Ministry, government agency or department, where it is found necessary at the commencement of preparation of a Bill, regulations, policy, strategy, programme or plan to carry out a SEA. In so doing the responsible authority may form a team to undertake the assessment, comprising experts in SEA or environmental and natural resource management from a sector ministry, government agency, department and public higher learning and research institutions or registered environmental experts.

Table 10.1.5-1 Previous and ongoing SEA in Tanzania (JICA project team, 2014)

	Name of the project/policy/plan	Applicant	Year	Approval status
1	Mafia Airport Upgrade	Millennium Challenge Account Tanzania	October, 2008	Approved
2	Southern Agriculture Growth Corridor of Tanzania (SAGCOT) Investment Project	Prime Minister's Office (World Bank financed project)	December, 2013	Approved
3	Comprehensive Transport and Trade Systems Development Master Plan in Tanzania, Building and Integrated Freight Transport System	Ministry of Transport (JICA funded project)	2014	Approved
4	Biofuel Policy	Ministry of Energy and Minerals	2012-2014	ongoing (almost completed)
5	Bagamoyo Special Economic Zone	Export Processing Zones Authority	2014	ongoing
6	Proposed Land Reclamation Project at the Coastal Area of Dar es Salaam city	Tanzania Tourist Board	2014	ongoing
7	Tengeru Satellite town development in Meru District Council, Arusha Region	Meru District Council	2014	ongoing
8	The Kibada Satellite City, Temeke	National Housing	2014	ongoing

	Name of the project/policy/plan	Applicant	Year	Approval status
	District, Dar es Salaam	Corporation		
9	National Gas Policy, Petroleum Policy, Natural Gas Local Content	Ministry of Energy and Minerals (WB financed)	2014	ongoing

(5) Steps of SEA

According to VPO-DOE, followings are the major steps of SEA. The SEA report will be reviewed by the regulatory authorities, which will prepare a report on adequacy of the assessment and make recommendations to the relevant decision-makers. If favourable, the assessment report will be approved.

	Step		Duration (approx.)
1	Screening	1.1 Submit letter to VPO ✓ Registration letter ✓ Attachment (brief description of the Master Plan) 1.2 VPO conduct screening and send the result to MEM	1 week (max 2 weeks)
2	Scoping	2.1 Develop Scoping report and detailed TOR 2.2 Submit Scoping report and TOR to VPO 2.3 VPO will send the copy to key stakeholders asking for their comments. After receiving comments, VPO approve them (no stakeholder workshop)	2 to 3 weeks
3	Conduct SEA	3.1 Conduct SEA based on the approved TOR	
4	SEA report	4.1 Submit 1st draft SEA report to VPO 4.2 VPO will send the copy and have a stakeholder workshop 4.3 Submit 2nd draft SEA report to VPO 4.4 VPO will send the copy and have a stakeholder workshop 4.5 Submit final draft SEA report to VPO	2 to 3 weeks 2 to 3 weeks
5	Review	Technical review team will review the final draft SEA report and prepare advice for the minister responsible for environment	
6	Approval	Minister responsible for environment approves the SEA	2 to 3 weeks

(6) Information to be covered by SEA report

Following items are the content for SEA report as described in the Third Schedule of SEA regulation, 2008.

1. An outline of the contents and main objectives of the plan or programme, and of its relationship with other relevant Bill, regulations, policy, strategy, plans and programmes.
2. The relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the Bill, regulations, policy, strategy, plan or programme.
3. The environmental characteristics of areas likely to be significantly affected.
4. Any existing environmental problems which are relevant to the Bill, regulations, policy, strategy,

plan or programme.

5. The environmental protection objectives, established at national level, which are relevant to the Bill, regulations, policy, strategy, plan or programme and the way those objectives and any environmental considerations have been taken into account during its preparation.
6. The likely significant effects on the environment, including short, medium and long-term effects, magnitude and extent of impact, likelihood of occurrence, reversibility, permanent and temporary effects, positive and negative effects, and secondary, cumulative and synergistic effects, on issues such as; (a) biodiversity; (b) population; (c) social; (d) human health; (e) fauna; (f) flora; (g) soil; (h) water; (i) air; (j) climatic factors; (k) material assets; (l) cultural heritage, including architectural and archaeological heritage; (m) landscape; and (n) the inter-relationship between the issues referred to in sub-paragraphs (a) to (l).
7. The measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the Bill, regulations, policy, strategy, plan or programme.
8. An outline of the reasons for the selecting the alternatives dealt with, and a description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information.
9. A description of the variables and measures envisaged for monitoring.
10. A non-technical summary of the information provided under paragraphs 1 to 9.
11. Comprehensive Swahili version of the non-technical summary.

10.1.6 Environmental Standards and other regulation

In terms of section 140(1) of the EMA, the National Environmental Standards Committee of the Tanzanian Bureau of Standards is required to develop, review and submit proposals for environmental standards relating to: water quality, discharge of effluent, air quality, noise and vibration, subsonic vibration, ionising and other radiation, soil quality, noxious smells, light pollution, electromagnetic waves and microwaves.

The National Environmental Standards Compendium is a collection of various standards, divided into three parts. Part 1 comprises compulsory standards; these are categorised as generic or specific. Specific standards cover industries with particular effects on the environment, while other industries without a specific standard are regulated by generic standards. These standards are listed in Tables 10.1.6-1 to 10.1.6-4.

Table 10.1.6-1 Ambient air quality standards

Pollutant	Guideline	Limit level
Sulphur oxides, SOx	Annual mean of 40 – 60 µg/Nm^3 (0.05 – 0.08 mg/kg) or 24-hour average 100 µg/Nm^3 (0.129 mg/kg)	Daily average of hourly values shall not exceed 0.1 mg/kg 0.5 mg/Nm^3 for 10 minutes
Carbon monoxide, CO	Aims at preventing carboxyhaemoglobin levels exceeding 2.5% – 3% in	A maximum permitted exposure of 100 mg/Nm^3 for periods not exceeding 15 minutes

Pollutant	Guideline	Limit level
	non-smoking people	Time-weighted exposure at the following levels: • 100 mg/Nm^3 for 15 minutes • 60 mg/Nm^3 for 30 minutes • 10 mg/Nm^3 for 8 hours or Daily average of hourly values shall not exceed 10 mg/kg and average of hourly values in eight consecutive hours shall not exceed 20 mg/kg.
Black smoke and suspended particulate matters (PM10)	Black smoke: 40 – 60 μg/Nm^3 (0.05 – 0.08 mg/kg) PM10: 60 – 90 μg/Nm^3 (0.05 – 0.116 mg/kg)	Daily average of hourly values shall not exceed 0.10 μg/Nm^3 and hourly values shall not exceed 0.20 μg/Nm^3
Nitrogen dioxide (NOx)	Annual mean of 0.1 μg/Nm^3	150 μg/Nm^3 for 24-hours average value 120 μg/Nm^3 for 8 hours
Lead	Annual mean of 0.5 – 1.0 μg/Nm^3	1.5 μg/Nm^3 for 24-hours average value
Ozone	Annual mean of 10 – 100 μg/Nm^3	120 μg/Nm^3 for 8-hours average value

PM10: particulate matter smaller than about 10 micrometres

Table 10.1.6-2 Air quality emission limits

Pollutant	Guideline	Limit level
Sulphur oxides, SOx	LCP using solid fuel with thermal effect of: 50 – 100 MWth 100 – 300 MWth >300 MWth LCP using liquid fuel with thermal effect of: 50 – 100 MWth 100 – 300 MWth >300 MWth LCP using gaseous fuel LCP using low calorific gases from gasification of refinery residues, coke oven gas, blast furnace gas	 850 mg/Nm^3 200 mg/Nm^3 200 mg/Nm^3 850 mg/Nm^3 400 – 200 mg/Nm^3 (linear decrease) 200 mg/Nm^3 35 mg/Nm^3 800 mg/Nm^3
Carbon monoxide, CO	Liquid fuel combustion with heat output exceeding 5 MW Solid fuel combustion with the heat output exceeding 50 MW	Not to exceed 175 mg/Nm^3 Not to exceed 250 mg/Nm^3
Hydrocarbon (as total organic carbon)		Not to exceed 20 mg/Nm^3
Dust	Inert dust, including cement	Not to exceed 250 mg/Nm^3 (24-hour mean value)
Nitrogen oxides * (NOx)	LCP using solid fuel with thermal effect of: 50 – 500 MWth >500 MWth LCP using liquid fuel with a thermal effect of:	Yearly average of: 600 mg/Nm^3 500 mg/Nm^3

Pollutant	Guideline	Limit level
	50 – 500 MWth >500 MWth LCP using gaseous fuel with a thermal effect of: 50 – 500 MWth >500 MWth	450 mg/Nm^3 400 mg/Nm^3 300 mg/Nm^3 200 mg/Nm^3
Lead		Not to exceed 5 tonnes/year of lead or lead compounds (measured as elemental lead) by a stationary source

LCP: large combustion plants

Table 10.1.6-3 Permissible limits for municipal and industrial wastewater

Parameter	Limit (mg/l)
Biological oxygen demand at 20˚C	30
Chemical oxygen demand	60
Colour	300 TCU
pH range	6.5 – 8.5 units
Temperature range	20 – 35˚C
Total suspended solids	100
Aluminium (as Al)	2.0
Arsenic (As)	0.2
Barium (Ba)	1.5
Cadmium (Cd)	0.1
Chromium (total)	1.0
Chromium (hexavalent)	0.1
Chlorides (Cl)	200
Cobalt (Co)	1.0
Copper (Cu)	2.0
Fluorides (F)	8
Iron (Fe)	5.0
Lead (Pb)	0.1
Manganese (Mn)	5.0
Mercury (Hg)	0.005
Nickel (Ni)	0.5
Nitrates (NO3)	20
Phosphorus total (as P)	6
Selenium (Se)	1.0
Silver (Ag)	0.1
Sulphate (SO4)	500
Sulphides (S)	1
Tin (Sn)	2.0
Total Kjedahl nitrogen (as N)	15
Vanadium (V)	1.0
Zinc (Zn)	5.0
1,1,2 – Trichloroethane	0.06
1,1,1 –Trichloroethane	3.0
1,2 - Dichloroethylene	0.2
1,2 – Dichloroethane	0.04
1,3 – Dichloropropene	0.2
Alkyl benzene sulphonate	0.5
Aromatic nitrogen-containing compounds (e.g. aromatic amines)	0.001
cis-1, 2- Dichloroethylene	0.4
Dichloromethane	0.2
Oil and grease (fatty matter and hydrocarbons)	10
Organochlorine pesticides (Cl)	0.0005
Other aromatic and/or aliphatic hydrocarbons not used as pesticides	0.05

Parameter	Limit (mg/l)
Pesticides other than organochlorines	0.01
Phenols	0.002
Tetrachloroethylene	0.1
Tetrachloromethane	0.02
Trichloroethylene	0.3
Total coliform organisms	10 000 counts/100ml

TCU: true colour unit, NTU: nephelometric turbidity unit

Table 10.1.6-4 Maximum permissible levels for general environmental noise

Facility	Noise limits (dBA (Leq))	
	Day	Night
Any building used as a hospital, convalescence home, home for the aged, sanatorium, learning institution, conference room, public library or environmental and recreational site	45	35
Residential buildings	50	35
Mixed residential (with some commercial and entertainment)	55	45
Residential and industry or small-scale production and commerce	60	50
Industrial areas	70	60

10.1.7 Offences and Penalties

Offences and penalties are stipulated in Part XVI of the EMA. Those related to EIA and environmental standards are as shown in Table 10.1.7-1 below.

Table 10.1.7-1 Offences and penalties related to EIA and environmental standards

EMA section	Infringement	Penalty
184	Failure to submit a Project Brief or an EIA or making a false statement in an EIA	Tsh 0.5–10 million and/or imprisonment for two to seven years
186	Contravention of any environmental standards or guidelines	Tsh 2-10 million and/or imprisonment for two to seven years
187	Causing pollution contrary to the provision of the EMA	Tsh 3-50 million and/or imprisonment for up to 12 years, and the full cost of the clean-up of the polluted environment
191	General penalty for non-compliance with any provision in the Act for which no specific penalty is prescribed	Tsh 50,000-50 million and/or imprisonment for three months to seven years

10.1.8 The Major Gaps between JICA guideline, World Bank's Safeguard Policy and Tanzanian legislation on environmental and social consideration

There are some gaps between JICA guideline, World Bank Safeguard Policy and Tanzanian legislation on environmental and social consideration (Table 10.1.8-1). In terms of ecosystem/wildlife conservation, there is a gap in that it is not prescribed as for comparing economic benefits and environmental cost for decision-making about projects in important habitats. It is necessary to pay attention to that projects may be permitted even within national parks depending on the EIA result. There are also some gaps in terms of legal framework and resettlement policy.

Table 10.1.8-1 Gaps between JICA guideline, World Bank Safeguard policy and Tanzanian legislation

Response policy including JICA's guideline and the World Bank's Safeguard Policy	Relevant laws in Tanzania	Main gaps
Natural environment		
Illegal logging of forests must be avoided. Project proponents etc. are encouraged to obtain certification by forest certification systems as a way to ensure the prevention of illegal logging.	The Forest Act, 2002 stipulates that no person other than a right-holder are prohibited from cutting down, digging up, residing and constructing any roads, bridges, railways and waterways. (Article 26)	The Forest Act, 2002 prohibits illegal logging and there is not a gap.
・ Projects must not involve significant conversion or significant degradation of critical natural habitats and critical forests. ・ Whenever feasible, projects are sited on lands already converted (excluding any lands considered to have been converted in anticipation of the project). JICA does not support projects involving the significant conversion of natural habitats unless there are no feasible alternatives for the project and its siting, and comprehensive analysis demonstrates that overall benefits from the project substantially outweigh the environmental costs. If the environmental assessment indicates that a project would significantly convert or degrade natural habitats, the project includes mitigation measures acceptable to JICA. Such mitigation measures include, as appropriate, minimizing habitat loss (e.g., strategic habitat retention and post-development restoration) and establishing and maintaining an ecologically similar protected area. JICA accepts other forms of mitigation measures only when they are technically justified.	・ The Environmental Management Act 2004 stipulates that the Minister responsible for Environmental Protected Areas by considering flora and fauna, special feature, the interests of the local communities and accordance with international society. (Article 47) ・ Under the National Policies for National Parks in Tanzania, 1994, although, the primary objectives are the protection and inheritance of natural resources (Article3.1), permission of all projects in National Parks is granted based on Environmental Impact Assessment, which clarify positive and negative impacts.	Under the domestic law in Tanzania, even within National Parks, project permission can be granted depending on the EIA result. It is not prescribed as for the necessity of analyzing if the economic benefits outweigh environmental costs.
・ Appropriate conservation and mitigation measures ・ Appropriate conservation and mitigation measures remove or reduce adverse impacts on natural habitats or their functions, keeping such impacts within socially defined limits of acceptable environmental change. Specific measures depend on the ecological characteristics of the given site. For example, complete land protection through project formulation, strategic habitat conservation, restriction of conversion or modification, reintroduction of seeds, mitigation measures to minimize ecological loss, restoration after development, restoration of deteriorated habitat, construction and conservation of ecologically similar protected areas in appropriate dimension and proximity. ・ Such measures should always include provision for monitoring and evaluation to provide feedback on conservation outcomes and to provide guidance for developing or refining appropriate corrective actions.	Under the Environmental Management Act 2004, for each national protected area, environmental management plan shall be prepared, which includes zoning, access restrictions, use restrictions and benefit sharing in order to conserve areas.	Environmental Management Plan formulated for each protected area includes conservation and mitigation measures that JICA Guidelines require. Therefore when reviewing projects requested, it is necessary to confirm if the content of Environmental Management Acts meet the requirements of JICA Guidelines and the projects required are in accordance with them.

Response policy including JICA's guideline and the World Bank's Safeguard Policy	Relevant laws in Tanzania	Main gaps
Social environment		
Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	No specific provisions on avoiding involuntary resettlement and loss of means of livelihood although these can come from Environmental and Social Impact Assessment (ESIA)	Avoiding involuntary resettlement is not mentioned in Tanzania land laws.
When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	・ When displacement is unavoidable, compensation will be given as follows (Land Act, 1999 – Cap 113, Part II Section 3 (1) (g) , Section 34 and 156) ・ Market value of unexhausted improvement [1] , disturbance allowance, transport allowance, accommodation allowance and loss of profits, although depreciated replacement value is given and valuation is often not done properly because some aspects that need to be included are not taken into account – for example, using market values is sometimes ignored and information to affected persons is not sufficiently provided	・ Full replacement value (market value) plus transaction costs are not mentioned in Tanzania laws. ・ Measures to minimize impacts are not explicit in Tanzania laws.
People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	Livelihood restoration is not addressed although, sometimes done through provision of alternative affected social services- for example, providing an alternative health facility or a school are cases in point.	Livelihood restoration is not explicit in Tanzania laws.
Compensation must be based on the full replacement cost as much as possible. (JICA GL)	Market values but usually in practice provide with depreciated replacement values (although the law does not direct the use of depreciated values)	Full replacement cost not paid.
For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	For large scale involuntary resettlement compensation must be provided (Land Acquisition Act 1967 Part II Section 11 and Land Cap 113, Part II Section 3 (1) (g))	Tanzania Law does not consider Resettlement Action Plan as mandatory.

[1] Land Act, 1999 interprets unexhausted improvement as anything or any quality permanently attached to the land directly resulting from the expenditure of capital or labor by an occupier or any person acting in his behalf and increasing the productive capacity, the utility, the sustainability of its environmental quality and includes trees standing crops and growing produce whether of an agricultural or horticulture nature. This condition has been amended by the Land (Amendment Act), 2004 by replacing Subsection 8 and 9 of the Land Act 1999 to allow for sale land without unexhausted improvements. For development purposes or as joint venture.

Response policy including JICA's guideline and the World Bank's Safeguard Policy	Relevant laws in Tanzania	Main gaps
Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	Tanzania land laws provides a mechanism for dealing with grievances including lodging complaints to the courts (Land Acquisition Act 1967, Section 13 (1) and (2) and Land Act, Cap 113. Part XIII Section 167 (1))	Tanzania grievance mechanism is not easily accessible to affected persons.
Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of valuation but have <u>invested</u> on land will be eligible for compensation of assets but not land (recognized as tenants) Land Act Cap 133	Tanzania Law does not recognize encroachers.
Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	-	The law is silent about provision of support during transition and for livelihood restoration.
Legal framework		
・Confirm that projects comply with the laws or standards related to the environment and local communities in the central and local governments of host countries; it also confirms that projects conform to those governments' policies and plans on the environment and local communities. ・Also, confirm that projects do not deviate significantly from the World Bank's Safeguard Policies.	There is Environmental Impact Assessment System provided by EMP.	There is not a difference in particular.
・EIA reports (which may be referred to differently in different systems) must be written in the official language or in a language widely used in the country in which the project is to be implemented. For explanations, documents must be formulated in a language and manner, and that are understandable to the affected local people.	EISs (EIA reports) etc. should be formulated in languages understandable to stakeholders.	There is not a difference in particular.
・In principle, host countries etc. disclose information about the environmental and social considerations of their projects. Assist project proponents etc.as needed. ・Encourage host countries etc. to disclose and present information about environmental and social considerations to local stakeholders. ・EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. The EISs are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted. ・In principle, host countries etc. consult with local	・From screening step of project, participation opportunities are provided. During EIS review period, public consultation is held and EIS is made public and comments are received verbally and in writing. ・Also, EIS is stored as official document by NEMC and available for perusal when needed.	There is not a difference in particular.

Response policy including JICA's guideline and the World Bank's Safeguard Policy	Relevant laws in Tanzania	Main gaps
stakeholders to a reasonable extent. Assist host countries as needed. ・In the case of Category A projects, encourage host countries etc. to consult with local stakeholders about their understanding of development needs, the likely adverse impacts on the environment and society, and the analysis of alternatives at an early stage of the project, and assists host countries as needed.		
・Confirm monitoring results through host countries etc. to verify environmental and social considerations are implemented surely. The information necessary for monitoring confirmation must be supplied by host countries etc. by appropriate means, including in writing. ・Also, disclose the results of monitoring conducted by host countries etc. on its website to the extent that they are made public in host countries etc.	NEMC shall conduct environmental assessment. Project proponents should store monitoring data and formulate annual report and report actual result compared with original plan to NEMC. When negative impacts were occurred, appropriate mitigation measures shall be planned and implemented.	There is not a regulation regarding monitoring result.

10.2 Location of the planned power development and the potential impacts

(1) Location of the planned power plants

Figure 10.2-1 shows the location of the planned thermal power plants. Most of the plants are located in southern part of Tanzania either along the coast or around coal mining site.

Potential location of Local Coal and Coastal Coal thermal power plants:

- Local Coal (No.22-27): Around Muchuchuma and Ngaka (coal mining area)
- Coastal Coal (No.21): along the coast in the east

Potential location of the model plants:

- Gas combined cycle power plants (No.38-43): along the coast between Mtwara and Dar es Salaam
- Coal fired (if the coal is imported) (No.44-45): along the coast between Mtwara and Dar es Salaam
- Coal fired (if local coal is used) (No.44-45): Around Muchuchuma and Ngaka

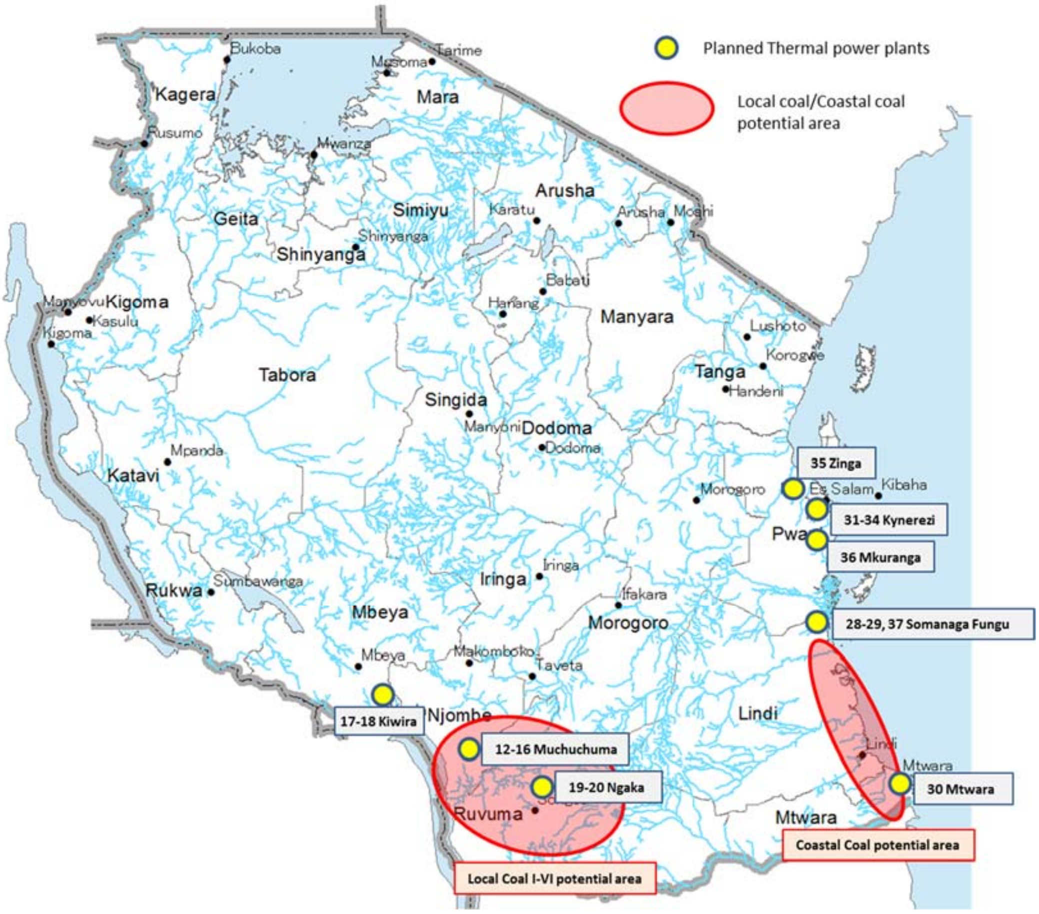


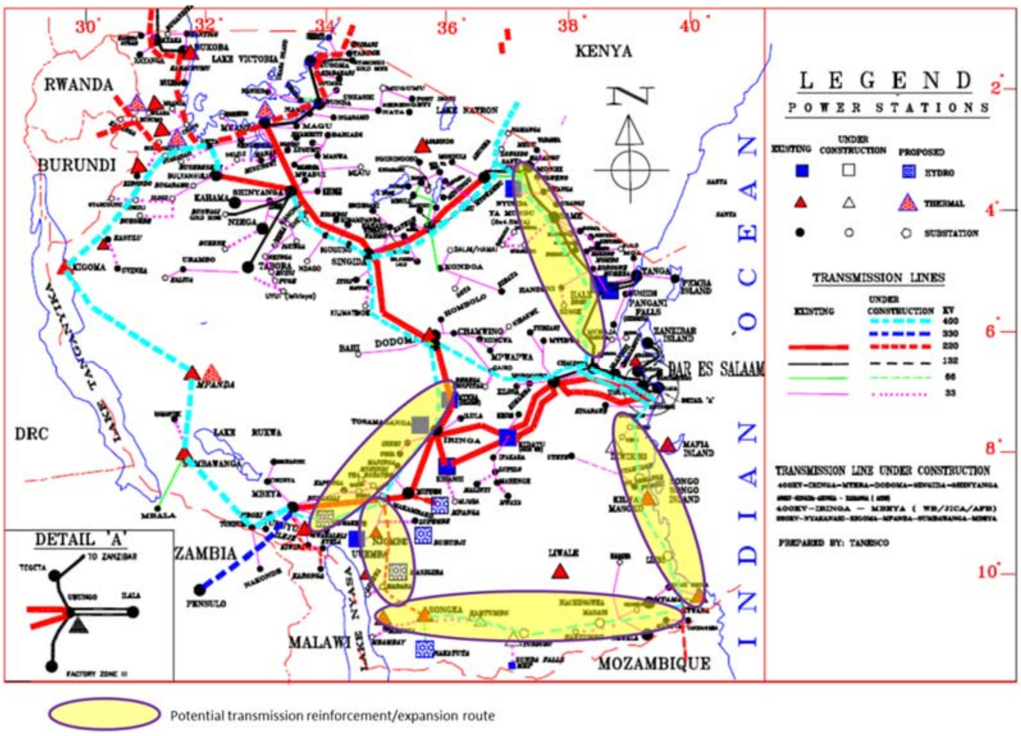
Figure 10.2-1 Location of the planned thermal power plants

Figure 10.2-1 shows the location of the planned hydro power plants and reinforcement hydro power plants. Many of the plants are located in the southwestern part of Tanzania around Kilombero valley (Rufiji River basin and sub-basins). Tanzania's south agricultural growth corridor (SAGCOT) is overlapped with this area.

Figure 10.2-2 Location of the planned hydro power plants and reinforcement hydro power plants

(2) Potential routes of transmission line expansion/reinforcement

Potential transmission reinforcement/expansion routes at the moment are shown in Figure below with yellow highlighted area.



(3) Possible impacts

Table 10.2-1 below shows the possible impacts of power plants and transmission lines. Further assessment will conducted during the course of the SEA.

Table 10.2-1 Possible impacts

Environmental Item	Gas fired thermal	Coal fired thermal	Hydro power	Transmission
1.Pollution Control				
Air Quality	B-	A-/B-	D	D
Water quality	B-	B-	A-/B-	D
Waste	B-	B-	B-	D
Soil Contamination	B-	B-	D	D
Noise and Vibration	A-/B-	A-/B-	B-/D	B-/D
Ground Subsidence	D	D	D	D
Odor	D	D	B-	D
Bottom Sediment	D	D	B-	D
2.Natural Environment				
Protected Areas	B-/D	B-/D	A-/B-	A-/B-
Ecosystem	B-	B-	A-/B-	A-/B-
Hydrology	D	D	A-/B-	D
Topography and Geology	D	D	A-/B-	D
3.Social Environment				
Resettlement	B-/D	B-/D	A-/B-	A-/B-
Living and livelihood	B-/D	B-/D	A-/B-	B-
Heritage	D	D	D	D
Landscape	B-	B-	A-/B-	B-
Ethnic Minorities and Indigenous People	N/A	N/A	N/A	N/A
Land Use and Natural Resources	B-/D	B-/D	A-/B-	B-
Water Use	B-/D	B-/D	A-/B-	D
Existing Social Infrastructure and Institution	B-/D	B-/D	A-/B-	B-
Misdistribution of Benefit and Damage	B-	B-	B-	B-
Gender/Children's right	D	D	D	D
Local Conflict of Interest	B-	B-	B-	D
HID/AIDS and diseases	B-	B-	B-	D
Working Condition	D	D	D	D
4.Others				
Accidents	B-	B-	B-	B-
Electromagnetic waves	D	D	D	B-

A+/-: Significant positive/negative impact
B+/-: Positive/negative impact to some extent.
D: No impact

10.3 Baseline information and issues to be considered

Key baseline information on environment is described below and further detail baseline information will be considered during the course of the further SEA process, based on the revised power system development plan options.

(1) Forest

According to the National Forest Resources Monitoring and Assessment of Tanzania Mainland (NAFORMA) in 2015, Tanzania has 3.36 million ha of forest area and 44.72 million other wood land.

Annual rate of reduction in forest area between 1995 and 2010 was 372,716 ha. Based on the wood balance analysis, household wood demand was the most significant, 43.0 million m^3/year.

Table 10.3-1 Annual rate of change of area for forests, other wooded lands

Year	Forest (ha)	Other Wood Land (ha)
1984-1995	-403,870 ha	-328,643 ha
1995-2010	-372,816 ha	-248,871 ha

Source: NAFORMA, MNRT, 2015

Natural Forest: There are three types of natural forests in Tanzania namely miombo woodlands, montane forests and mangroves. Tanzania is endowed with several valuable terrestrial resources that are also unique not only to Tanzania but also to the rest of the world. Such resources include the Eastern Arc Mountain forests, the Coastal forests as well as Mount Kilimanjaro, with the highest peak in Africa. Other areas include: the Ngorongoro Conservation area (NCA), Serengeti National Park, Selous Game reserve (the largest in Africa) and spectacular wetlands like Lake Natron, Moyowosi/Kigosi and Kilombero Valley without forgetting the Rufiji Delta. Nationally the montane catchment forests and other watershed areas throughout the country play an important role by conserving not only important biodiversity resources but also ensuring that water is available and flowing in streams and rivers throughout the year. Major rivers in Tanzania include Kilombero, Kihansi, Pangani, Ruvu, Wami, Rufiji, Malagalasi, Kagera, Ruvuma and Zigi.

The Eastern Arc Mountain forests are of exceptional global importance because of their high biodiversity values. The forests in the Eastern Arc area possess high endemism for instance about 100 vertebrates (10 mammals, 20 birds, 38 Amphibians, 29 reptiles) are endemic to the Eastern Arc Mountain forests. Also and about 1500 plant species including some 68 tree species, are known to be endemic to the Eastern Arc Mountains. The Uluguru Mountains alone has about 135 plant species that are confined to that single mountain block. More than 100 endemic species are known to exist in West and East Usambara Mountains and Udzungwa Ranges.

The coastal forests including about 115,000 ha of mangroves found along the India Ocean stretching from Mtwara region in the south to Tanga region in the north covering about 800 km are essential forest resources for conservation and sustainable use. The coastal forests are habits for important bird species and support fauna, which are dominated by locally endemic species. The coastal forests are centers for the valuable species such as *D. melanoxylon*, which exceptional valuable tree for wood curving and production of other important products like music clarinets.

Conservation and management of coastal forests has been a challenging task. Due to increased human pressure the coastal forests for instances Pugu, Kazimzumbwi, Zaraninge, Pande, Matumbi hill, Rondo and other forests in Coast, Lindi, Mtwara and Tanga regions have been subjected to high intensities of forest resources utilization.

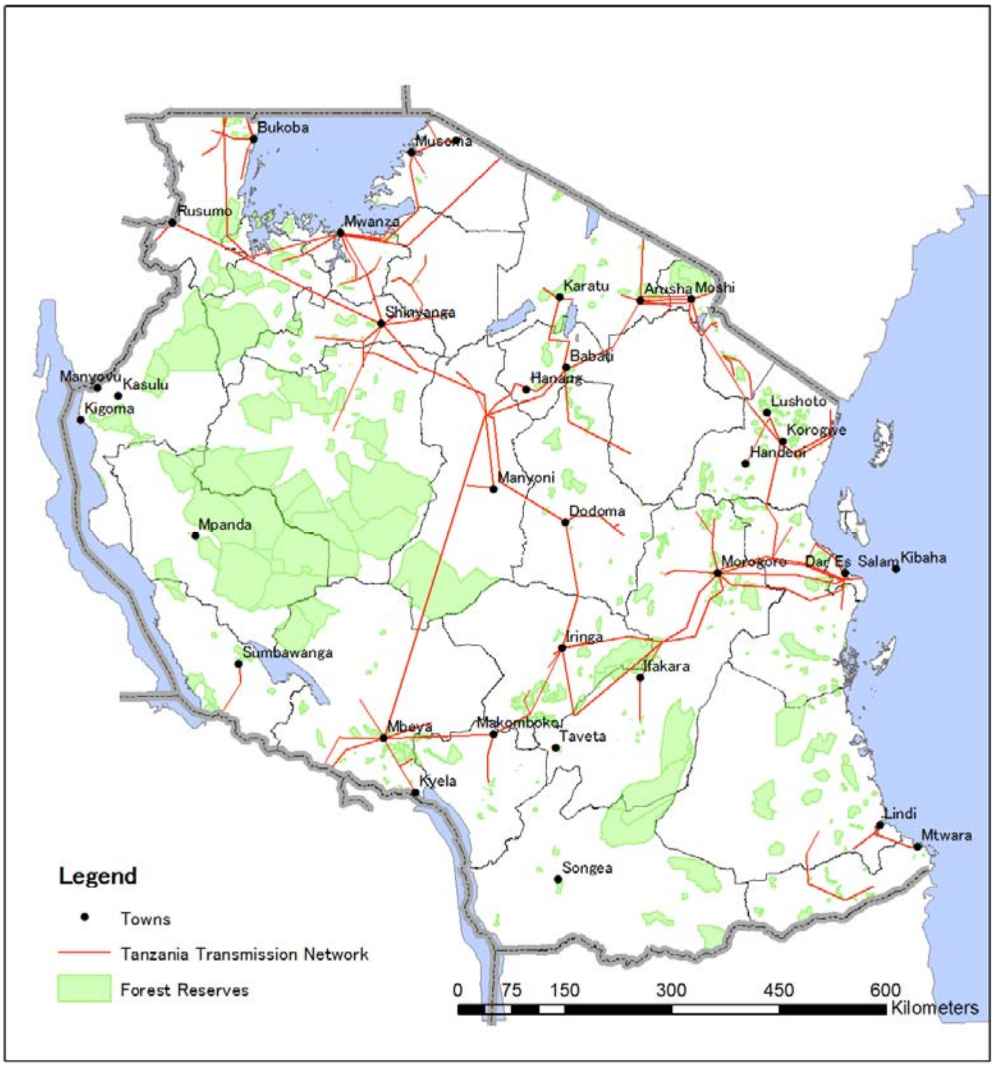


Figure 10.3-1 Forest Reserves (FRs) in Tanzania

(2) Wildlife and Protected Area (PAs)

Tanzania is endowed with significant amount of wildlife whose habitats are mainly within the Savannah grasslands characterized by dry miombo woodlands dominated by the genera of *Acacia* and *Combretum* with *A. tortilis* beatifying the landscape. About 25% of total mainland area is dedicated to conservation and protection of wildlife habitats (Table 10.3-2). The habitats further include 14 National Parks (NPs); 34 Game Reserves (GRs) as indicated in Table 10.3-3 and Table 10.3-4 respectively and 34 Game Controlled Areas (GCAs).

Table 10.3-2 Categories of Protected Areas under Wildlife Conservation

	Category	No	Area (ha)	% of total area
1	National Parks	14	3,842,800	4.1
2	Game Reserves	28	10,401,250	10.4
3	Game Controlled Areas	38	9,086,502	9.6
4	Ngorongoro Conservation Area	1	828,800	1.0
	Total		**24,660,552**	25

(State of the Environment, VPO-DOE, 2006)

Table 10.3-3 National parks (NPs) and Ngorongoro Conservation Area (NCA)

	Name of National Park	Area (ha)	When established
1	Serengeti	1,467,300	1951
2	Ruaha	1,296,000	1964
3	Mikumi	323,000	1964
4	Tarangire	260,000	1970
5	Katavi	225,300	1974
6	Mahale Mountain	157,700	1984
7	Kilimanjaro	75,600	1973
8	Rubondo	73,600	1977
9	Lake Manyara	32,500	1960
10	Arusha	13,700	1960
11	Gombe	5,200	1968
12	Udzungwa	199,000	1992
13	Saadani		2004
14	Kitulo	41,200	2005
15	Ngorongoro Conservation Area (NCA)**	828,800	1959

** Ngorongoro Conservation Area is not a national park but included in this table for convenience and easy reference. It is not managed by TANAPA but managed by the Ngorongoro Conservation Area Authority (NCAA).

(State of the Environment, VPO-DOE, 2006)

Table 10.3-4 Game Reserves

	Name of Game Reserve	Area (ha)	When established
1	Selous *	5,000,000	1905
2	Rungwa*	900,000	1951
3	Kigosi	700,000	1983
4	Moyowosi*	600,000	1981
5	Uwanda	500,000	1959
6	Ugala River	500,000	1965
7	Kizigo	400,000	1972
8	Maswa*	220,000	1969
9	Burigi*	220,000	1973
10	Umba*	150,000	1974
11	Biharamuro	130,000	1959
12	Mkomazi*	100,000	1951
13	Rumanyika	80,000	1965
14	Mt. Kilimanjaro	76,000	1951
15	Mt. Meru	30,000	1951
16	Ibanda*	20,000	1972
17	Saa Nane Island	50	1964

* National projects managed by the Wildlife Division, MNRT. Total area of Game Reserves 10,300,000 ha

(State of the Environment, VPO-DOE, 2006)

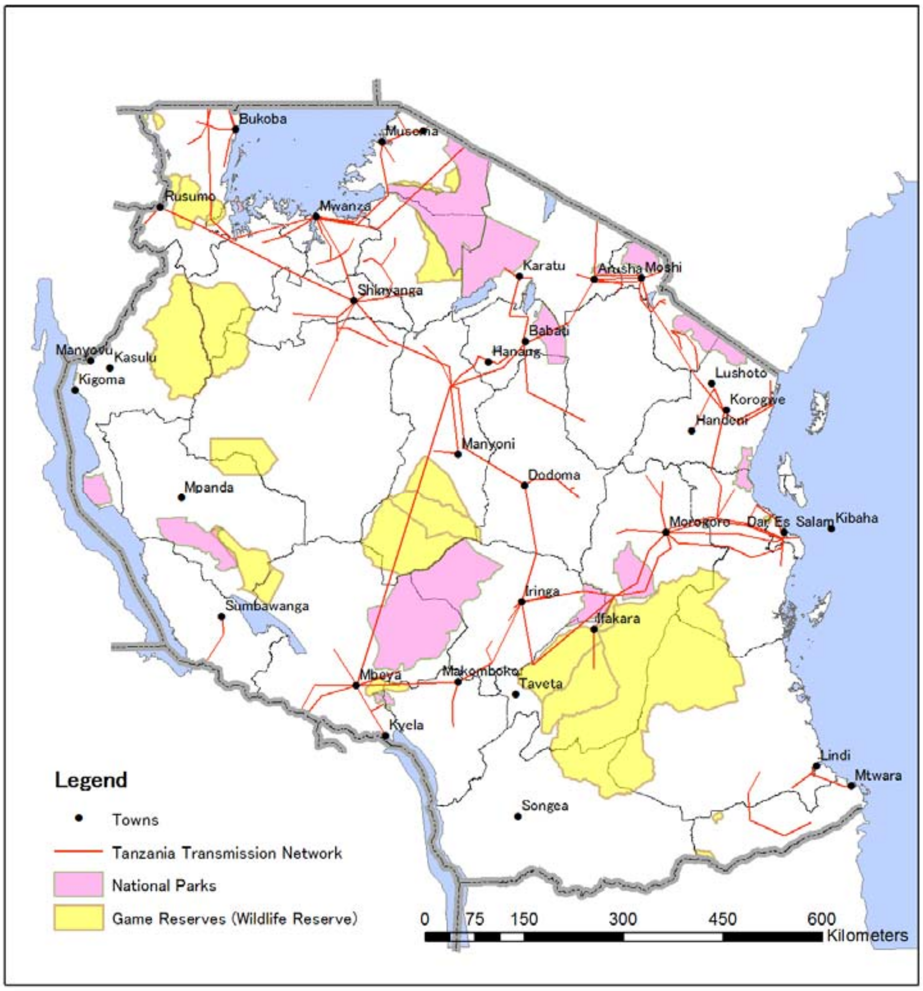


Figure 10.3-2 Location of National Parks and Game Reserves

Species Diversity: More than 300 terrestrial mammals exist in Africa and most of them are found in Tanzania. The key species include the larger carnivores such as Lions, Leopards, Cheetahs, and wild dogs. Furthermore, some additional critical species include Chimpanzee, red and blue Colobus and Mangabey monkeys including the *Lophocebus kipunji*, which are endemic to the Eastern Arc Mountain forests. Furthermore, the mammalian fauna includes the rich assemblage of species of Antelopes and Giraffes are also numerous and found in most the NPs and GRs. Endemism within the wildlife resources is high i.e. 4% (about 13 species) of terrestrial mammals and five sub-species are endemic to Tanzania. Majority of the endemic species are found only in natural forests: duikers, primates and shrews. The Eastern Arc Mountain forests (North and South Pare; East and West Usambara; Uluguru and Udzungwa) and the Coastal forests are areas of high biodiversity including endemic species. The extent of Endemism in Tanzania is shown in Table 10.3-5.

Tanzania is rich in small mammal species such as Bats (97 species), shrews (32 species) and rodents (100 species). Tanzania has 293 species of reptiles in 104 genera and 21 families and most species has a wide distribution range. The number of bird is 1065 of which 25 (2%) are endemic and mostly are forest-based species.

Wildlife corridor: Figure 10.3-3 shows wildlife corridor in Tanzania in 2008 and the majority of documented corridors in the country now seem to be in a critical condition. Corridors are being destroyed by rapid agricultural expansion, unplanned land use strategies, unmanaged natural resource extraction, increased bushmeat trade and the building of roads.

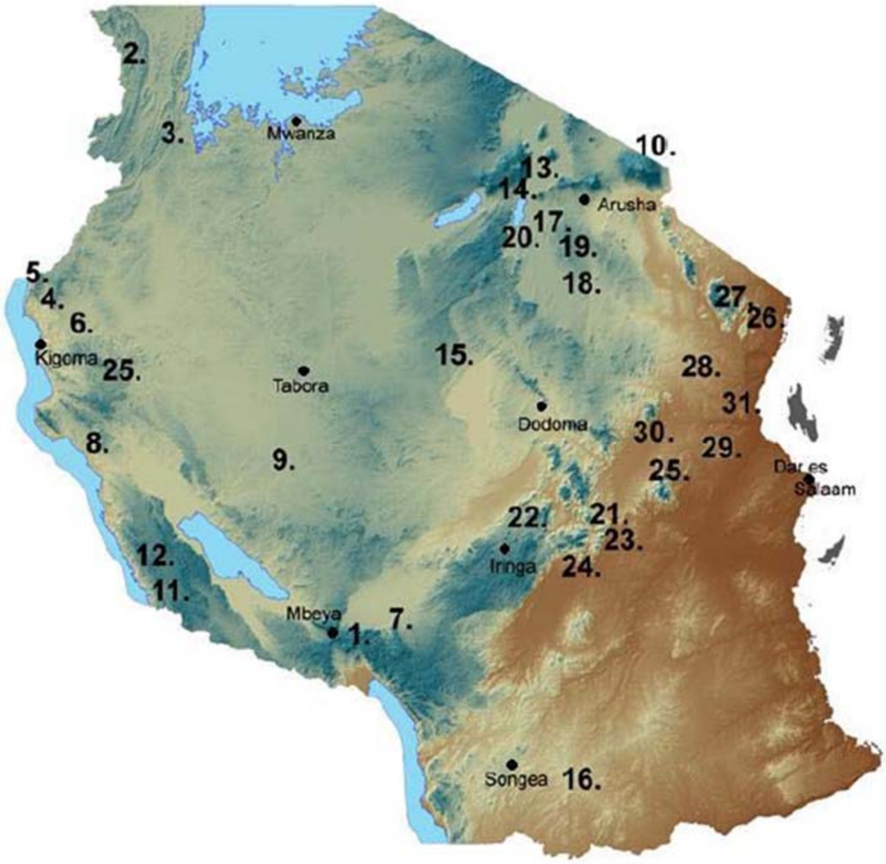


Figure 10.3-3 Summary map of wildlife corridor in Tanzania

(Wildlife Corridors in Tanzania, Tanzania Wildlife Research Institute, 2009)

Table 10.3-5 Endemic Species among the Groups and Category and their Numbers in Coastal Forests

Endemism of various groups		Endemism in Coastal Forests (biological groups)	
Type of Spp	Endemic	Biological group	No. of Endemic Species
Duikers	Abbot's Duiker	Plants	400
Shrews	Peter's musk Shrew, Amani Musk shrew, Uluguru Musk Shrew, Usambara Musk Shrew, Tanzania Mouse Shrew and Uluguru Forest Shrew	Mammals	5
Fruit-eating bats	Pemba flying fox	Birds	5
Insect-eating bats	Tanzania Woolly bat, Dar-es-Salaam Pipistreslle	Birds	20
Primates	Sanje Crested Mangabey (endemic subspecies), Uhehe (Gordon's Bay)	Frogs	5

Endemism of various groups		Endemism in Coastal Forests (biological groups)	
Type of Spp	Endemic	Biological group	No. of Endemic Species
	Colobus, Zanzibar Colobus		
Rodents	Mt. Kilimanjaro Mole Rat, Swynnerton's Bush Squirrel	Butterflies Millipedes	40 20

(State of the Environment, VPO-DOE, 2006)

Protection Status: Total area for both the NPs and the GRs is 24,326,750 ha. No permanent human settlements are allowed in PAs especially in NPs and GRs. Despite this condition some 10% of human settlements are allowed in PAs where wildlife co-exist with human beings for instance in the NCA and GCAs. There are 815 FRs which amount to about 15 million ha (about 45% of forest estate) legally protected under the forest laws, but internationally they are not categorized as protected areas. However, efforts are underway to rectify this shortfall so that the FRs are coded according to the IUCN criterion and eventually be recognized as PAs. Over 100 forest reserves that are within the Eastern Arc Mountains area have been coded. Management of PAs in Tanzania is entrusted in three different institutions namely the Wildlife Division in the Ministry of Natural Resources and Tourism (MNRT), conserving and managing the GRs, GCAs and the Wildlife Management Areas (WMAs); the Tanzania National Parks Authority (TANAPA) that is responsible for managing all the current 14 NPs and the Ngorongoro Conservation Area Authority (NCAA) entrusted to conserve and manage wildlife resources within the NCA.

(3) Coastal ecosystem

Tanzania has a coastline which stretches for about 800 km along the Western Indian Ocean from the Mozambique border in the South to the Kenya border in the North. The coast includes all areas bordering the Ocean in the five regions of Tanga, Coast, Dar es Salaam, Lindi and Mtwara as well as three large islands of Unguja and Pemba (which make up Zanzibar), Mafia and numerous islets. About two thirds of the coastline has fringing reef, often close to the shoreline, broken by river outlets like the Rufiji delta, Pangani, Ruvuma, Wami and Ruvu. It is characterized by a very narrow continental shelf which is 5.8 km wide except the Zanzibar and Mafia channel, where the continental shelf reaches a width of about 62 km. Most of the continental shelf bed is covered with coral outgrowths and some parts of the coastal margin have extensive mangrove stands.

The Sea surface temperature of the coastal waters of Tanzania averages at 27 degree but many reach 25 degree during July to September and rise to 28 degree, 29 degree in shallow areas during January to March.

Salinity values are lower during May following the peak freshwater outflow and the highest in November. The salinity values starts to decrease in February before the beginning of rains. In open ocean salinity value normally range from 34.0 to 35.5 permill. However, the salinity is low near the coast due to freshwater runoff.

Coaral Reefs: The greatest concentrations of well developed coral reefs are along the coast of Tanga, Pemba, Unguja, Mafia, Kilwa (Songo Songo Archipelago) and Mtwara.

Mangrove forests: Mangrove forests are found in all coastal districts of Tanzania. There are eight species of mangrove in Mainland Tanzania. These are *Avicenia marina, Bruguiera gymnorrhiza, Cerips tagal, Heritiera littoralis, Lumnitzera racemosa, Rhizophora mucronata, Sonneratia alba, and Xlocarpus granutum*. The largest continuous mangrove forests occur in Rufiji, Kilwa, Tanga, Muheza and Mtwara districts.

Marine Mammals: An outstanding diversity of marine mammals exists in Tanzania. The most common seen is the dolphin. Out of ten species of dolphin found in the Western Indian Ocean, eight species have been reported in Tanzanian waters. They are Indo-Pacific bottlenose dolphin (Tursiops aduncus), bottlenose dolphin (Tursiops truncate), Indo-Pacific humpback dolphin (souse chinensis), Spinner dolphin (Stenella longirostris), Pan-tropical spotted dolphin (Stenella attenuata), Risso's dolphin (Grampus griseas); rough-ttothed dolphin (Steno brendanensis) and Sousa plumbes which is a sub-species of the Indo-Pacific humpback dolphin. They are typically found in Zanzibar, Mtwara, Bagamoyo and Tanga.

Sea Turtles: Five species of sea turtles are found in Tanzania waters. These are the Green turtles, Hawksbill turtle, Olive Ridley turtle, Loggerhead turtle and Leather back turtle. Two of the five species Green and Hawksbill are known to nest on Tanzanian waters.

Sea grass: Thirteen species of sea grasses have been reported in Tanzania. They are found in abundance in sheltered areas of the coast around Tanga, and tidal zones fronting the deltas of Ruvu, Wami, and Rufiji rivers and around Kilwa.

Marine protected areas and reserves:

Marine and coastal protected areas (MPAs) in Tanzania are:

a) **Mafia Island Marine Park:** Mafia Island Marine Park (MIMP) encompasses two reserves of Chole Bay and Tutia Reef which was officially gazetted in April 1993, following the approval of the Marine Parks and Reserve Act of 1995.

b) **Mnazi Bay Marine Park:** The Mnazi Bay Marine Park which include the Mnazi Bay and Ruvuma estuary, is located at the southern end of Tanzania coast bordering Mozambique. Mnazi Bay and Ruvuma estuary have extensive mangrove forests which are breeding and nursery ground for prawns and other species including commercial fish.

c) **Marine Reserves:** Several areas were designated as Marine Reserves, and became subject to the regulations laid down in the repelled Fisheries Act of 1970, Government Notice No. 1370 of 1975. Marine reserves are areas being used for recreation, aesthetic, education and research activities. Designated marine reserves in Tanzania are found at:

- **Dar es Salaam area**: the Islands of Mbudya, bongoyo, Pangavini, and Fungu Yasini;
- **Tanga Region**: Maziwi Island (off Pangani) which has submerged in 1978.

(4) Wetland

In Tanzania wetlands are all over the country constituting about 10% of the country's land area. Wetlands have both economic and ecological importance and they are delicate therefore they have to be managed diligently to avoid destruction or drying up. Wetlands are important ecosystems which in their natural state play an important role in the water cycle through numerous functions. Figure 10.3-4 shows distribution of major wetlands in Tanzania.

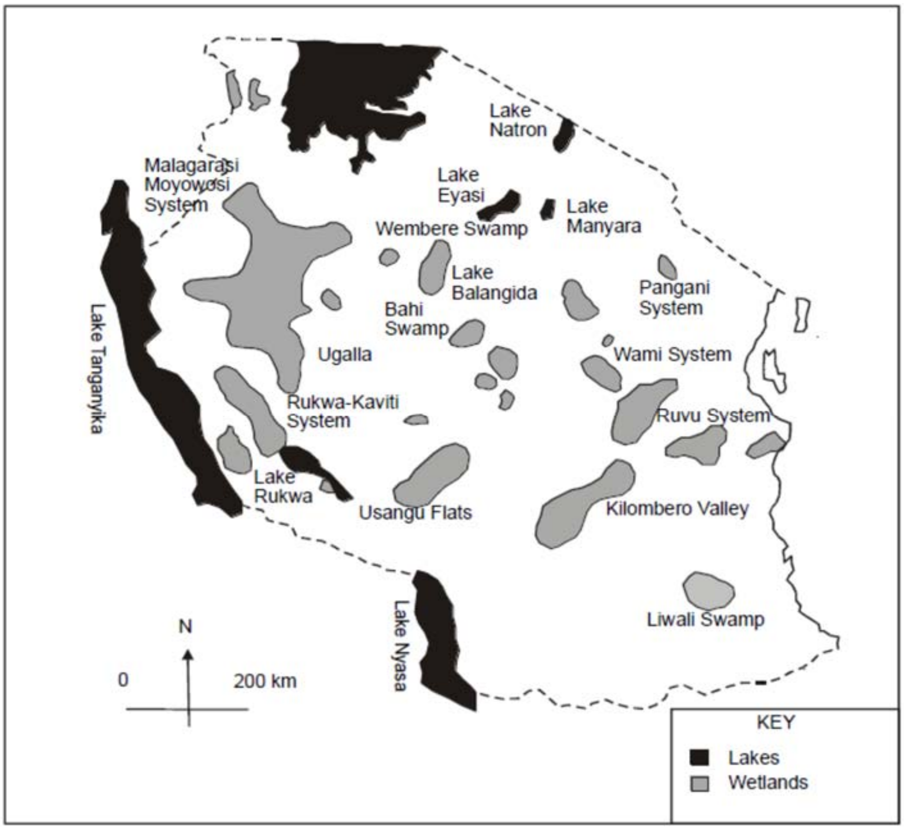


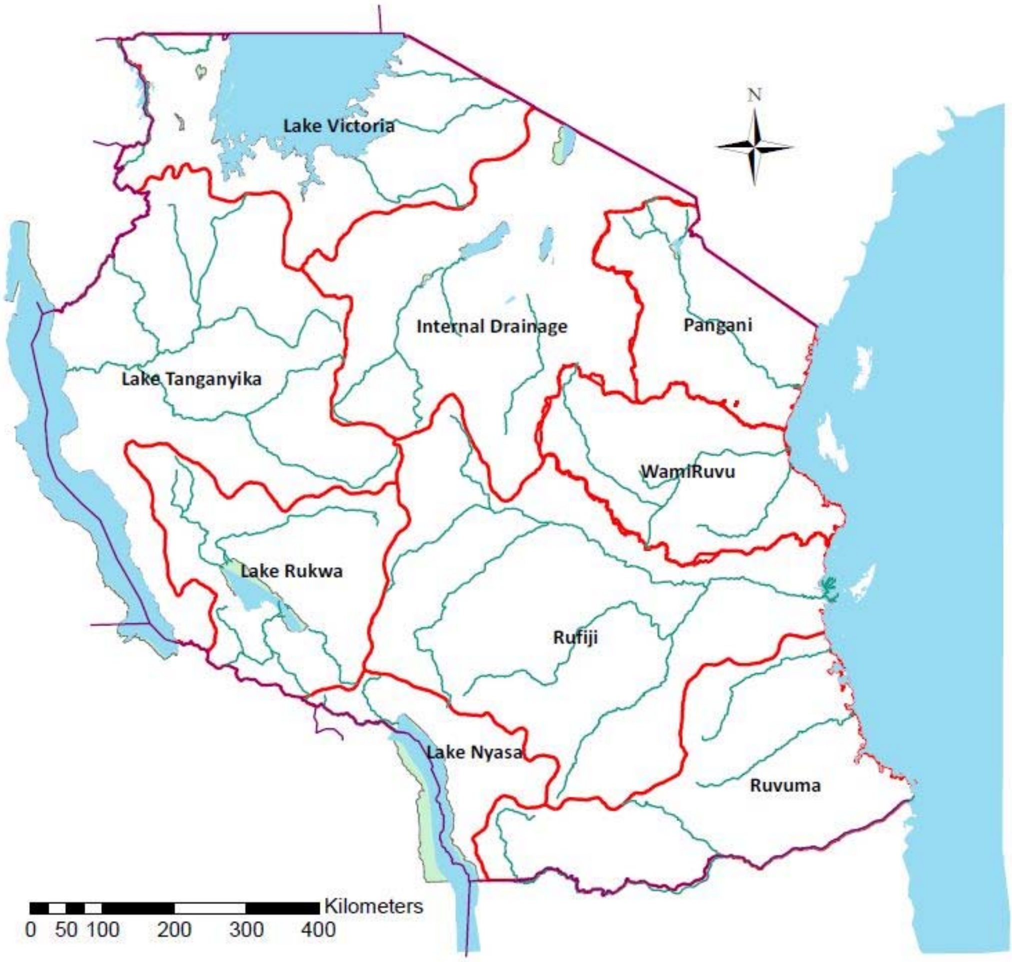
Figure 10.3-4 Major wetlands in Tanzania (State of Environment, VPO-DOE, 2006)

Tanzania complied with the Ramsar Convention in August 2000. Four wetlands with a total surface area of about 4,868,424 hectares have been designated as Ramsar sites; these are:

- Kilombero valley floodplain
- Lake Natron Basin
- Malagarasi-Muyowosi wetlands
- Rufiji-Mafia-Kilwa Marine Ramsar site

(5) Water resources

Hydrologically river basins offer the best opportunity as an appropriate planning unit. To this effect and in accordance with the Water Utilization and Pollution Control Act No. 42 of 1974, and its Amendments of Act No. 10 of 1981 the country is divided into nine Drainage River Basins (Figure 10.3-5, Table 10.3-6). Catchment degradation resulting from indiscriminate tree cutting for fuel and poor agricultural practices have caused severe land degradation at many places resulting into increased incidence of flooding in the lowland areas, sedimentation and reduced dry season flows.



Source: JICA study team

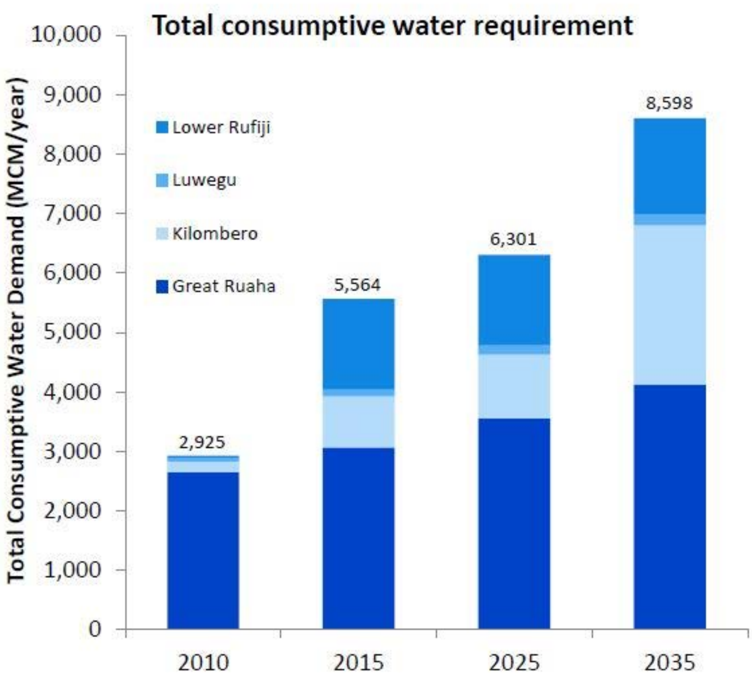
Figure 10.3-5 Map of the river basins in Tanzania

Table 10.3-6 River Basins (State of Environment, VPO-DOE, 2006)

	River Basin	Key Management Challenges
1	Pangani	High population density; water shortages; water conflicts between supply for hydropower generation and agricultural production; resource degradation.
2	Rufiji	High population density in the Ruaha Basin; water shortages; water conflicts between supply for hydropower generation, agricultural production, livestock needs, floods and environmental uses.
3	Wami/Ruvu	Increased demand and acute water shortages for Dar es Salaam, low flows in Upper Ruvu have affected reliability, unregulated river source; vulnerable to drought and floods; catchment degradation, inadequate hydrometric networks and poor baseline information.
4	Lake Nyasa/ Songwe River	Unstable Songwe River course leading to unstable international border with Malawi; fisheries management in Lake Nyasa, inadequate hydrometric networks and poor baseline information
5	Lake Victoria	Water pollution; fisheries management; wetlands and catchment degradation; and water hyacinth proliferation; local supply shortages, inadequate hydrometric networks and poor baseline information.
6	Lake Tanganyika	Water pollution; catchment degradation; fisheries management, inadequate hydrometric networks and poor baseline information.
7	Internal Drainage	Frequent droughts, acute water shortages, catchment degradation, inadequate hydrometric networks and poor baseline information.

	River Basin	Key Management Challenges
8	Lake Rukwa	Domestic water supply shortages, inadequate hydrometric networks and poor baseline information.
9	Southern Coast/ Ruvuma	Floods, land degradation, landslides, inadequate hydrometric networks and poor baseline information.

According to the latest Rufiji IWRMD Plan developed by the Ministry of Water, the consumptive water use sectors in Rufiji Basin are domestic water supply and sanitation, agriculture (crops), livestock, manufacturing, and mining. Agricultural irrigation dominates this group of users, accounting for 78 percent of the consumptive water use in an average year. The area under irrigation is currently estimated at 87,000 ha and consumes 2.4 BCM of water annually. The area of cropland under irrigation is projected to grow to 319,000 ha by 2035, and to require 7.6 BCM of water per year. The irrigation sector is dominated by traditional irrigation schemes which constitute about 60% of all schemes. Most of the schemes have poorly constructed and maintained infrastructure, and suffer from high water losses, poor water use efficiency, and low productivity. It is projected that the consumptive water demand would increase significantly in the most of the sub-basins in Rufiji Basin as shown in Figure 10.3-6. This consumptive water demand is expected to affect the hydropower generation downstream.



Source: Rufiji IWRMD Plan Draft Final Report. Volume I: Draft Plan, Ministry of Water, 2015

Figure 10.3-6 Total water demands by Rufiji sub-basin for 2010, 2015, 2025, and 2035

- **Kilombero Sub-basin (in Rufiji Basin):** The Kilombero plains receive about 1,200 to 1,400 mm of rainfall annually. Kilombero Sub-Basin comprise one of the largest freshwater wetlands in East Africa, covering an area of approximately 260 km by 52 km, that is also a designated Ramsar Site. There is also a manmade lake, the Kihansi Reservoir, which has a 25 m high dam and an installed hydropower capacity of 180 MW, with a total turbine discharge capacity of approximately 25 m^3/s. With regard to water users, although fishing and livestock rearing have traditionally been the primary economic activities in the sub-basin, agriculture (especially rice farming) is rapidly expanding and irrigation water use by far surpasses all other uses in volumetric terms. Estimates of potential irrigable area in the Kilombero Sub-Basin total some 330,000 ha.

- **Great Ruaha Sub-Basin (in Rufiji Basin):** The sub-basin has an area of approximately 85,550 km2 (some 46% of the total Rufiji Basin area) and provides approximately 15% of the average annual runoff from the Rufiji Basin, which equates to 3,300 Mm^3/year. There are two large manmade lakes in the Great Ruaha Sub-Basin. These largely regulate the hydrological regime of the river downstream: the Mtera and Kidatu Reservoirs, both of which were constructed in the 1970s. Mtera is the larger of the two and was built to store water for hydropower production at both Mtera (80 MW) and Kidatu (200 MW). Upstream of the hydropower plants the river is heavily used for irrigation. Farming in the Great Ruaha is concentrated in the southern Usangu Plains (where the Mbarali Cluster is located) and involve cultivation of maize, beans, rice, and vegetables, with the former two crops grown mostly under rainfed conditions, and the latter under irrigation. Paddy rice is the predominant irrigated crop; a core area of 15,000 to 20,000 ha can be irrigated every year, which can expand to a maximum of about 40,000 to 55,000 ha depending on water availability.
  According to the Rufiji IWRMD Plan, the total upstream water use (in Usangu as well as in the Little Ruaha and Kisigo watersheds) has already considerably impacted the inflows to Mtera hydropower reservoir. The average unimpaired Mtera inflow is 4.55 bcm/yr, but has currently been reduced to 2.95 bcm/yr. For the 2035 water use projections, Mtera inflow is estimated to decrease to 2.49 bcm/yr, corresponding to a 45% decline relative to unimpaired inflow levels.

Surface water resource: About 50% of the surface runoff flows directly into the Indian Ocean, from the major river systems of Pangani, Wami, Ruvu, Rufiji, Mbwemkuru, Matandu and Ruvuma. The Rufiji contributes 50% of this.

Groundwater resource: Groundwater potential varies from one locality to another and so does its development. Over a wide part of the country groundwater development have concentrated on small scale mainly shallow groundwater for domestic purposes. In assessing groundwater availability in the basins, Pangani basin seems to be quite potential and adequate supplies can be obtained for both domestic, industrial and irrigation purposes. Adequate supplies can be extracted for Moshi, Arusha and Tanga city water supplies. Utilization of groundwater for irrigation is possible in Sanya plains and Kahe plains. At present 88% of groundwater extracted in Pangani basin is used for irrigation purposes, 4% for Industrial use and 8% for domestic use. Sanya plains and Kahe are the areas being irrigated using groundwater.

Water use demand: Major uses of water in the country are domestic, hydropower production and irrigation.

- **Irrigation water use:** According to the State of Environment (VPO-DOE, 2006), it is estimated that about five million hectares of land in Tanzania is under cultivation. Irrigated agriculture however, covers only about 150,000 hectares of which about 120,000 hectares or 80% of the current irrigation takes place on existing traditional irrigation schemes. The remaining area of about 30,000 hectares covers the centrally managed schemes including large parastatal farms, private and public institution owned farms and modern smallholder schemes.
- **Hydropower generation:** Hydropower generation and irrigated agriculture in the basins of Pangani where Hale and Pangani Falls hydropower stations are located, and Great Ruaha where Kidatu and Mtera hydropower stations are located are in direct conflict due to the fact that all the hydropower generating plants are situated at the most downstream of basins. The problem of water conflicts, are also caused by lack of integrated and sound water resources planning. Water allocation mechanisms have been on ad hoc basis and arbitrary.

10.4 Approach to the SEA for PSMP and its implementation

10.4.1 The Objectives of the SEA

It is now apparent that many decisions affecting environmental quality, and more broadly sustainability, are made at the plan (as well as policy and programme) level rather than at the project level. The overall objective of this SEA is to integrate environmental and social considerations into power system master plan development, to improve development decisions on power system, by identifying environmental and social issues (both opportunities and constraints).

(a) SEA Screening

The screening application document was sent from the Ministry of Energy and Minerals (MEM) to the Vice President Office (VPO) in July, 2014 and a confirmation note acknowledging that MEM should continue to undertake a SEA for updating PSMP 2012 was given verbally in July 2014 but a formal letter to MEM will be attached in the draft SEA once this has been received by MEM.

(b) Objectives (Sustainability criteria) of this SEA

As described above, the key objective of this SEA is to mainstream sustainability issues in the Power System Mater Plan in Tanzania. The sustainability criteria for this SEA includes the following:

- Minimize use of non-renewable resources
- Use renewable resources within limits of capacity for regeneration
- Environmentally-sound use and management of hazardous/polluting substances and wastes
- Conserve and enhance the status of wildlife, habitats (including reduced deforestation) and landscapes
- Maintain and improve the quality of soils and water resources

- Maintain and improve the quality of environmental services both upstream and downstream of power plants
- Maintain and improve the quality of historic and cultural resources
- Maintain and enhance affordability and access to electricity for majority of Tanzanians
- Maintain and improve local environmental quality including air quality and reduction of human diseases
- Protection of the atmosphere (global warming).
- Develop environmental awareness, education and training
- Promote public participation in decisions involving sustainable development

Table 10.4.1-1 SEA objectives and potential indicators

Sustainability issues	SEA Objective	SEA indicator
Ecosystem, Fauna, Flora	・ Prevent damage to terrestrial and aquatic and soil biodiversity, particularly designated habitats sites and species.	- Status of protected areas/reserved areas/NPs - Loss or deterioration of priority habitats/species
Air quality	・ Minimize emission to air as a result of the updated PSMP implementation compared to the least cost business as usual (BAU) scenario.	- Estimated emission levels from power stations and mining areas for gases and particulate matter (Carbon Dioxide, Sulfur Dioxide, various oxides of Nitrogen)
Climatic factor (emission)	・ Minimize contribution to climate change by emission of greenhouse gases with appropriate energy mix compare to least cost business as usual (BAU) scenario.	- GHG emission from power stations
Water use	・ Avoid water use conflict between hydropower and agricultural use ・ Secure environmental flow in rivers where hydropower stations are established. ・ Maintain and improve quality of water resources (rivers and dams) from pollution ・ Maintain and improve the quality of environmental services upstream and downstream of dams	- Status of environmental flows based on 2015 baseline data on major rivers feeding hydro dams - Levels of water pollution in major hydro and coal mining and powered plants
Population	・ Minimize disruption and displacement to the local population ・ Provide reliable electricity supply ・ Maintain and improve local environmental and health quality including reduction of diseases associated with power generation	- Compulsory purchase orders in implementing the updated PSMP. - Electricity cost per unit - Number of hours of power outages due to supply and demand issues. - Number of people connected to electricity as % of 2014 baseline by 2035 - Number of people reporting respiratory, malaria, lungs and cancer related diseases associated with power generation in selected areas based on 2015 baseline conditions

Sustainability issues	SEA Objective	SEA indicator
Natural resource uses	・ Minimize use if nonrenewable resources ・ Use renewable resources within limits for capacity for regeneration	- Status of water catchment areas and environmental flows - Rate of deforestation by 2014 based on the 2015 levels
Solid and liquid waste generation	・ Environmentally-sound use and management of hazardous/polluting substances and wastes	- Amount of recycling and reuse of waste e.g. from coal as proportion of coal used

10.4.2 Steps of SEA

Followings are the steps of the SEA for PSMP.

Step 1: Scoping Study

- Identification and consultation with key stakeholders
- Identify areas or regions to be considered in the master plan.
- Identify environmental and social issue and constraints to be considered in more detail for remainder of the assignment.
- Set up appropriate institutional arrangement
- Determine the objective of SEA:
- Review relevant regulations and guidelines and outline the approach framework for carrying out the SEA
- Develop a public participation strategy
- Undertake scoping work and Produce Scoping report

Step 2: Development of detailed Terms of Reference (TOR)

- Develop detailed terms of reference for the SEA based on the result of the scoping study. Following the approval, undertaking full SEA will commence based on the approved TOR.

Step 3: The SEA Study

- The SEA study includes collection of baseline data to cover environment, social, economic, development initiatives in the proposed sites, natural resource base (water, land, wildlife, forest) their use, management and issues. Others include population dynamics. Tools include GIS will be used to present and analyze various scenarios.
- Other issues to be undertaken as part of this Task include a review of legal and institutional framework, scenario analysis, identification of impacts and development of mitigation measures, development of environmental and Social Management and Monitoring Framework for the selected development scenario.

Step 4: Development of SEA report

- The SEA report for PSMP will be developed based on the Third Schedule for the SEA Regulations, 2008.

10.4.3 Approach and implementation of the SEA

(1) General Approach

The proposed SEA process is intended to inform and involve planners, decision-makers and the general public on decision making processes that fosters sustainable development, facilitate the search for the best alternatives and ensure a democratic decision-making process. The idea is to enhance the credibility of decisions, leading to more sustainable options for power generation, supply and utilization in Tanzania.

- ✓ Administrative arrangement for the implementation of this SEA

  The Environmental Management Act Cap 191 and subsequently the Strategic Environmental Assessment Regulation of 2008 designates the Division of Environment in the Vice President's Office as the institution responsible for SEA processes. However, it also directs sector ministries to initiate and supervise the preparation of the SEA. The implementation of the programs, policy, legislation, or plan for which the SEA is necessary falls under the sector responsible for those activities, in collaboration with others sectors.

  The main institution relevant for the implementation of the SEA and its recommendations is the Ministry of Energy and Mineral (MEM). The ministry is responsible for policy issues, legal processes, and overall implementation of the policies in this SEA; it will also be responsible for overseeing the implementation of the proposed updating PSMP, 2012. The Environmental Management Act (Cap. 191) directs all sector ministries to establish Sector Environmental Coordination Units responsible for ensuring implementation of environmental law in its sector. The Ministry of Energy and minerals has established such a unit is in fully functional and with adequate manpower and facilities.

  At the level of implementation of PSMP, the Ministry of Energy and Mineral has created the EWURA, Tanzania Electricity Supply Company (TANESCO), TPDC, and Rural Energy Agency to deal with specific issues related to Energy. Overall the proposed updating of PSMP falls under MEM and will be implemented by TANESCO. EWURA directs and regulates Energy utilization, and issues licenses for generation and operation. Besides the Ministry of Energy and Minerals, several sectors may be directly involved in implementation of PSMP.

(2) Scoping study

Literature Review: Large part of this SEA will be desk based review and analysis of various issues. It is in the light of this understanding that the SEA team will embark on the review of various literature including the current PSMP, 2012 in order to understand the issues related to power generation, supply and distribution and use. Among the key documents to review will be the Tanzania Energy Policy, 2003, National Gas Policy, 2013, Electricity Act 2008, Environmental Management Act, 2004; Tanzania Development Vision 2025, Tanzania Five Year Development Plan 2012-2016; Environmental Action Plan, 2011-2016; National Climate Change Strategy 2012; the Strategy for Economic Growth and Reduction of Poverty (MKUKUTA 1 and 11).

Consultation with stakeholders: The consultative approach will ensure inclusion of all key stakeholders and segments of affected groups throughout the various stages of the SEA. The consultative strategy will facilitate sharing information with and collect inputs from various stakeholders, district-level actors and national level. The strategy will be designed not only to collect reliable information for the SEA but also to promote fuller and more systematic communication with stakeholders at different levels and with different levels of education and experience.

(a) Tanzanian Requirements for stakeholder consultations

Public consultations and stakeholder involvement are a legal requirement in Tanzania's SEA regulations. Part XIV of the Environmental Management Act No. 20 of 2004 provides directives on public participation in the environmental decision making processes. Section 178 (1) of the act provides further directives on the right of the public to information and participation in decision making, and states that public shall have the right to be informed in a timely manner of the intention of the public authorities to make executive or legislative decisions affecting the environment and of available opportunities to participate in such decisions.

(b) Stakeholder Identification

In order to develop an effective stakeholder's engagement it was necessary to determine who the stakeholders are and understand their priorities and objectives in relation to the PSMP. Recognizing the strategic importance of the energy sector, a diverse range of stakeholders were identified that could be involved in the consultation process. Having an understanding of the connections of a stakeholder group helps identify the key objectives of engagement. Following the identification of stakeholder groups and their connections, further details of stakeholder interests will be compiled. This list is a 'living documents' that will be updated as engagement progresses. This SEA identifies three main groups of stakeholders as follows:

- **Ministries**: There are various Ministries within the Government of Tanzania that have a direct link in the implementation of the Energy Master Plan these include Vice Presidents Office- Division of Environment, Ministry of Energy and Minerals as well as Ministry of Water. Ministry of Land, on land issues, Ministries of Agriculture, Ministry of Industries and trade as major consumer of energy
- **Government Parastatals**: These are Parastatals that will have a direct or indirect role in the implementation of the Energy Master Plan these include NDC, TANESCO, TPDC.
- **Private sector**: One of the major objectives of the Government of Tanzania is to engage Private sector in the investment of the energy sector; therefore investors both local and international have a major role in the updating of the PSMP. Various mechanisms are being done to prepare a conducive environment for investment as well as to ensure that there is a

harmonized relationship between investors and the Government as well as TANESCO.

This listing of stakeholders should not be seen as definitive rather it should serve as a checklist to enable an initial list to be drawn up to include the main sectors who will be interested in the outcome of the SEA. Table 10.4.3-1 below shows the initial list of identified stakeholders.

Table 10.4.3-1 List of Stakeholders

STAKEHOLDERS	ROLE/RESPONSIBILITY	ISSUES TO ADDRESS
Client Stakeholder's Group		
Ministry of Energy and Minerals (MEM)	Policy and decision maker; Beneficiary (Revenue); Key	・ Policy guidance
Vice President's Office (VPO) – Division of Environment	Regulators	・ Regulations and standards for power systems in relation to environment ・ SEA review and approval
TANESCO	Developer; Implementer; Beneficiary of the master plan Key stakeholder;	・ Production capacity ・ Power transmission and distribution infrastructures ・ Cost of production, transmission and distribution management ・ Power transmission and distribution management
Key Stakeholder's Group		
Ministry of Agriculture, Food Security and Cooperatives	Policy makers; Beneficiary; Key	・ Demand for energy for agro-processing ・ Demand for water for agriculture development
Ministry of Natural Resources and Tourism	Policy makers; Affected Not Key	・ Natural resource base (water, land, wildlife, forest) their use, management and issues.
Ministry of Industries, Trade and Marketing	Policy makers; Beneficiary: Key	・ Consumers; Demand for energy for industries
Ministry of Water	Policy makers; Affected; Key	・ Water rights; Water resource management (Quality and quantity) – Hydro-power generation
Ministry of Lands, Housing and Human Settlements Development	Policy makers; Key	・ Land acquisition and land rights (titles); Resettlement
Prime Minister's Office- Regional Administration and Local Government (PMO-RALG)	Policy makers: Beneficiary/Affected; Key	・ Land losses; Energy Consumers
EWURA	Regulator; Beneficiary (revenue); Key	・ Price and quality of electricity service to consumers
Ministry of Finance	Policy maker; Financier; Key;	・ Implementation and sustainability of the Power Master Plan
REA	Investor; Beneficiary; Key	・ Policy and regulations compliance ・ Cost of production ・ Power demand in rural areas ・ Ability and willingness to pay for power in rural areas
TPDC	Investor; Beneficiary; Regulator; Key	・ Exploration, Production and Technical services, Finance and Administration, Marketing and Investment, and Managing
National Development Corporation	Investor; Beneficiary; Key	・ Cost of production ・ Power demand and market availability
Other Stakeholders - Private Sectors/Companies		
Water Basin Bodies Authorities	Regulator;	・ Availability of water

STAKEHOLDERS	ROLE/RESPONSIBILITY	ISSUES TO ADDRESS
	Beneficiary (revenue); Key.	· Conservation measures in Catchment areas · Investors responsibility in conservation
Tanzania Chamber of Commerce Industry and Agriculture (TCCIA) -	Beneficiary	· Power availability · Power cost
Independent Power Suppliers – IPTL, SONGAS, SYMBION	Developer/investor; Key	· Investment procedures · Cost of production · Compliance to policy, laws and regulation in relation to power production
Tanzania Chambers of Minerals and Energy	Mediator between the mining investment community and key stakeholders	· Availability of electricity · Price
Tanzania Consumer Advocacy Society (TCAS)	Beneficiary; Key; Regulator	· Availability of electricity · Price
The Southern Agricultural Growth Corridor of Tanzania (SAGCOT)	Beneficiary; Key	· Availability of electricity · Water use conflict · Price

(c) Key Stakeholders Consulted during Initial/Scoping Phase

During the scoping stage, several stakeholders groups were consulted from August - October 2014. The main objective of the consultation during this phase was to:

- Introduce the study and inform stakeholders about the updating of PSMP
- Obtain their views and concerns regarding the update of the PSMP

(d) Second Phase Consultation

This entails to undertake consultation with stakeholder groups that were not consulted at the scoping stage; this mainly included private companies that are investing in the energy sector and large consumers of energy in the country. During the second phase, further consultation has been done with central government authorities mainly government ministries and its agents. The purpose of these meetings was to update stakeholders on various major issues of concern that either requires their immediate attention or need to be in the updated to take into consideration the implementation of the Master Plan.

(e) Consultation outcomes to date

Stakeholders consulted had various opinion and concerned with regard to the PSMP. Stakeholders raised several issues including the following:

- **Funds:** Stakeholders are concerned that the Government does not have sufficient funds to implement PSMP projects that fall under the plans and associated project implementation issues such as funds to pay compensation.
- **Harmonization of policies among sectors:** This was mainly a concerned due to resource utilization for instance water is an important resource for agriculture, domestic, environment, energy production and industrial development and therefore its utilization should be coordinated and in cases where an alternative is available it should be opted.

Currently, within most sectors that use water as a major raw material there are various programmes that will increase water abstraction, this needs to be harmonised.

- **Energy Projection:** The current energy projection for the Nation is 3,000MW however for other sectors it was revealed that this is a suppressed demand and has hindered heavy industries investors from investing in the country.
- **Environment:** It was recommended that investments in the energy sector should consider environmental issues such as climate change that can affect sources of energy (mainly water), technology used for various investments should be scrutinised to ensure they have minimal impact to the environment as well as ensuring that energy investments consider payment for environmental services.
- **Stakeholder's involvement in the preparation of the PSMP**: It was recommended that the PSMP should consider involving various stakeholders at the initial stages for instance donors.
- **Alternative source for base load:** Currently in Tanzania the source for base load is hydro and now gas is considered to supplement hydro, however stakeholders are recommending other sources such as coal as this has been the experience in other developed countries.
- **PPP issues**: Currently the Government has invited private companies to invest in the energy sector; however the modalities are still not clear and needs to be stipulated in the PSMP
- **Land acquisition**: Projects under PSMP involve land issues and challenge is with size of land acquired, compensation issues and land ownership.

Spatial Scope

Several regions have been identified based on the identification potential sources of power for the updated PSMP. Therefore, the spatial scope for the SEA will be all the regions where such resources are found however, detailed analysis as part of the resource assessment cost etc. may result in the selection of few such regions. For now, there are about eleven regions in Tanzania that forms the SEA scope for this PSMP as indicated on Table 10.4.3-2 below

Table 10.4.3-2 Planned Power Development and spatial scope of SEA

Regions	Hydro	Thermal		Key features and environmental issues
		Coal	Gas	
Ludewa		✔		Water demand, water pollution in major rivers and lake, emission levels, hazardous materials
Ruvuma		✔		Water demand, water pollution in major rivers and lake, emission levels, hazardous materials
Mbeya		✔		Water demand, water pollution in major rivers and lake, emission levels, hazardous materials
Mtwara			✔	Marine, coastal forest
Lindi			✔	Marine, coastal forest
Pwani			✔	Marine, coastal forest
Dar es Salaam			✔	Marine, coastal forest

Regions	Hydro	Thermal		Key features and environmental issues
		Coal	Gas	
Kagera	✔			Water demand, water pollution, agricultural lands, fresh water fisheries
Mbeya	✔			Water demand, water pollution, agricultural lands, fresh water fisheries
Njombe	✔			Water demand, water pollution, agricultural lands, fresh water fisheries
Iringa	✔			Water demand, water pollution, agricultural lands, fresh water fisheries
Morogoro	✔			Water demand, water pollution, agricultural lands, fresh water fisheries

Preparation of Scoping Report: Subsequently, a draft scoping report with up-dated TOR will be prepared and submitted to TANESCO, JICA, VPO-DOE and circulated to key stakeholders at the national, regional levels. The Scoping report has been submitted to MEM and VPO in December.

10.4.4 Implementation of the detailed SEA based one the Scoping study

10.4.4.1 Power Development Scenarios compared in the SEA

In revising the PSMP, the following five different generation mix scenarios were considered as indicated in Table 10.4.4-1. 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 10.4.4-1 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%

*: 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.

10.4.4.2 Major potential impacts

(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, SO2, and NOx in implementing the PSMP are shonwn in Figure 10.4.4-1 and Figure 10.4.4-2. The amount of emissions was estimated based on the projected annual fuel consumption and related guidelines; “2006 IPCC Guidelines for National Greenhouse Gas Inventories,” and “EMEP/EEA air pollutant emission inventory guidebook 2013.”

During the period up to 2040, emissions of GHG increases 15-fold, NOx 10-fold. SOx releases increase from 14 thousand tonnes in 2020 to 210 thousand tonnes in 2040 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, vegtation and drinking water. The acidification of soils can also have an adverse impact on agricultural productivity.

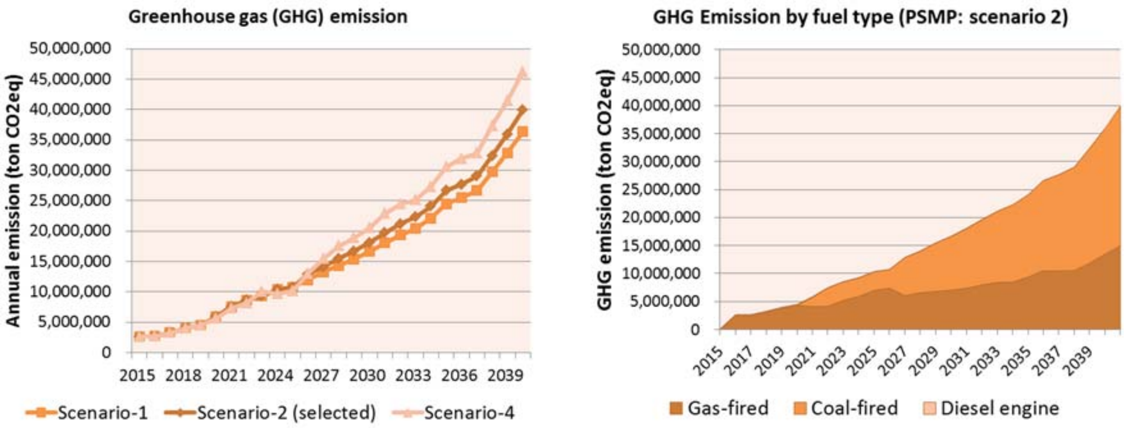


Figure 10.4.4-1 Estimated GHG emission in impelmenting PSMP

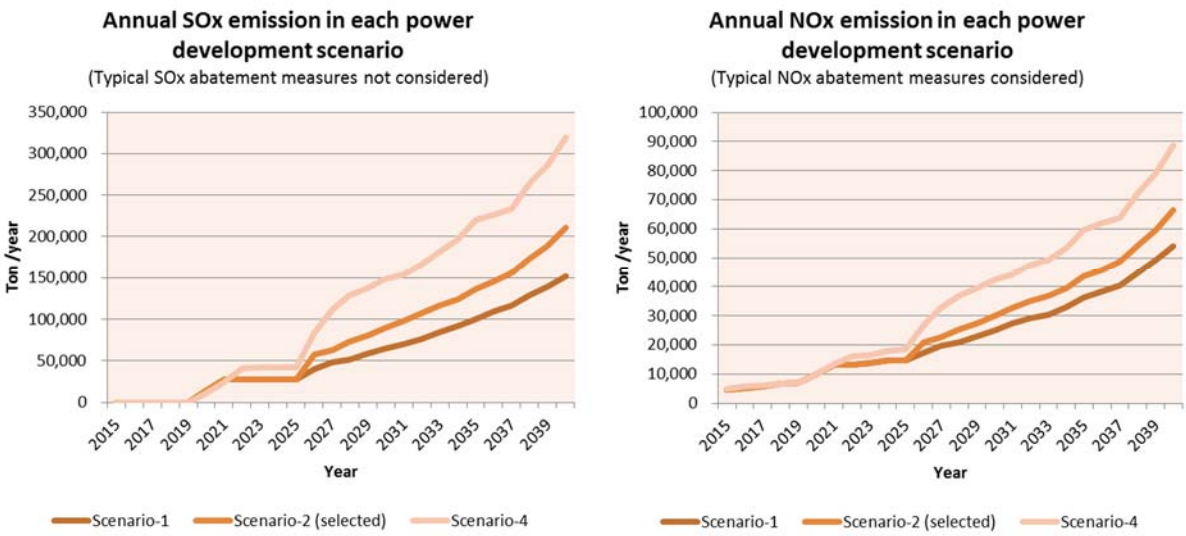


Figure 10.4.4-2 Estimated NOx, SOx emissions in impelmenting PSMP

(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 for domestic water and irrigation. It is projected that the human water demand including agricultural and domestic use would increase in the most of the sub-basins in Rufiji Basin. This human water use demand could affect the hydropower generation downstream. Catchment degradation resulting from indiscriminate tree cutting for fuel and poor agricultural practices have caused land degradation at many places 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.
Due to the large amount of water required to cool thermal power plants, and in light of the predicted future increase in energy consumption for the coming years, water withdrawals associated with power generation must be taken into consideration.

Table 10.4.4-2 Estimated water consumption by the planned thermal power plants

Fuel	Power plant name	Plant Type	Installed capacity (MW)	Water use without cooling tower (once-through-cooling) (m3/hour)	Water use with cooling tower (m3/hour)	Sub-toal without cooling tower in each area (m3/hour)	Sub-toal with cooling tower in each area (m3/hour)
Gas	Kinyerezi I	CCGT	150	13,391	223	130,407	2,169
	Kinyerezi II	CCGT	240	21,425	357		
	Kinyerezi III(Ph1) 1-3	CCGT1	300	29,886	495		
	Kinyerezi III(Ph2) 1-2	CCGT2	300	32,852	547		
	Kinyerezi IV 1-2	CCGT2	330	32,852	547		
	Bagamoyo (Zinga)	CCGT2	184	16,426	274	16,426	274
	Mtwara	CCGT2	400	32,852	547	32,852	547
	Mkuranga (PPP) 1-2	CCGT1	333	29,886	495	59,776	995
	Somanga (PPP)	CCGT1	333	29,886	495		
	Somanga Fungu-1	SCGT2	210	2.9	2.9		
	Somanga Fungu-2	SCGT2	110	1.5	1.5		
	Future CGT1(1-3)	CCGT1	990	89,657	1,485	720,367	11,990
	Future CGT3(1-10)	CCGT3	7050	630,710	10,505		
Coal	Mchuchuma-1	Sub-C	600	53,563	2,976	133,909	7,439
	Mchuchuma(Exp)1-6	A-SUB	900	80,345	4,463		
	Ngaka 1-3	Sub-C	600	53,563	2,976	133,909	7,439
	Ngaka (Exp)1-7	A-SUB	900	80,345	4,463		
	Kiwira 1-2	Sub-C	400	69,632	3,868	149,978	8,332
	Kiwira (Exp)1-2	A-SUB	900	80,345	4,463		
	Rukwa 1-2	A-SUB	900	80,345	4,463	80,345	4,463

Source: JICA study team

(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.

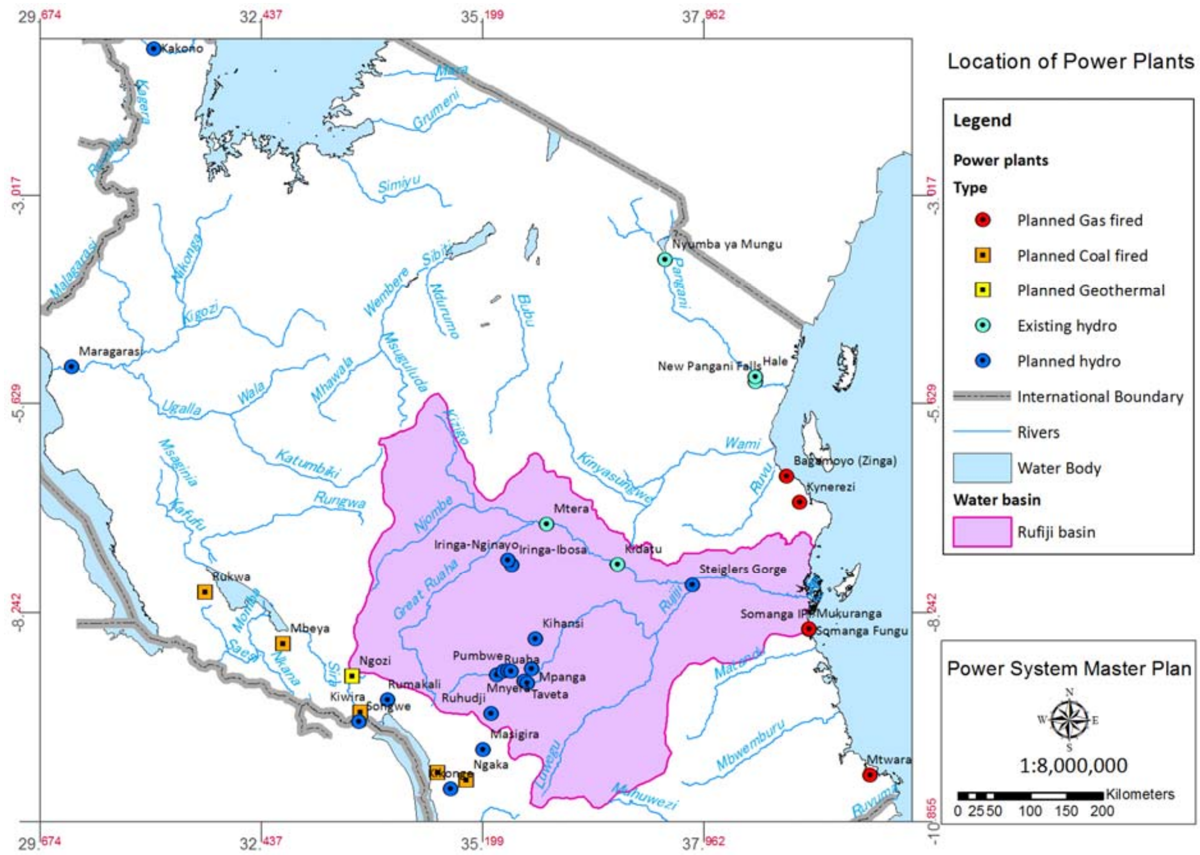


Figure 10.4.4-3 Location of planned power plants of the PSMP

(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.

(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. The amount of solid waste (coal ash) from thermal power production is estimated about 89,000 tonnes in 2020 and 1.36 million tonnes in 2040. It increases by 15 times from 2020 to 2040. The land area required for managing solid waste will increase accordingly; therefore appropriate management of coal ash is required. Coal ash contains a few lethal substances such as heavy metals, which can cause serious impacts on water resources and air pollution in waste dump areas if not managed properly.

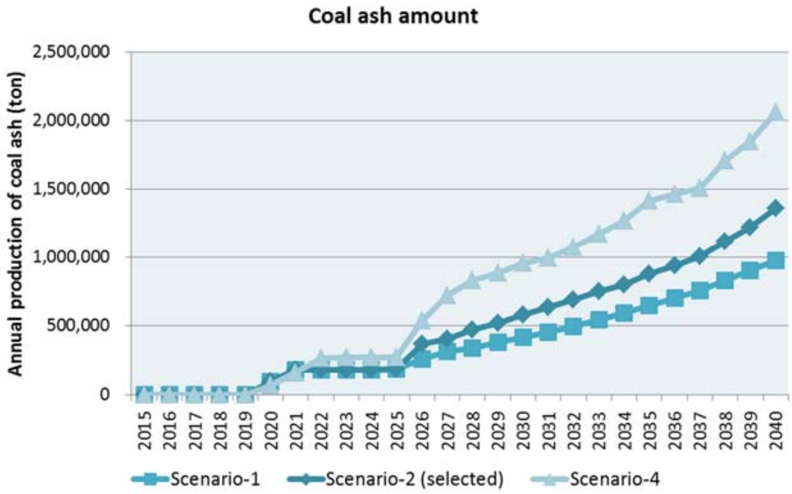


Figure 10.4.4-4 Estimated coal ash amount in implementing the PSMP

When in full operation, roughly about 436 thousand tons of coal ash would be produced in whole Muchuchuma area in a year, while about 436 thousand tons in whole Ngaka area.

Table 10.4.4-3 Estimation of coal ash amount produced by the planned coal power plants

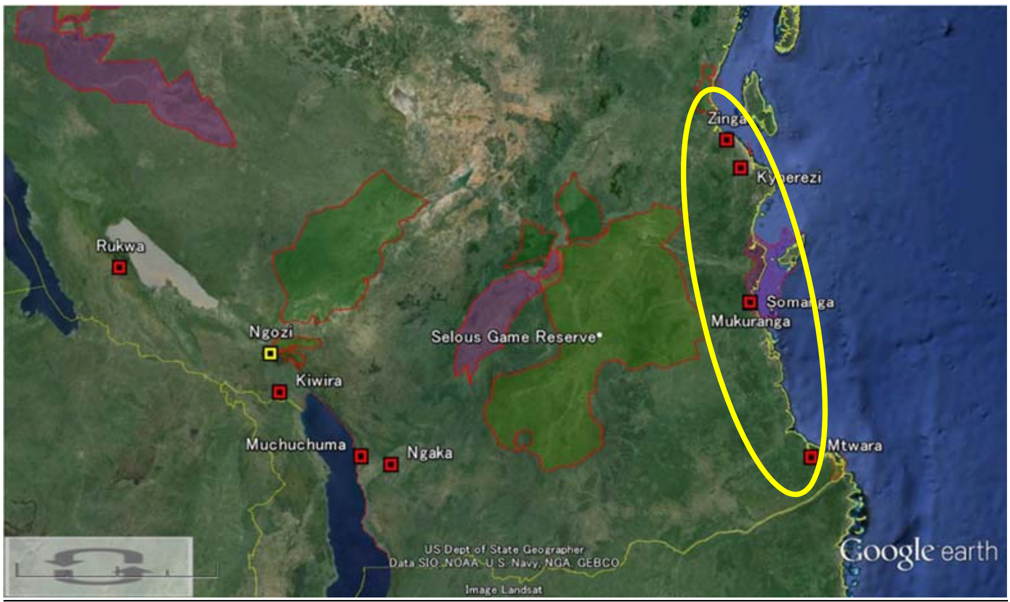
Name of the plant	Plant Type	Installed capacity (MW)	Annual Coal Ash amount (ton/year)	Sub-total annual coal ash amount in each area (ton/year)
Mchuchuma-1 Mchuchuma(Exp)1-6	Sub-C A-SUB	600 900	177,855 258,595	436,450
Ngaka 1-3 Ngaka (Exp)1-7	Sub-C A-SUB	600 900	177,855 258,595	436,450
Kiwira 1-2 Kiwira (Exp)1-2	Sub-C A-SUB	400 900	115,606 258,595	374,201
Rukwa 1+Exp	A-SUB	900	258,595	258,595

Source: JICA study team

(5) Natural environment

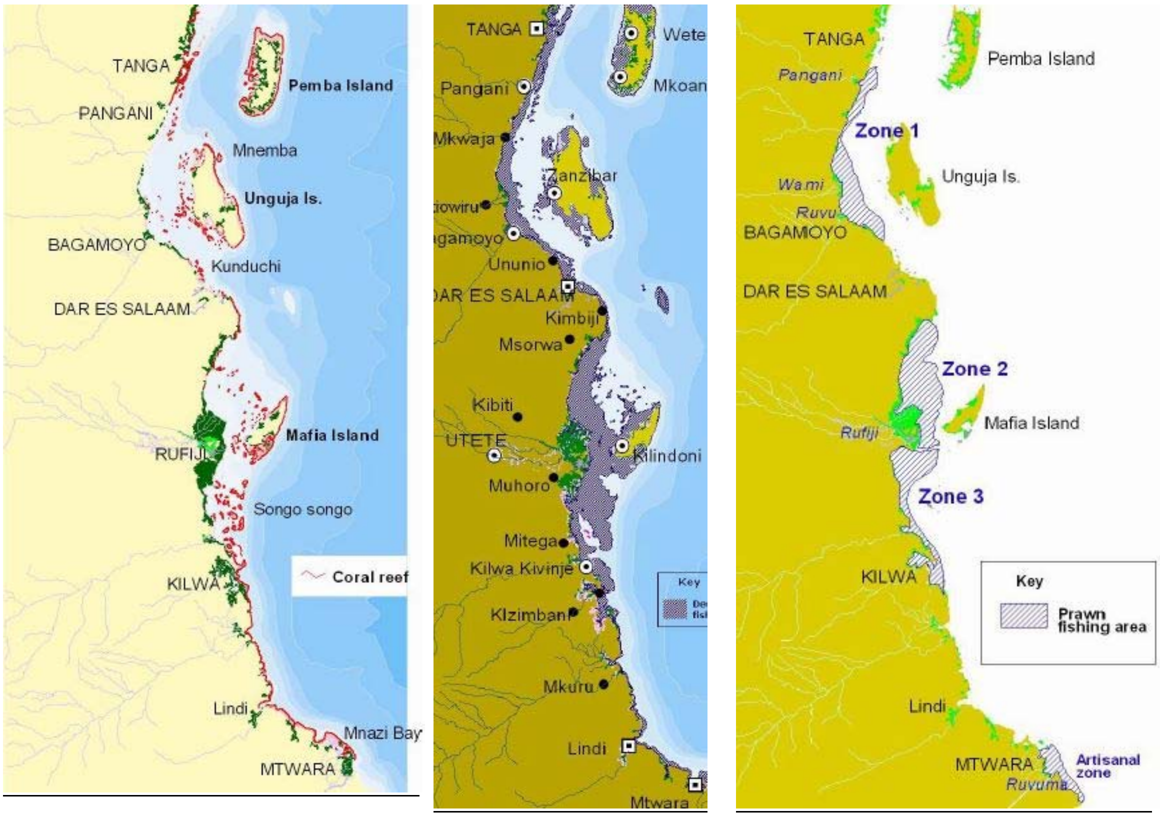
As shown in Figure 10.4.4-5, gas-fired power plants will be planned along the coastal area of Tanzania (yellow circled area), while coal power plants will planned in the western part of Tanzania nearby coal mining sites.

(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.



Source: JICA study team

Figure 10.4.4-5 Location of the planned thermal power plants and the geothermal power plant



A) Coral reef (red), mangrove forest (green)

B) Fishing area (shaded area)

C) Prawn fishing area (shaded area)

Source: Ministry of Natural Resources and Tourism, 2008

Figure 10.4.4-6 Coastal environment and fishing area along the coast where gas-fired power plants will be located

Mtwara gas-fired power plant could be located near Mnazi Bay Ruvuma Estuary Marine Park (MBREMP), which is located in Mtwara District, Mtwara Region, in southern Tanzania. MBREMP covers an area of approximately 650km^2, approximately 430km^2 of which is sea, including islands and mangrove forests and the remainder 220km^2 is terrestrial. The park was gazetted in 2000 and originally enclosed 11 villages along Mnazi Bay and the Ruvuma River's mangroves. MBREMP has extensive mangrove forests, which are breeding and nursery grounds for prawns and other species of fishes. Fisheries resources in the park area include fish, lobsters, prawns, sea cucumber, bivalves and gastropods. Sea grass beds occur in shallow water areas in the bays. Coral reefs occur as patch reefs in the Mnazi Bay and continuous fringing reefs outside the bay.

Coral reefs are located along about-two thirds (600 km) of Tanzania's continental shelf, thus comprising a very significant resource. Fringing reefs and patch reefs predominate. These reefs are found along the continental shelf, which is 8-10 km wide along most of the coast. Large continuous mangrove forests are located in Tanga, Kilwa, outlet of Rufiji river and Ruvuma river. Gas-fired power plants along the coast are necessary to consider those marine habitats (coral reef and mangrove).

(b) **Hydropower Plants:** 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.

Since many of the proposed hydropower plants are located in Rufiji Basin as shown in Figure 10.4.4-3, it is recommended to coordinate and harmonize the water use in the Basin with other water user such as for domestic water and irrigation.

Steiglers Gorge is located within the Selous Game Reserve, which is a World Heritage Site. According to RUBADA, the development of Steiglers Gorge is supported among the stakeholders after the stakeholder meeting on January 15th. During the process of EIA, UNESCO, IUCN, and other key local stakeholders should be involved. In accordance with discussion with UNESCO, the detailed ESIA is necessary to be undertaken and appropriate mitigation measures must be taken. The dam can be mentioned in the PSMP as potential source of power however, more discussions will need to be taken to clear it for development. Rufiji Basin Development Authority (RUBADA) is working with TANESCO and MEM to develop this site for power.

Table 10.4.4-4 shows the length of the zone with reduced river flow in the river where the hydropower plant is located. Some of the hydropower plants are considering environmental release, however there was no specific description on environmental release for most of the plants in the EIAs and FS reports. Depending the site environment and human activity along the river, environmental flow is recommended to be considered.

Table 10.4.4-4 Environmental flow and the planned hydropower plants

	Planned Project	Installed capacity (MW)	Basin	Name of the River	Maximum Plant discarge (m^3/s)	Environmental release (m3/s)	Reduced flow zone in the river between the intake and the tailrace outlet (km)
1	Ruhudji	358	Rufiji	Ruhudji	54.40	N/A	15km
2	Mnyera - Ruaha	60	Rufiji	Mnyera	67.00	N/A	2.8km
3	Mnyera - Mnyera	137	Rufiji	Mnyera	103.20	N/A	6.3km
4	Mnyera - Kwanini	144	Rufiji	Mnyera	105.00	N/A	N/A
5	Mnyera - Pumbwe	123	Rufiji	Mnyera	111.00	N/A	5.7km
6	Mnyera - Taveta	84	Rufiji	Mnyera	133.40	N/A	2.6km
7	Mnyera - Kisingo	120	Rufiji	Mnyera	134.00	N/A	4.2km
8	Mpanga	160	Rufiji	Mpanga	51.56	N/A	12.2km
9	Lower Kihansi Expansion	120	Rufiji	Kihanshi	16.6 /40.4	N/A	5.4km
10	Upper Kihansi	47	Rufiji	Kihanshi	25.70	N/A	1.4km
11	Iringa - Ibosa	36	Rufiji	Little Ruaha	27.85	N/A	3.1km
12	Iringa - Nginayo	52	Rufiji	Little Ruaha	30.47	N/A	3.4km
13	Steiglers Gorge Phase 1	1,048	Rufiji	Rufiji	approx. 1,077	N/A	N/A
14	Steiglers Gorge Phase 2	1,048	Rufiji	Rufiji	N/A	N/A	N/A
15	Rusumo	90	Lake victoria	Kagera	357.00	N/A	1.1km
16	Kakono	87	Lake victoria	Kagera	315.00	0.00	0m (no reduction zone)
17	Malagarasi Stage 3	45	Lake tanganyika	Malagarasi	171.00	10.00	1.4km
18	Rumakali	222	Lake Nyasa	Rumakali	19.05	N/A	N/A
19	Masigira	118	Lake Nyasa	Ruhuhu	57.00	N/A	N/A
20	Kikonge	300	Lake Nyasa	Ruhuhu	approx.265	20.00	4.5km
21	Songwe Manolo(Lower)	176	Lake Nyasa	Songwe	70.00	2.00	5.8km
22	Songwe Sofre (Middle)	159	Lake Nyasa	Songwe	60.00	1.60	6.4km

Source: JICA study team

Catchment Management: One of the key cross cutting issues identified in the course of SEA is the catchment management for hydropower. Since Kihansi catchment has been reported to be one of the good example where conservation and environmental management are taking place. Therefore, the field visit which was conducted by the SEA team (including MEM and TANESCO staff) in December in 2015, intended to explore and learn various conservation and management programs in the catchment and see if these programs can be adopted to other catchment in order to ensure sustainability of Hydro power generation for further implementation of new PSMP in the country. Kihansi catchment and Hydro Plant is located along the Udzungwa escarpment about 200 km by road southwest of the Kidatu Power Plant. The field study revealed that the implementation of conservation activities involved several stakeholders. These stakeholders are:

- The Vice President Office – under the National Environmental Management Council (NEMC)
- The Ministry of Natural Resource and Tourism – through Tanzania Wildlife Research Institute (TAWIRI).
- The Ministry of Water - through Rufiji Water Basin Office (RWBO)
- The Ministry of Energy and Minerals – through TANESCO

- Local Government Authorities and NGO’s

The main livelihood activities in the area include rain-fed agriculture; livestock keeping; fishing and fish-farming; trading on basic necessities; and harvesting of forest products. These activities are causing a major threat to water sources arises due to deforestation in search for more land for cultivation and uncontrolled valley bottom cultivation as it is shown in the following photos.

Source: JICA study team

Figure 10.4.4-7 Burning and farming along the concrete gravity dam on the Kihansi River

- Kihansi hydropower catchment is well conserved and therefore, its power generation capacity is not much affected by shortage of water as compared to other hydropower plants such as Kidatu and Mtera.
- The catchment conservation projects has been triggered by the discovery of Kihansi Spray Toads
- Tanzania, being a signatory to the Convention on Biological Diversity and Convention on International Trade of Endangered Species (CITES) is compelled to abide by these conventions
- The Kihansi catchment conservation and management is undertaken by different stakeholders including the Vice President Office – through NEMC, Ministry of Water – through RBWO, Ministry of Natural Resource and Tourism – TAWIRI and Ministry of Mineral and Energy – TANESCO
- Despite these initiatives, the environment surrounding the gravity dam on the Kihansi River is under threat to sedimentation due to various human activities taking place around the dam.

In order to ensure the sustainability of hydropower plant generation from other hydropower plants such as Kidatu, Mtera, Hale and Nyumba ya Mungu, it is important to have collective initiatives in catchment conservation and management.

(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.

(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.

10.4.4.3 Mitigation measures to potential impacts

(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.

(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.

(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.

(4) Cross-cutting issue

Inter-ministerial cooperation for water resource management: Different institutions as shown in Table 10.4-8 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. Payment for Ecosystem Services (PES) for water management and erosion control is a potential measure to ensure sustainable water supply for power generation.

Table 10.4.4-5 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

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.

10.4.4.4 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 10.4.4-6 Potential key items for monitoring the projects under PSMP2016 Update

Category	Potential key monitoring item	Related component			
		Hydro power	Thermal power	Renewables	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.

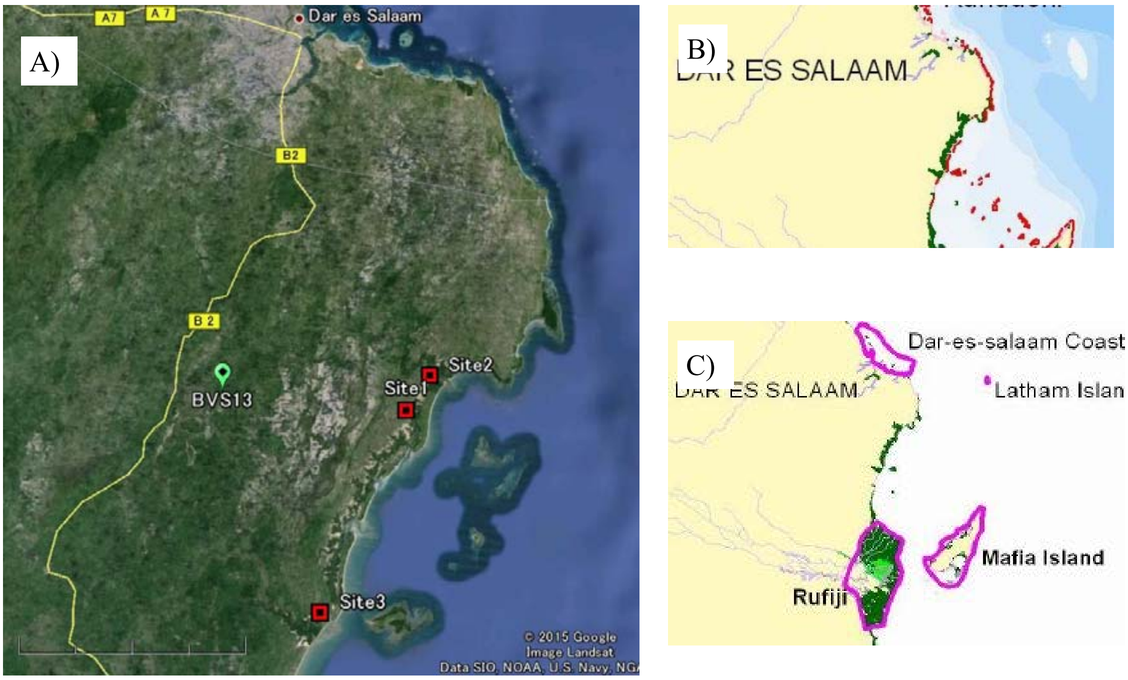
10.5 Provisional Scoping for the priority project

10.5.1 Scoping for the priority project (Combined cycle gas turbine power plant)

A scoping (plan) was formulated for the initial stage of the gas-fired power plant, which was considered as the priority project in the power development plan in section 8.3.5. An overview of this priority project is as follows.

＜Gas-fired power generation＞

- Form: Combined cycle gas turbine based on an aero-derivative gas turbine
- Fuel: Natural gas
- Expected method for cooling: Seawater cooling as the power plant is located in a coastal area (near the gas pipeline)
- Location: As shown in Figure 10.5.1-1, a site in the Mukuranga region, located 40km to 60km south of Dar es Salaam, which is part of the coastal region located along the gas pipeline stretching from Dar es Salaam and Mtwara. There are 3 potential sites in the Mukuranga region.
- Summary of expected impacts: As confirmed on Google Earth, there was hardly any indication of residents living in the vicinity of the 3 sites. Thus, it can be considered that no large-scale resettlement will take place. On the other hand, mangrove forests and coral reefs are found in the coastal region, and these ecosystems can possibly be impacted by the construction of the power plant or by the discharge of water used for cooling (impacts to seawater temperatures and flow, marine fauna and flora, costal fisheries can be expected with the discharge of warm water). There are no National Parks, wildlife reserves, marine reserves, or Ramsar wetlands in the vicinity. However, fieldwork should be conducted before deciding upon the final location for the power plant, as the mangrove forests near site 1 and 2 can possibly be mangrove forests that are subject to conservation.



A:3 potential sites, B:distribution of the mangrove forest near the potential site (green) and coral reefs (red)、C:habitats for important wild birds in the vicinity of the potential site (pink)
Source: A:JICA investigation team、B and C: Ministry of Natural Resources and Tourism in Tanzania 2008

Figure 10.5.1-1 Vicinity of the potential sites for the priority project

Table 10.5.1-1 Preparatory scoping for the priority project (gas combined cycle power generation)

Environmental items	Preparatory scoping		Reasons for evaluation
	During construction	After operation	
1.Measures against pollution			
Air pollution	B-	B-	<During construction> Emissions of exhaust gas and dust can be expected from construction vehicles and machinery. <After operation> Generation of nitrogen oxide is anticipated from the combustion of natural gas.
Water contamination	B-	B-	<During construction> Decline in water quality due to sewage from the site of construction, construction machinery, dormitories for workers etc., spilled oil and wastewater can be expected. <After operation> Water quality deterioration from the discharge of sewage, oil-related waste water, heat recovery boiler water, and cooling water from the worker dormitories etc. can be expected.
Waste	B-	B-	<During construction> The generation of waste soil and debris from construction can be expected. <After operation> During operation: the generation of industrial waste (oil waste, raw sludge etc.) resulting from power plant operation, maintenance and management activities can be expected to some extent.
Soil contamination	B-	B-	<During construction and after operation> There is a possibility for the generation of effluents, such as oil waste, that could contaminate the soil.
Noise and vibration	B-	B-	<During construction> Noise and vibration resulting from the operation of construction machinery and the passage of construction vehicles can be expected. <After operation> Noise and vibration can be expected from the operation of the power plant.
Ground subsidence	D	D	<During construction and after operation> Large-scale groundwater pumping is not expected. Although excavation work will be conducted where the power plant will be installed, the possibility of ground subsidence is low.
Odor	D	B-	<During construction> No odor from construction or operation is anticipated since this project does not expect to use any substances that generate odor. <After operation> Odor can possibly be generated from substances such as fuel that is used in the operation of the power generation facility.
Bottom Sediment	B-	D	<During construction> Soil erosion could be occurred during the partial cut soil construction works.

Environmental items	Preparatory scoping		Reasons for evaluation
	During construction	After operation	
2.Natural Environment			
Protected Areas	B-	B-	<During construction and after operation> National Parks, Marine parks, Wildlife reserves, Ramsar sites are not located at and around the proposed sites. However, fieldwork should be conducted before deciding upon the final location for the power plant, as the mangrove forests near site 1 and 2 can possibly be mangrove forests that are subject to conservation.
Ecosystem	B-	B-	<During construction and after operation> Mangrove forests and coral reefs are found in the coastal area nearby the proposed sites, and these ecosystems can possibly be impacted by the construction and operation of the power plant.
Hydrology	B-	B-	<During construction and after operation> Since the construction work is conducted near/around the estuary, excavation works and placement of the intake and outlet would affect the river hydrology.
Topography and Geology	B-	D	<During construction> Due to the cut soil works, the topography of around the project area would be altered.
3.Social Environment			
Resettlement	B-	C	<During construction> As confirmed on Google Earth, there was hardly any indication of residents living in the vicinity of the 3 sites. Thus, it can be considered that no large-scale resettlement will take place. Depending on the final site selection, several relocations could be expected. <After operation> If there is any resettlement in relation to the power plant development, monitoring after the resettlement should be conducted.
Poverty group	B-	B-	<During construction and after operation> Although there is hardly any indication of residents living in the vicinity of the 3 sites, coastal sea area is also fishing area for fishery. Some fishermen belong to poverty group would be affected due to the construction and operation of the power plant.(If there is such poor fisherman)
Living and livelihood	B+	B+	<During construction> Opportunities for employment could increase during construction. < After operation> Improvement of power supply could improve livelihood.
Heritage	D	D	<During construction and after operation> There is no cultural and historical heritage in the project site.
Landscape	B-	B-	<During construction and after operation> Installation of power plant facility would affect coastal landscape.

Environmental items	Preparatory scoping		Reasons for evaluation
	During construction	After operation	
Ethnic Minorities and Indigenous People	D	D	<During construction and after operation> There is hardly any indication of residents living in the vicinity of the 3 sites, and no impact on ethnic minority and indigenous people is expected in the project area.
Land Use and Natural Resources	D	D	<During construction and after operation> Careful selection of the power plant site could prevent deforestation of mangrove forest around the project area.
Water Use	B-	B-	<During construction and after operation> Apart from water use during the construction, large amount of water intake from the sea is expected for cooling since the once-though cooling system is expected to be adopted in the proposed combined cycle gas turbine power plants.
Existing Social Infrastructure and Institution	D	B+	<During construction> There is no existing social infrastructure nearby the proposed sites. < After operation> Stabilization of power supply is expected.
Social capital and social institutions related to community decision making	B-	B-	<During construction and after operation> Since the coastal sea area nearby the proposed power plant sites is the fishing area, fishery communites would be affected.
Misdistribution of Benefit and Damage	B-	B-	<During construction and after operation> Proposed power plant sites are not located populated area, installation of the power plant would not affect any specific community groups around the proposed area. However, fishery group(s) using the coastal sea near the power plant sites would be negatively affected.
Gender/Children's right	D	D	<During construction and after operation> No significant impact on gender and children's right are expected.
Local Conflict of Interest	D	D	<During construction and after operation> There is hardly observed people living around the proposed site and therefore no local conflict is expected. The project will improve the local electricity supply as public service. This item is, therefore irrelevant.
HIV/AIDS and diseases	B-	B-	<During construction and after operation> As the scale of the construction, operation and maintenance work is not a large scale and local laborers will be employed, there is no tangible risk of a disaster or occurrence of infectious diseases due to the mass inflow of laborers from other areas.
Working Condition	B-	B-	<During construction> Injuries due to accidents or incidence of diseases could increase during construction. < After operation> Risks of electrocution and falling from high places would be expected.
3.Others			
Accidents	B-	B-	<During construction and after operation> Although there is hardly observed people living around the proposed site, traffic volume might increase due to the construction

Environmental items	Preparatory scoping		Reasons for evaluation
	During construction	After operation	
			and operation of the power plant and the risk of traffic accident at major route for those vehicles would be increased.
Trans-boundary and global issue	D	B-	< After operation> Emission of greenhouse gases is expected by the combustion of natural gas at the power plant. Compared to other type of power plants such as simple cycle gas turbine power plant, emission will be less because of the efficiency.

A+/-: Significant positive/negative impact is expected

B+/B-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown

D+/-: No impact is expected

10.5.2 Potential Environmental and Social Impacts and its mitigation measures for the Priority project

With regard to the priority project, the potential major impacts to be investigated and assessed during the course of EIA, the survey methods for those impacts, and its mitigation measures are summarized as follows.

Item	Assessment aspect	Method	Mitigation measures
Consideration of Alternatives	・ Based on the potential three sites, compare alternatives of power plant location	・ Comparison of the extent of potential impact on mangrove and coral reef. ・ Comparison of the extent of potential impact on fishery	・ Selection of the alternative location with least impact on surrounding ecosystem environment and fishery.
Air quality	・ Air pollution from vehicles during the construction ・ Air emission by the power plant operation	・ Baseline survey on the current ambient air quality ・ Estimation of construction vehicle traffic amount ・ Identification of source of air emissions and estimation of emission amount ・ Conduct air dispersion simulation for smoke emission including NOx emission	・ Appropriate management of construction vehicle ・ Adoption of low NOx burner ・ Comply with IFC/Tanzanian air quality standards ・ Installation of monitoring equipment at the stack ・ Secure enough height of the stack
Water quality	・ Impact of effluent discharge ・ Impact of the cooling water discharge	・ Baseline survey on the water quality in the river and sea near the project site. ・ Survey on the types and amount of waste water and its treatment ・ Survey on the planned water quality of the effluent and comparison with the IFC/Tanzanian standards ・ Survey on the location of the discharge point and way of discharge ・ Survey on the location and the way of the cooling water intake ・ Projection of the potential impact on the marine habitat by the cooling water discharge	・ Installation of appropriate wastewater treatment facilities such as oily water separator, septic tank, neutralization treatment facility. ・ Periodical monitoring of wastewater at the discharge passage ・ Appropriate location selection of cooling water intake and installation of protective fence against marine habitat into the intake ・ Control of velocity of intake and discharge of cooling water ・ Control the temperature difference between intake and discharge water (e.g. maximum 7℃) ・ Conduct monitoring of the impact on mangrove , coral reef, and fishing area
Waste	・ Waste management during the construction and operation of the power plant	・ Survey on the types and amount of the waste produced during the construction and operation. ・ Survey on the amount and treatment of the general waste and hazardous waste ・ Survey on the waste management policy and organization	・ Establishment of waste reduction and reuse plan during the construction and operation phase ・ Development of waste management procedures ・ Establishment of waste management organization ・ Use authorized waste treatment companies
Noise and vibration	・ Noise and vibration caused by the construction and operation of the power plant	・ Baseline survey on current ambient noise level around the project site and comparison with the related standards. ・ Projection of the noise level caused by the construction and operation of the power plant and comparison of IFC/Tanzanian	・ Installation of sound proof-wall and silencer to the source of noise during construction and conduct monitoring of noise level ・ Facilities which produce high noise such as a gas turbine, a heat recovery steam generator (HRSG), and a steam turbine are within

Item	Assessment aspect	Method	Mitigation measures
		standards	the building having enough noise reduction ・ Conduct noise monitoring at the boundary of the power plant site.
Protected area	・ Confirmation of mangrove forest preservation status around the site 1 and site 2	・ Survey on the current condition of the mangrove forest around site 1 and site 2 and confirmation of preservation status with the Ministry of Natural Resources and Tourism.	・ Selection of power plant site considering the preservation status of mangrove forest around the site 1 and site 2.
Ecosystem	・ Impact on the terrestrial and marine ecosystem around the potential three sites	・ Survey on terrestrial and marine habitat around the project site (especially on important and endangered species) ・ Baseline survey on mangrove forest and coral reef around the project site and assessment of potential impact on these habitat by the cooling water intake and discharge ・ Survey on habitat around the potential intake and outlet points	・ Transplanting seagrass to appropriate location if seagrass bed is located within the impacted area ・ Installation of artificial reef for coral ・ Take prevention measures on spillage of hazardous substances ・ Conduct ecosystem monitoring ・ Prevent from discharging wastewater which does not meet the waste water quality standards
Resettlement	・ Identification of potential resettlement impact by the construction of the power plant and its mitigation measures, if identified.	・ Residential survey around the potential three sites.	・ Having consultation with affected people and implement appropriate compensation and assistance, if any ・ If there is any resettlement, conduct monitoring on resettlement.
Livelihood	・ Impact of the fishery around the potential three sites	・ Survey on current fishery activity around the coastal area near the project site ・ Assessment of potential impact of cooling water intake and discharge	・ Selection of appropriate location and structure of water intake and outlet. ・ Prior explanation to fishermen ・ Monitoring of impact on fishery resources
HIV/AIDS and diseases	・ Impact of influx of workers outside the project area during the construction and operation	・ Survey on the volume of influx workers from outside the area during the construction and operation ・ Survey on the workers camp site and its facility plan ・ Consideration of potential contact with local residents ・ Survey on health service facilities around the project site	・ Establishment of health service facility in the workers campsite ・ Awareness raising on HIV/AIDS and diseases to the workers ・ Control of pest and vector, disinfection
Accidents	・ Consideration of accident risk and its mitigation measures during the construction and operation	・ Assessment of potential accident risk and consideration of prevention measures such as installation of safety facility and equipment, and establishment of safety management organization	・ Development of the procedure for emergency response ・ Traffic safety awareness training ・ Installation of fire extinguishing equipment, oil-proof facility, warning system. ・ Installation of secondary container for liquid material tanks

10.5.3 Environmental and Social Monitoring Plan

Based on the above mentioned potential impacts and mitigation measures, the draft environmental and social monitoring plan is as shown in below.

Impacts	Item	Monitoring Location	Monitoring Frequency	Reporting
Construction Phase				
Marine Ecological Environment	Condition of the important marine habitat such as mangrove forest, coral reef.	Determined during the EIA	Once a month	Once a year
Effluent Water Quality	Items in accordance with the Effluent Water Quality standard	Water Outfall	When discharged	Every half a year
Waste	Types of the waste, amount, disposal method	Construction site	All times	Once a year
Resettlement	Relocated households, Affected households, Compensation	Project affected area (if identified)	Once a month	Once a year
Accident	Implementation of heal and safety management plan, Incident of accidents	Construction site	Once a month	Once a year
Operational Phase				
Ambient Air Quality	NOx, SO_2, PM10, etc.	Determined during the EIA	Continuously	Every half a year
Emission Gas	NOx, SOx, CO, etc.	Stack of the gas turbine Stack of the HRSG(heat recovery steam generator)	Continuously	Every half a year
Effluent Water Quality	pH, Temperature, Residual Choline, Salinity, Dissolved Oxygen	Water Outfall	Continuously	Every half a year
Sea Water Quality	pH, Temperature, Residual Choline, Salinity, Dissolved Oxygen,	Monitoring Point, Reference Point	Continuously	Every half a year
	TPH (Total Petroleum Hydrocarbon), BOD, COD, Fecal Coliform		Once a month	
Noise	Noise Level	Project Boundary Work area with high noise level	Once a month	Every half a year
Marine Ecological Environment	Condition of the important marine habitat such as mangrove forest, coral reef.	Determined during the EIA	Conducting baseline survey after the construction. During the operation phase, monitoring to be implemented at appropriate frequency	After the survey completed
Waste	Types of the waste, amount, disposal method	Power plant site	All times	Once a year

Chapter 11 Proposal to TANESCO for Implementation of PSMP

11.1 Challenges for the Implementation of Power System Master Plan

11.1.1 Financial Situation of TANESCO

Audited financial statements of TANESCO are published up to the year 2013. Therefore, the financial statements are analyzed up to 2013.

(1) Profit and Loss Account

The Profit and Loss of TANESCO is showed in Table 11.1.1-1.

Table 11.1.1-1 Profit Loss Statement of TANESCO

Unit: TSh. million

Item / Year	2,005	2,006	2,007	2,008	2,009	2,010	2,011	2,012	2,013
Revenues									
Domestic	32,606	35,258	43,588	50,910	47,430	47,288	47,255	60,574	53,978
General use	72,881	70,237	93,452	114,291	130,370	164,611	205,175	335,276	410,254
Low-voltage	36,654	39,927	50,192	62,937	62,481	71,280	76,231	111,955	116,062
High Voltage	61,029	65,648	79,944	107,330	136,755	152,471	146,027	220,672	248,206
Zanzibar	6,038	6,799	8,453	18,650	22,020	15,065	27,548	37,586	47,450
Gold mines & other mining	12,450	14,277	16,377	17,139	14,445	15,762	43,422	54,373	57,575
Total sales revenues	221,658	232,146	292,006	371,257	413,501	466,477	545,658	820,436	933,525
Government contribution	41,075	55,132	109,312	32,709	37,501	30,651	171,134	185,903	225,301
Chargeable works for Customers	7,911	3,433	5,453	39,689	26,182	40,289	34,755	55,586	43,163
Interest on overdue bills	27,309	26,872	28,882	26,433	18,452	15,237	20,436	6,954	8,050
Support services & grant	4,596	1,713	579	252	1,537	-	1,338	198	7,482
Reconnection fees	473	335	648	283	491	528	634	759	589
Profit on disposal of plant, etc.	101	127	108	106	60	145	73	72	-
Other	1,743	2,563	7,148	13,200	82,367	19,657	50,961	49,917	41,389
Total other operating revenues	83,208	90,175	152,130	112,672	166,590	106,507	279,331	299,389	325,974
Total operating revenues	304,866	322,321	444,136	483,929	580,091	572,984	824,989	1,119,825	1,259,499
Sales expenditures									
Own Gener. & Transm.	32,039	56,748	59,204	71,438	109,423	120,541	230,730	401,379	359,971
Purchased electricity	179,252	241,998	243,503	193,433	195,446	211,713	346,021	527,816	812,396
Distribution expenses	41,277	44,260	51,271	67,121	95,497	107,828	121,355	160,359	160,896
Depreciation	26,788	27,812	30,349	35,032	38,758	52,170	55,291	72,883	84,252
Total sales expenditures	279,356	370,818	384,327	367,024	439,124	492,252	753,397	1,162,437	1,417,515
Trade & other impairment	13,586	62,978	35,008	33,395	25,781	-			-
VAT liability provision			2,627	7,454	1,462	7,349			-
Support service & consultant	5,986	1,713	579	252			9,685	3,091	9,649
Staff costs	20,038	27,939	30,326	34,676	32,476	39,613	43,985	58,522	54,674
Depreciation	3,380	3,531	3,495	5,245	10,135	10,474	17,295	13,797	12,087
AFUDC prepayment amortiz'n	528	528	528	20	2,176	4,217			
Obsolete inventory provision		1,337	(4,209)	2,247	(4,079)		(3,361)	(139)	587
Stock write-off (provisions)	18,989		4,308	4,041	2,295	(665)	116	8,035	-
Repairs & maintenance	760	680	669	2,202	1,160	505	297	636	260
Transport & travel	2,275	1,695	1,815	2,614	3,284	3,643	5,453	7,365	9,038
Other administrative expenses	7,757	15,629	47,785	22,152	39,706	11,715	32,807	39,649	142,342
Retrenchment costs	12	7							
Capital work write-off	2,115	45	149						
Operating expenditures	75,426	116,082	123,080	114,298	114,396	76,851	106,277	130,956	228,637
Total operating expenditures	354,782	486,900	507,407	481,322	553,520	569,103	859,674	1,293,393	1,646,152
Investment adjustm't impairm't		1,054	12						
Operating profit or loss	(49,916)	(165,633)	(63,259)	2,607	26,571	3,881	(34,685)	(173,568)	(386,653)
Net finance expense/income	73,646	(17,523)	(3,975)	(24,311)	(63,200)	(47,810)	(41,526)	(50,515)	(81,051)
Profit/ loss before tax	23,730	(183,156)	(67,234)	(21,704)	(36,629)	(43,929)	(76,211)	(224,083)	(467,704)
Income tax/ credit	(24,590)	(187)			76,786	(3,383)	32,784	45,629	-
Profit/ loss after tax	(860)	(183,343)	(67,234)	(21,704)	40,157	(47,312)	(43,427)	(178,454)	(467,704)

Source: TANESCO, 「Financial Statements of TANESCO」, 2006 - 2013

Operating activity in 2013 shows historic operating loss of Tsh.467,704 million (about JPY 30billion). The other operating income includes the government contribution that account for 18% of operating revenue in 2013. The operating activity showed profit during 2008 to 2009. However, even in this period operating accounts were losses without the government contribution as those contributions were bigger than operating profits.

The main reason of loss in operating activity is that sales expenditure exceeds sales revenue consistently, and the big losses were realized specially since 2011 as sales expenditure increased rapidly against revenue (Table 11.1.1-2). Therefore, TANESCO's business is basically keep losing money; cannot be sustained without the financing contribution from the government.

Table 11.1.1-2 Ratio of the Government Contribution in Operating Revenue & Sales Expenditure in Sales Revenue

Items	2005	2006	2007	2008	2009	2010	2011	2012	2013
Government Contribution/ Operating Revenue	13.5%	17.1%	24.6%	6.8%	6.5%	5.3%	20.7%	16.6%	17.9%
Sales Expenditure/ Sales Revenue	126.0%	159.7%	131.6%	98.9%	106.2%	105.5%	138.1%	141.7%	151.8%

In the sales revenues, the general use (using power for general purposes including residential, small commercial, light industry uses and public lighting) is the largest, accounting for 43.9% of the total sales revenues in 2013. The high voltage is the second largest (accounting for 26.6% in 2013). Once accounts for 15% in sales revenue, the current domestic usage declined to 6% (Table 11.1.1-3).

Table 11.1.1-3 Ratio of Electric Type Usage in Sales Revenue

Items	2005	2006	2007	2008	2009	2010	2011	2012	2013
Domestic Use	14.7%	15.2%	14.9%	13.7%	11.5%	10.1%	8.7%	7.4%	5.8%
General Use	32.9%	30.3%	32.0%	30.8%	31.5%	35.3%	37.6%	40.9%	43.9%
Low Voltage	16.5%	17.2%	17.2%	17.0%	15.1%	15.3%	14.0%	13.6%	12.4%
High Voltage	27.5%	28.3%	27.4%	28.9%	33.1%	32.7%	26.8%	26.9%	26.6%

Concerning the expenditure, the purchased electricity accounts biggest ratio in operating expenditure. Especially a big expand of this cost in 2013 was the main cause of the historic loss of TANESCO in 2013 (Table 11.1.1-3).

TANESCO's own generation and transmission cost account for 20%~30% recently, up from 9.0% in 2005. These expenditures include staff costs and O&M expenses for generation, transmission and distribution. The depreciation in sales expenditures derives also from the assets for generation, transmission and distribution. The other operating expenditures such as depreciation and staff costs are for general administration such as head office and regional office administration functions.

Table 11.1.1-4 Ratios of Purchased Electricity, Generation and Transmission in Sales Expenditure

Items	2005	2006	2007	2008	2009	2010	2011	2012	2013
Purchased Electricity	50.5%	49.7%	48.0%	40.2%	35.3%	37.2%	40.3%	40.8%	49.4%
Generation & Transmission	9.0%	11.7%	11.7%	14.8%	19.8%	21.2%	26.8%	31.0%	21.9%

(2) Balance Sheet

The balance sheet of TANESCO is shown in Table 11.1.1-5 and ratio of main items in Table 11.1.1-6. Property, plant & equipment account for more 70% and capital in work for 11% respectively. These two items occupy around 80% in total assets recently.

Share capital and advance towards share capital accounts for 35.6% of the total equity and liabilities in 2013, showing the decreasing share trend. On the other hand, grant and borrowings in non-current liabilities account for 53.6%, increasing the debt ratio. As a result, the capital ratio decreased consistently to 20% in the most recent data, the long-term investments for fixed assets were financed by the borrowings instead of the capital and reserves. Also, the accumulated loss increases year by year and exceeds the total amount of the share and the advance towards capital.

Table 11.1.1-5 Balance Sheet of TANESCO

Unit: TSh. million

Item / Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
Non-current assets									
Property, plant equipment	1,144,890	1,157,578	1,181,449	1,302,071	1,828,480	1,982,451	2,035,738	2,247,081	2,662,769
Capital work in progress	25,895	14,579	124,813	77,221	66,359	189,165	396,106	435,314	427,424
Intangible asset					232	116		-	2,734
Investment property								-	725
Investments	1,055	1	13	13	13	13	13	1,056	1,056
Capacity charges prepayment	9,274	8,746	8,218	8,198	65,393	61,176	56,356	51,878	47,399
Total non-current assets	1,181,114	1,180,904	1,314,493	1,387,503	1,960,477	2,232,921	2,488,213	2,735,329	3,142,107
Current assets									
Inventories	33,004	24,382	35,435	53,535	65,452	57,761	73,566	127,739	123,659
Assets held for sale								-	561
Trade & other receivable	79,325	56,409	58,543	89,873	250,101	169,515	209,198	224,914	260,618
Prepayments								100,650	65,663
Current income tax recoverable	6,269	6,082	4,742	4,901	5,392	2,140	2,479	2,617	3,013
Bank & cash balances	11,929	43,113	88,724	176,017	94,470	104,256	139,891	127,591	178,241
Total current assets	130,527	129,986	187,444	324,326	415,415	333,672	425,134	583,511	631,755
Total assets	1,311,641	1,310,890	1,501,937	1,711,829	2,375,892	2,566,593	2,913,347	3,318,840	3,773,862
Capital & reserves									
Share capital	293,912	293,912	986,717	986,717	986,717	986,717	986,717	986,717	986,717
Advance towards share capital	693,193	837,846	154,346	156,967	158,406	158,635	159,943	161,913	359,909
Accumulated losses	(493,445)	(676,788)	(733,136)	(753,640)	(713,483)	(760,795)	(804,222)	(982,676)	(1,450,380)
Revaluation reserve	501,286	501,286	499,784	499,033	781,370	853,192	853,270	854,325	854,325
Total equity	994,946	956,256	907,711	889,077	1,213,010	1,237,749	1,195,708	1,020,279	750,571
Non-current liabilities									
Grants	154,568	19,167	130,283	169,382	249,172	406,046	629,768	816,097	1,021,181
Borrowings	60,038	101,603	248,785	408,833	466,891	402,236	377,299	237,206	1,000,543
Consumer deposits	8,710	10,568	11,961	13,105	13,865	14,431	15,329	15,895	23,048
Other employment benefits			19,116	18,766	19,273	20,028	20,275	21,396	22,482
Trade and other payables								-	34,594
Total non-current liabilities	223,316	131,338	410,145	610,086	749,201	842,741	1,042,671	1,090,594	2,101,848
Current liabilities									
Bank overdraft							36,723	126,728	-
Trade & other payables	70,968	108,560	164,887	202,236	321,883	302,798	472,213	707,012	789,439
Borrowings	22,411	114,736	19,194	10,430	47,582	104,925	120,403	374,227	132,004
Deferred tax liability					44,216	78,380	45,629	-	-
Total current liabilities	93,379	223,296	184,081	212,666	413,681	486,103	674,968	1,207,967	921,443
Total liabilities	316,695	354,634	594,226	822,752	1,162,882	1,328,844	1,717,639	2,298,561	3,023,291
Total equity & liabilities	1,311,641	1,310,890	1,501,937	1,711,829	2,375,892	2,566,593	2,913,347	3,318,840	3,773,862

Source: TANESCO, 「Financial Statements of TANESCO」 2006 - 2013

Table 11.1.1-6 Ratio of Major Assets, Liability and Capital in total assets of Balance Sheet

tems	2005	2006	2007	2008	2009	2010	2011	2012	2013
Property, Plant & Equipment	87.3%	88.3%	78.7%	76.1%	77.0%	77.2%	69.9%	67.7%	70.6%
Capital work in progress	2.0%	1.1%	8.3%	4.5%	2.8%	7.4%	13.6%	13.1%	11.3%
Share capital + Advance towards Share capital	75.3%	86.3%	76.0%	66.8%	48.2%	44.6%	39.4%	34.6%	35.7%
Grants + Borrowings	16.4%	9.2%	25.2%	33.8%	30.1%	31.5%	34.6%	31.7%	53.6%
Total Equity (owned capital)	75.9%	72.9%	60.4%	51.9%	51.1%	48.2%	41.0%	30.7%	19.9%

Source: JICA Study Team based on TANESCO data

(3) The Borrowings

The borrowings and grans balance in 2013 are stated in the Table 11.1.1-7 and Table 11.1.1-8. The borrowings increased due to the new borrowings from the syndicate loans. Loan payments to the some commercial loans are delayed.

Table 11.1.1-7 Borrowings

(Long-term: Tsh. 1,000,543 million, Short-term Tsh. 132,004 million.)

- Tanzanian Government (converted into equity): TSh. 100,072 million
- Syndicated loan: TSh. 54,086 million
- Tanzanian Government (Capacity charge): TSh. 237,515 million
- ING Bank (Optical fiber): TSh. 34,265 million
- ING Bank (Tageta 45MW): TSh. 32,706 million
- IDA (Songosongo): TSh. 6,188 million
- EDCF-TEDAP: TSh. 10,962 million
- ADF (Electricity V): TSh. 15,111 million
- EDCF-Korea (Transmission): TSh. 10,456 million

New borrowings in 2013

- EIB (Transmission): TSh. 15,217 million
- IDA (Transmission) : TSh. 14,543 million
- ADF (Transmission) : TSh. 8,511 million
- JICA (Transmission) : TSh. 7,578 million
- Syndicated loan (Facility A): TSh. 205,475 million
- Syndicated loan (Facility B): TSh. 135,553 million
- Government (Standard Bank): TSh. 158,868 million
- Government (IDA): TSh. 49,137 million
- CRDB Short credit: TSh. 36,304 million

Source: TANESCO、「Financial Statements of TANESCO」2013

Table 11.1.1-8 Grants

TSh. million

- SIDA (Electrification of Urambo & Serengeti and Transmission): TSh. 10,533 million
- ORET (Netherlands): TSh. 38,069 million
- TEDAP (Transm. & Distr.): TSh. 52,272 million
- Songosongo: TSh. 16,800 million
- JICA (Transm. & Distr. system): TSh. 29,944 million
- Treasury (EPP): TSh. 279,735million
- World Bank (Songas capacity charges): TSh. 39,046 million
- JICA (Rehab.): TSh. 35,084 million
- MCC T&D: TSh. 163,088 million

Source: TANESCO、「Financial Statements of TANESCO」2013

(4) Tariffs

The customer categories for the tariff are as follows.

- D1: Domestic low usage (single phase 230V)
- T1: General usage (general purposes including residential, small commercial and light industrial use, public lighting and billboards: not exceeding 7,500kWh on average)
- T2: Low demand voltage (400V, less than 500kVA per month)
- T3-MV: Medium demand voltage: (11 kV and above)
- T3-HV: High demand voltage (132 kV and above including Zanzibar Electricity Corporation, Bulyanhulu Mines and Twiga Cement)

Tariffs for the customer categories are shown in the Table below.

Table 11.1.1-9 Tariffs for the customer categories

Unit: TSh. VAT excluded

TANZANIA ELECTRIC SUPPLY COMPANY LIMITED														
TARIFF RATES FROM MAY 2002 TO JANUARY 2014														
VAT EXCLUSIVE														
TARIFF STEP		**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
		Tsh	**Tsh**	**Tsh**	**Tsh**	**Tsh**	**Tsh**	**Tsh**	**Tsh**	**Tsh**	**Tsh**	**Tsh**	**Tsh**	**Tsh**
D1	0-50 kWh	0	0	30	38	38	40	49	49	49	60	60	60	100
	Over 50	0	0	115	115	121	128	156	156	156	195	273	273	350
	Service charge	0	0	0	0	0	0	0	0	0	0	0	0	
T1	0-100 kWh	26	26	90	95	100	106	129	129	129	157	221	221	306
	Over100	90	90	0	0									
	Service charge	1,500	1,500	1,660	1,700	1,785	1,892	2,303	2,303	2,303	2,738	3,841	3,841	5,520
T2	kWh	59	59	60	63	66	70	85	85	85	94	132	132	205
	kVA	6,220	6,220	6,500	6,900	7,245	7,680	9,347	9,347	9,347	12,078	16,944	16,944	15,004
	Service charge	6,000	6,000	6,000	6,300	6,615	7,012	8,534	8,534	8,534	10,146	14,233	14,233	14,233
T3	kWh	56	56	56	59	61	65	79	79	79	84	118	118	163
	kVA	6,050	6,050	6,050	6,400	6,720	7,123	8,669	8,669	8,669	10,350	14,520	14,520	13,200
	Service charge	6,000	6,000	6,000	6,300	6,615	7,012	8,534	8,534	8,534	10,146	14,233	14,233	16,769
T4	kWh	54	54	23	24	26	28	75	75	75	83	106	106	159
ZANZ.	kVA	7,344	7,344	3,350	3,510	3,686	3,907	4,755	4,755	4,755	8,610	12,079	12,079	16,550
	Service charge	10,507	10,507	6,000	6,300	6,615	7,012	8,534	8,534	8,534	10,146	14,233	14,233	14,233

Source：JICA Study Team based on TANESCO data

For each category, there is service charge per month and energy charge per kWh except D1, which does not have service charge. In addition, T2 and T3 have demand charge per kVA. Furthermore, there are connection (new service line) charge and other service charges. The new service line charge consists of new application (TSh. 5,000) and connection charge depending on the distance and pole numbers as well as (LUKU) meter depending on rural or urban and single- or three-phase customers. However, this meter charge is not accounted as revenues in profit and loss account, but in non-current liabilities as consumer deposits because if the customer stopped the use, the deposit will be refunded. The other service charges are for testing and inspecting installations, replacing meters, reconnection and temporary supplies.

Based on the revenues and consumption (kWh) by customer category, unit prices or average consumption rates (TSh./kWh) can be calculated shown in Table 11.1.1-10.

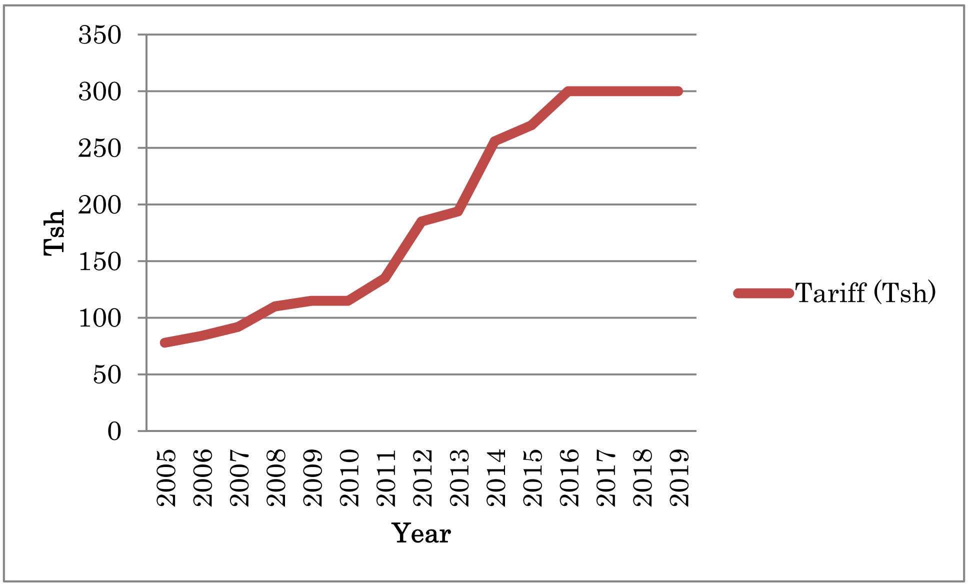
Table 11.1.1-10 Unit Price of Average Consumption Rates

Item / Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
Revenues (TSh. Million)									
Domestic	32,606	35,258	43,588	50,910	47,430	47,288	47,255	60,574	53,978
General use	72,881	70,237	93,452	114,291	130,370	164,611	205,175	335,276	410,254
Low-voltage	36,654	39,927	50,192	62,937	62,481	71,280	76,231	111,955	116,062
High Voltage	61,029	65,648	79,944	107,330	136,755	152,471	146,027	220,672	248,206
Zanzibar	6,038	6,799	8,453	18,650	22,020	15,065	27,548	37,586	47,450
Gold mines & other mining	12,450	14,277	16,377	17,139	14,445	15,762	43,422	54,373	57,575
Total sales revenues	221,658	232,146	292,006	371,257	413,501	466,477	545,658	820,436	933,525
Consumption (kWh)									
Domestic	367,291,048	390,890,974	444,301,963	424,631,445	401,671,302	389,704,974	328,773,221	320,834,460	280,608,016
General use	819,208,705	785,786,547	923,905,456	995,220,975	1,083,511,458	1,330,426,826	1,270,748,395	1,508,043,271	1,749,133,443
Low-voltage	513,835,995	397,805,660	469,722,083	506,605,980	516,545,149	603,324,169	511,914,637	549,992,102	562,911,360
High Voltage	798,841,356	830,306,239	933,178,256	1,037,063,132	1,190,866,431	1,410,802,686	1,483,484,400	1,582,292,965	1,852,123,228
Zanzibar	185,584,000	204,071,000	230,911,000	229,285,781	257,763,000	175,358,400	277,251,000	298,548,000	218,652,000
Gold mines & other mining	146,337,082	160,577,513	176,054,460	184,612,950	138,943,200	138,043,000	156,232,600	168,740,803	155,406,927
Total consumption	2,831,098,186	2,769,437,933	3,178,073,218	3,377,420,263	3,589,300,540	4,047,660,055	4,028,404,253	4,428,451,601	4,818,834,974
Unit price (TSh./kWh)									
Domestic	89	90	98	120	118	121	144	189	192
General use	89	89	101	115	120	124	161	222	235
Low-voltage	71	100	107	124	121	118	149	204	206
High Voltage	76	79	86	103	115	108	98	139	134
Zanzibar	33	33	37	81	85	86	99	126	217
Gold mines & other mining	85	89	93	93	104	114	278	322	370
Total consumption	78	84	92	110	115	115	135	185	194
Total consumption excluding mining	78	84	92	111	116	115	130	180	188

Source：JICA Study Team based on TANESCO data

The historical average tariffs since 2005 are shown in Figure 11.1.1-1. Average tariff rate (Tsh./kWh) has increased to 3.3 times from 2005 to 2014, the recent increase of tariff was much rapid, went up 1.9 times in three years from 2011 to 2014. This new tariff setting reflects the government policy to aim realizing adequate operational revenue without the government contribution in future.

Unit TSh.



Source: JICA Study Team based on TANESCO data

Figure 11.1.1-1 Average Tariff Rate of TANESCO

(5) Energy Loss

Energy Loss is the volume of electricity that was lost during transmission to the consumer. Loss ratio is calculated based on the volume of generated electricity. Loss can be divided to the technical loss caused by technical factors and the non-technical loss caused by the human factors such as theft, abuse of meter mistake by tariff collector and cheating by consumers. The Energy loss ratio was shown in the Table 11.1.1-11.

Table 11.1.1-11 Energy Loss in 2013

	Target	Actual
Distribution Loss	14%	12.8%
Transmission Loss	5%	6.2%
Total	19%	19%

Source: TANESCO. 「Financial Statements of TANESCO」 2013

Based on TANESCO's report, the automated reading electric meter has contributed for reduction in energy loss in 2013, especially for non-technical loss. Besides, the activity and promotion to reduce the theft of electricity by Revenue Protection Dept. of TANESCO has the effect for finding abuse of 5,000 meter after the survey of 160,000 consumers. As a result, Tsh.13 million was accounted for receivable revenue to be collected.

(6) Estimation of TANESCO's Operational Performance

An Estimation of TANESCO's Operational Performance in 2014 is stated below.

Table 11.1.1-12 Estimate of Operational Profit and Loss in 2014 (Unit TSh. million)

	Actual	Estimate	
Year	2013	2014	Rate of Increase
Sales Revenue	933,525	1,296,884	28%
Other Op. Rev.	325,974	100,673	-224%
Total Op. Rev.	1,259,499	1,397,557	10%
Generation & Transmission Cost	359,971	358,080	-1%
Purchased Elec.	812,396	619,204	-31%
Distribution Cost	160,896	196,800	18%
Depreciation	84,252	97,394	13%
Total Sales Cost	1,417,515	1,271,478	-11%
Other Op. cost	228,637	293,412	22%
Total Op. Exp.	1,646,152	1,564,890	-5%
Op. P/L	(386,653)	(167,333)	

Source: JICA Study Team based on unaudited TANESCO data.

The sales revenue shows big rise of 28% by the increase of customer and revenue collection and 10% rise of operational revenue without the government contribution. Regarding the sales expenditure, the termination of contracts at last June with Dodma and Arusha of Symbion electric power plant contributed for the reduction of sales cost as such high cost EPPs accounted big portion of cost in 2013. As a result, purchased electricity cost is reduced drastically by 31%, the sales revenue exceeds over expenditure by Tsh 25.4 billion. Other expenditure increases by 22% along with the increase of sales revenue, but its increase is less than sales revenue that reflects the improved business efficiency and reduction of staff cost.

This estimation of the operational activity is still loss of Tsh167 billion (Jpy11billion), although it has improved a lot from 2013. Even though it is possible to realize the operational profits if the same level of the government contribution is given, the bottom line before tax is estimated to be loss after paying the financing expenses.

TANESCO aims to run the business with the private investments and the market competition and it is possible to be separated in the generation, transmission and distribution entitles in future. Even though the TANESCO has the role of the public utility, it is essential to earn the adequate profits for the running the business in future without the government support. Therefore, it is necessary to earn 1) Sales profit to cover cost, 2) Operational profit without the government contribution, 3) Realize profit before tax after deducting the financing expense and 4) Clearing the accumulated loss.

11.1.2 Investment Plan and Financial Analysis

An investment plan was made for 25 years from year 2016 to 2040 base on PSMP that correspond to long-term electric power demand in Tanzania and import demand of neighboring countries.

Business entities are TANESCO which generates, transmits and distributes electricity and IPP which generate and wholesale electricity to TANESCO.

11.1.2.1 Preconditions for the investment plan based on PSMP

Preconditions for this investment plan are stated below.

(1) Yearly development of capital expenditure based on PSMP

Yearly capital expenditures in most effective method are calculated for PSMP by WASP model that is described in chapter 8 and chapter 9. In this method, annual expenditure of generation, transmission and distributions are developed (Table 11.1.2-1). Yearly expenditure for generation is calculated in WASP model and transmission expenditure is calculated based on system planning. Distribution expenditure is calculated is fixed at 2.5% ratio of total expenditure of generation and transmission based on the financial data of TANESCO.

(2) Electricity supply volume in each sector of power generation

Electricity supply volume is calculated based on expected electricity demand of base scenario of Tanzanian economic growth, and then the most effective combination of electricity supply from each power generation sector is simulated by WASP model (Table 11.1.2-1).

(3) Operating period

Operating period of thermal, wind, solar and geothermal generation facilities are set at 35 years. Hydro power generation is set at 50 years. Volume of electricity generation is calculated in the investment plan based on these operating period.

(4) Foreign currency for the investment plan and the exchange rate

US Dollar is used as a currency to calculate for capital expenditure, revenue and cost.

Exchange rate between US Dollar/Tanzanian Shilling is set at US$ 1 = TZS 2200.

(5) Debt and equity ratio for financing

Debt: Equity ratio is set at 70: 30 for financing the investment plan.

(6) Interest during construction (IDC)

IDC is set at 7.0% and this interest cost is included in the capital expenditure.

(7) Electricity tariff rate

Average tariff rate of electricity for consumer is TZS 250/kWh in 2015.

The following tariff rate is set for the investment plan.

- From year 2016 to 2020: 300 Tsh/kWh (US$0.136/kWh)
- From year 2021 to 2030: 320 Tsh/kWh (US$0.145/kWh)
- From year 2031 to 2040: 330 Tsh/kWh (US$0.150/kWh)

(8) Sales revenue of electricity

Electricity supply volume is set by domestic electricity demand and import demand from neighboring countries. Yearly sale revenue is calculated by using the tariff rate stated above.

(9) IPP ratio for generation

Cost of generation is almost same with purchased electricity based on TANESCO financial statement in 2015. Therefore, IPP ratio for generation is set at 50% for this investment plan.

(10) Wholesale electricity price by IPP

Electricity price sold to TANESCO by IPP is set at 85% of average tariff price to consumer.

(11) Operation and maintenance (O&M) and Fuel cost

O&M and fuel cost are calculated that are required in the investment plan for power generation, transmission and distribution. O&M and Fuel cost for generation is calculated by WASP model. O&M cost for transmission is set at 5% and O&M cost for distribution is set at 10% of sale revenue respectively based of financial data obtained from TANESCO.

(12) Price escalation

Forecasting inflation rate in long term is hard to do and not reliable. 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.

(13) Depreciation

Depreciation is the accounting term of cost to realize depreciated value of assets annually. As it does not expense real cash flow, a depreciation cost is not included in the investment plan of the project. However, this depreciation is realized as cost for the projection of profit and loss of TANESCO.

(14) Discount rate

Discount rate is set at 10% in PSMP 2012 conducted by Tanzanian government. The same 10% rate is used for this investment plan for the hurdle rate of the business.

(15) Residual value

Residual value of plants and facilities that still have operational value at the end of investment plan are counted in benefits at year 2040.

(16) Borrowing cost

Loan interest rate is varied from 1.0% to 7.1% in the long-term borrowing of TANESCO. Loan interest cost for operation is set at 7.0% per annum for this investment plan.

(17) Tax and public due

Benefit exceeding cost is subject to be deducted by 30% by tax in this investment plan.

11.1.2.2 Capital Expenditure based on the investment plan

Capital expenditure for electricity power generation, transmission and distribution is calculated and stated in the table below 11.1.2-1 based on the long-term demand of Tanzania and exporting demand from neighboring countries.

Total capital expenditure is USD 46.2billion of which USD 34.9 billion for generation, USD 10.3 billion for transmission and USD 1 billion for distribution respectively.

Table 11.1.2-1 Capital Expenditure based on the investment plan

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	0	221	5	226	158	68
2017	139	49	5	192	135	58
2018	397	423	20	840	588	252
2019	1,525	922	59	2,506	1,754	752
2020	2,418	886	79	3,383	2,368	1,015
2021	643	361	24	1,028	720	308
2022	311	22	8	340	238	102
2023	508	45	13	566	396	170
2024	1,360	964	55	2,379	1,665	714
2025	2,509	1,356	91	3,956	2,769	1,187
2026	1,275	440	40	1,754	1,228	526
2027	946	167	26	1,139	797	342
2028	1,515	174	40	1,729	1,210	519
2029	2,015	387	56	2,458	1,720	737
2030	2,430	381	65	2,876	2,013	863
2031	2,534	134	60	2,728	1,909	818
2032	2,068	179	51	2,298	1,609	689
2033	2,106	78	49	2,233	1,563	670
2034	1,997	618	61	2,676	1,873	803
2035	1,296	707	46	2,049	1,434	615
2036	2,279	137	57	2,473	1,731	742
2037	2,513	20	60	2,593	1,815	778
2038	1,359	17	33	1,408	986	423
2039	441	819	30	1,290	903	387
2040	304	802	27	1,133	793	340
Sub Total	34,887	10,309	1,058			
Total Capital Cost for PSMP			46,254			
Total Capital Cost Financed by Debt			32,378			
Total Capital Cost Financed by Equity			13,876			

Source: JICA Study team

11.1.2.3 Financial analysis of the investment plan

Financial Internal Rate of Return (FIRR) is used for financial evaluation. IRR is a discount rate to make an equal NPV of both benefit and cost.

Cash flows for financial analysis for TANESCO and IPP are stated in the Table 11.1.2-2 and Table 11.1.2-3 respectively. Details of benefits and costs are shown in the Calculation Sheet 1.

Table 11.1.2-2 Cash Flows for TANESCO benefits and cost

Year	Cost for TANESCO (Generation, Transmission, Distribution	Electricity Revenue for TANESCO	Net Benefit for TANESCO	Tax for TANESCO (30%)	Net Benefit for TANESCO after Tax
2016	592	511	(81)	0	(81)
2017	549	586	37	11	26
2018	1,127	670	(457)	0	(457)
2019	2,292	768	(1,524)	0	(1,524)
2020	2,789	937	(1,852)	0	(1,852)
2021	1,414	1,178	(236)	0	(236)
2022	968	1,292	323	97	226
2023	1,176	1,481	305	92	214
2024	2,670	1,619	(1,051)	0	(1,051)
2025	3,749	1,775	(1,973)	0	(1,973)
2026	2,240	1,933	(307)	0	(307)
2027	1,882	2,107	225	67	157
2028	2,292	2,297	5	1	3
2029	2,875	2,505	(370)	0	(370)
2030	3,223	2,732	(491)	0	(491)
2031	3,186	2,982	(204)	0	(204)
2032	3,221	3,737	516	155	361
2033	3,257	4,079	823	247	576
2034	3,937	4,455	518	155	363
2035	3,878	4,866	988	296	691
2036	3,963	5,282	1,319	396	923
2037	4,156	5,735	1,578	474	1,105
2038	3,830	6,226	2,396	719	1,677
2039	4,473	6,760	2,287	686	1,601
2040	4,719	7,341	2,621	786	22,740
				IRR=	8.24%

Source: JICA Study team

Table 11.1.2-3 Cash Flows for IPP benefits and cost

US Dollar, million

Year	Cost for IPP (Generation)	Electricity Revenue for IPP	Net Benefit for IPP	Tax for IPP (30%)	Net Benefit for IPP after Tax
2016	233	370	137	41	96
2017	342	436	93	28	65
2018	510	511	1	0	1
2019	1,110	591	(519)	0	(519)
2020	1,594	682	(913)	0	(913)
2021	756	808	53	16	37
2022	635	898	263	79	184
2023	782	998	216	65	151
2024	1,279	1,108	(172)	0	(172)
2025	1,889	1,229	(660)	0	(660)
2026	1,306	1,352	46	14	32
2027	1,189	1,487	297	89	208
2028	1,529	1,634	104	31	73
2029	1,829	1,795	(34)	0	(34)
2030	2,114	1,972	(142)	0	(142)
2031	2,264	2,165	(99)	0	(99)
2032	2,074	2,452	378	113	265
2033	2,123	2,691	568	170	397
2034	2,154	2,952	798	240	559
2035	1,913	3,239	1,325	398	928
2036	2,449	3,529	1,080	324	756
2037	2,638	3,844	1,206	362	844
2038	2,213	4,187	1,973	592	1,381
2039	1,918	4,559	2,641	792	1,849
2040	2,033	4,964	2,930	879	15,040
				IRR=	16.28%

Source: JICA Study team

IRR for overall entity, TANESCO and IPP is stated in the table 11.1.2-4.

IRR is 10.7% for overall entity based on the precondition of investment plan, 8.4% for TANESCO and 16.3% for IPP. These returns satisfy the target set by the TANZANIS which is 8%~10% for TANESCO and over14% for IPP. Moreover, overall IRR is the above the target discount rate of 10% which means economically viable.

Table 11.1.2-4 IRR

IRR			
	Overall	TANESCO	IPP
With Residual Value	10.7%	8.4%	16.3%

Source: JICA Study team

11.1.2.4 Sensitivity Analysis

Sensitivity Analysis on the various tariff scenarios

Sensitivity analysis is conducted for the IRR on the different tariff scenarios. IRR on the different tariff is stated in the Table 11.1-2-5.

Table 11.1.2-5 Sensitivity of IRR on the different tariff scenarios

Tariff rate Tsh, kWH	Year			IRR		
	2016~2020	2021~2030	2031~2040	Overall	TANESCO	IPP
Lower Tariff	270	290	300	8.4%	6.7%	12.1%
Base Tariff	300	320	330	10.7%	8.4%	16.3%
Higher Tariff	310	330	340	11.5%	8.9%	18.0%

Source: JICA Study team

Sensitivity Analysis on the various fuel and operational cost of generation

Sensitivity analysis is conducted for the IRR on the different fuel and operational cost scenarios. IRR on the different cost on the base tariff is stated in the Table 11.1-2-6.

Table 11.1.2-6 Sensitivity of IRR on the different cost scenarios

Changes in cost of Fuel and O&M for generation					
	-10%	0%	10%	20%	30%
Overall Project IRR	11.9%	10.7%	9.6%	8.5%	7.5%

Source: JICA Study team

Sensitivity Analysis on the various IPP scenarios

Sensitivity analysis is conducted for the TANESCO IRR on the different IPP scenarios. IRR on the different IPP on the base tariff is stated in the Table 11.1-2-7.

Table 11.1.2-7 Sensitivity of TANESCO IRR on the different IPP scenarios

Changes in IPP Ratio for generation			
	IPP 40%	IPP 50%	IPP 60%
TANESCO IRR	9.0%	8.4%	7.6%

Source: JICA Study team

11.1.2.5 Financing and repayment plan of the investment plan

The projection of financing and repayment is stated in the Table 11.1-2-8. Annual financing amount necessary for the business operation based on the investment plan is shown in the Figure 11.1.2-1. Financing by loan and debt is peaked on US$ 3.5 billion at 2025. Additional financing is not required after 2037.

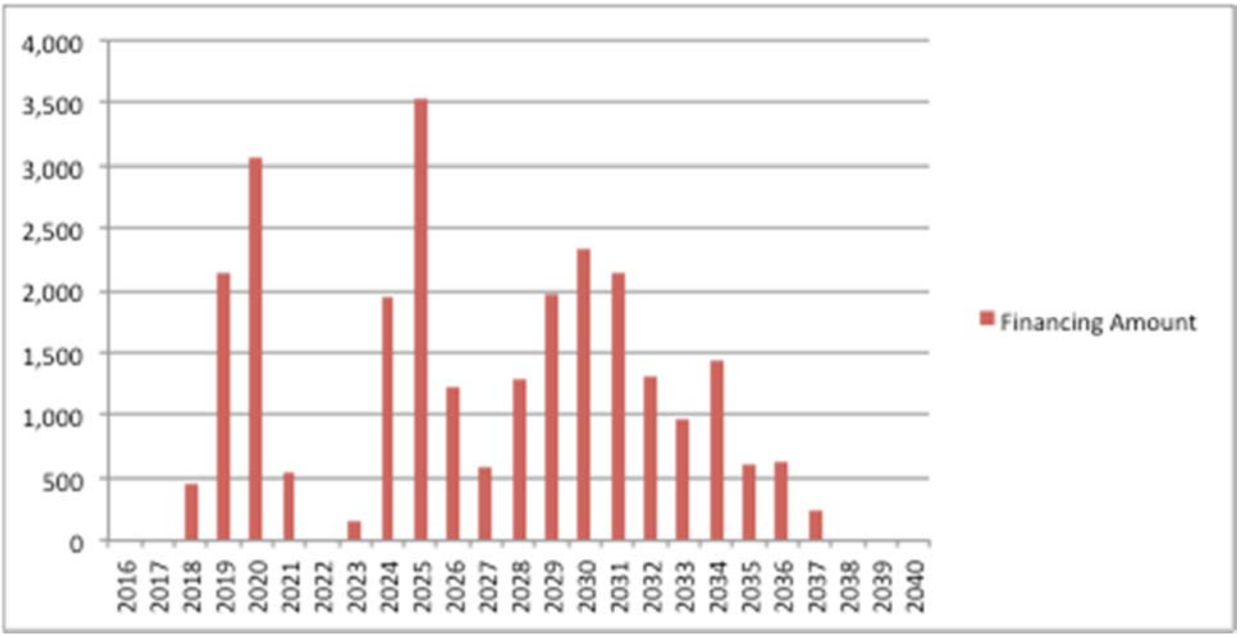
Table 11.1.2-8 The projection of financing and repayment

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	823	0	0	823	871	0	0	0	871	48
2	2017	892	0	0	892	1,025	0	0	0	1,025	133
3	2018	1,643	0	23	1,665	1,203	139	324	463	1,665	0
4	2019	3,410	0	128	3,538	1,390	644	1,503	2,148	3,538	0
5	2020	4,395	0	278	4,673	1,604	921	2,148	3,069	4,673	0
6	2021	2,181	32	302	2,516	1,978	161	377	538	2,516	0
7	2022	1,617	183	292	2,092	2,266	0	0	0	2,266	174
8	2023	1,974	398	285	2,656	2,499	47	110	157	2,656	0
9	2024	3,968	435	377	4,781	2,834	584	1,363	1,947	4,781	0
10	2025	5,658	435	550	6,643	3,119	1,057	2,467	3,524	6,643	0
11	2026	3,569	446	609	4,624	3,409	365	851	1,216	4,624	0
12	2027	3,097	583	628	4,307	3,726	174	407	581	4,307	0
13	2028	3,849	829	673	5,351	4,071	384	896	1,280	5,351	0
14	2029	4,734	914	763	6,412	4,451	588	1,373	1,961	6,412	0
15	2030	5,371	955	875	7,201	4,868	700	1,633	2,332	7,201	0
16	2031	5,487	1,012	976	7,475	5,323	646	1,507	2,153	7,475	0
17	2032	5,243	1,032	1,039	7,313	6,003	393	917	1,310	7,313	0
18	2033	5,323	1,130	1,080	7,533	6,566	290	677	967	7,533	0
19	2034	6,028	1,458	1,127	8,613	7,181	430	1,003	1,432	8,613	0
20	2035	5,722	1,588	1,147	8,457	7,855	181	422	603	8,457	0
21	2036	6,337	1,644	1,174	9,154	8,537	185	432	617	9,154	0
22	2037	6,713	1,619	1,187	9,519	9,279	72	168	239	9,519	0
23	2038	5,954	1,551	1,192	8,697	10,086	0	0	0	10,086	1,389
24	2039	6,294	1,756	1,177	9,227	10,962	0	0	0	10,962	1,735
25	2040	6,647	1,817	1,173	9,637	11,914	0	0	0	11,914	2,277

Source: JICA Study team

US Dollar, million



Source: JICA Study team

Figure 11.1.2-1 Financing Amount for the business operation

11.1.2.6 Debt stock of TANESCO

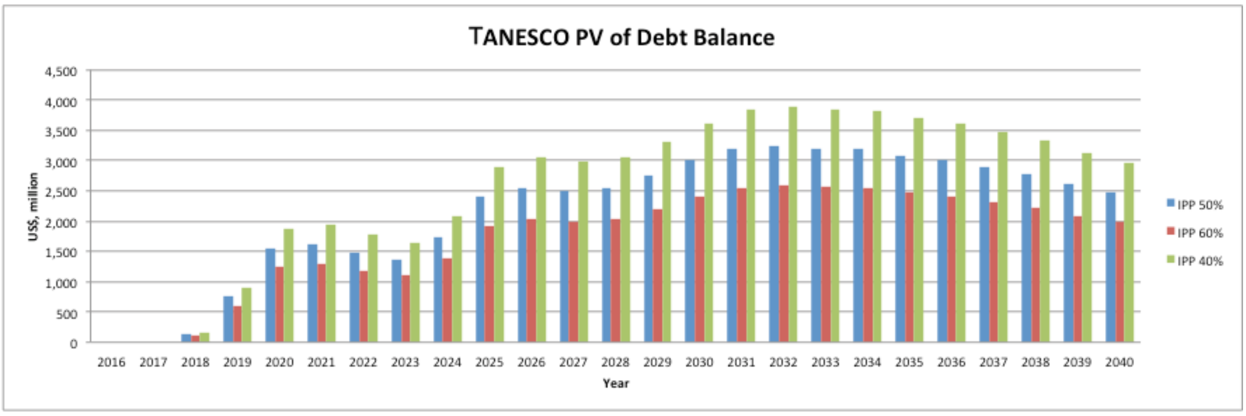
TANESCO Debt balance and stock to GDP with different IPP ratio is calculated. Present Value (PV) of debt is calculated by the discount rate of 5% which is used by Tanzanian government report "National Debt Sustainability Analysis 2013".

(1) With IPO ratio 50%, Present Value (PV) of TANESCO Debt balance will be peaked around US$ 3.2billion at year 2032 and Debt stock to GDP is peaked at 2.7% at year 2025.

(2) With IPO ratio 60%, Present Value (PV) of TANESCO Debt balance will be peaked around US$ 2.6 billion at year 2032 and Debt stock to GDP is peaked at 2.2% at year 2025 that is presented in the Figure 11.1.2-2.

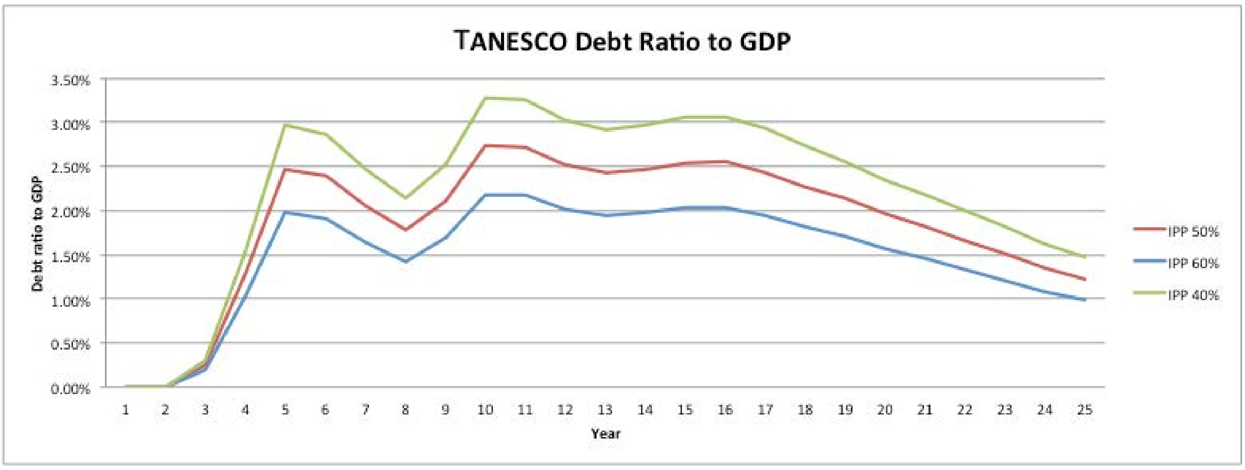
(3) With IPO ratio 40%, Present Value (PV) of TANESCO Debt balance will be peaked around US$ 3.9 billion at year 2032 and Debt stock to GDP is peaked at 3.3% at year 2025 that is presented in the Figure 11.1.2-3.

PV of TANESCO debt balance is presented in the Figure 11.1-2-2 and PV of debt ratio is presented in Figure 11.1-2-3. Details of the Cash flows for financing the project are presented in Calculation Sheet 2.



Source: JICA Study team

Figure 11.1.2-2 TANESCO Debt balance with IPP 40%, 50% and 60%



Source: JICA Study team

Figure 11.1.2-3 TANESCO Debt stock to GDP with IPP 40%, 50% and 60%

(4) TANESCO Debt balance and stock to GDP with different Interest Rate on Debt

TANESCO 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. The result is shown in the table 11.1-2-9.

Table 11.1.2-9 PV of TANESCO 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%	2,796	2031	2.58%	2025
7%	3,238	2032	2.73%	2025
9%	3,882	2034	2.92%	2026

Source: JICA Study team

11.1.2.7 Calculation of Long-run Marginal Cost (LRMC)

The competition towards "Price = Marginal Cost" does not exist in the natural monopoly of electricity market. Therefore, the policy for setting the electricity price towards marginal cost is necessary for allocation of natural resources. 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 in the Table 11.1-2-10. Details of cash flows are stated in the Calculation Sheet 3.

Table 11.1.2-10 LRMC of electricity for the investment plan

US Dollar, kWh

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

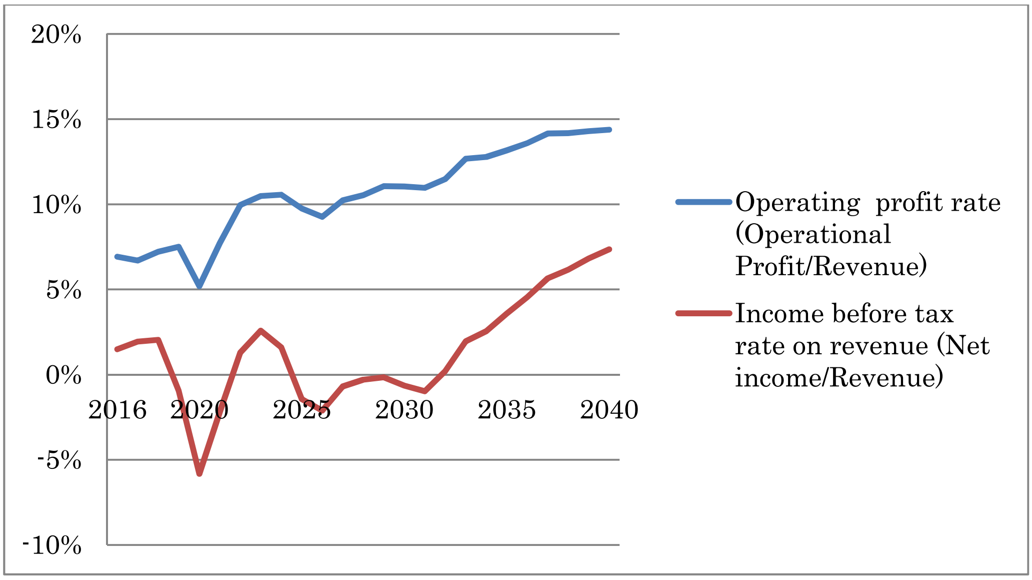
Source: JICA Study team

11.1.2.8 Financial analysis and projection of TANESCO's operation based on the investment plan

TANESCO's operational income, expense and interest rate cost is projected up to 2040 based of the investment plan (Calculation Sheet 5). Depreciation cost of fixed assets such as plants and facilities is deducted from operational income in accounting term. Depreciation period of the each facilities are stated as follows. Straight-line method is used for depreciation and residual value after the service life is set at nil.

- Thermal, wind , solar and geothermal generation facilities：35 years' service life
- Hydro generation facility：50 years' service life
- Transmission, distribution facilities and equipment：35 years' service life

Operating profit and Net Income after deducting interest cost before tax are projected and shown in the Figure 11.1.2-4. Operational profits ratio is oppressed between 5% ~10% up to 2020 due to the depreciation cost of the new investments and Net income after interest rate cost is negative. However, the both profit ratio will improve after 2030. Operational profit will reach to 14% and net income to 7% level by 2035. The level of Net income ratio 5%~10% is essential for the business entity in the public service as it is required to deliver appropriate profit to ensure continuous operating implementation. Therefore, it is expected that TANESCO's operation will be improved to realize valid financial performance in long term by the implementation of the investment project



Source: JICA Study team

Figure 11.1.2-4 Operational profit ratio of TANESCO

Calculation Sheet 1: Cash Flows for the invest on the PSMP

US Dollar, million

Year	Power Demand, JICA Base Case (GWh)	Export (MW)	Export Demand (GWh)	Total Power Demand (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	Total Cost with IDC
2016	6,387	0	0	6,387	0	0	0	0	0	466	466	233	233	212	9	43.5	264	5	87	92	823
2017	7,515	0	0	7,515	136	0	0	136	3	546	685	342	342	47	2	51.2	100	5	102	107	892
2018	8,819	0	0	8,819	383	0	0	383	14	622	1,019	510	510	406	17	60.1	483	20	120	140	1,643
2019	10,194	0	0	10,194	1,460	0	0	1,460	65	695	2,220	1,110	1,110	885	38	69.5	992	59	139	198	3,410
2020	11,760	0	0	11,760	2,319	0	0	2,319	99	771	3,188	1,594	1,594	850	36	80.2	967	79	160	240	4,395
2021	13,077	100	613	13,691	610	0	0	610	33	868	1,511	756	756	346	15	95.1	456	24	190	214	2,181
2022	14,534	200	1,226	15,761	298	0	0	298	13	960	1,270	635	635	21	1	105.7	127	8	211	219	1,617
2023	16,138	200	1,226	17,364	388	65	32	485	24	1,056	1,564	782	782	43	2	117.4	162	13	235	248	1,974
2024	17,920	300	1,840	19,759	654	442	188	1,284	76	1,199	2,559	1,279	1,279	924	39	130.3	1,094	55	261	316	3,968
2025	19,877	300	1,840	21,717	1,408	585	363	2,356	153	1,268	3,777	1,889	1,889	1,300	55	144.6	1,500	91	289	381	5,658
2026	21,870	300	1,840	23,710	656	208	323	1,187	88	1,338	2,612	1,306	1,306	422	18	159.1	599	40	318	358	3,569
2027	24,050	300	1,840	25,890	565	0	318	883	63	1,433	2,378	1,189	1,189	160	7	174.9	342	26	350	376	3,097
2028	26,426	300	1,840	28,266	897	0	517	1,414	101	1,544	3,059	1,529	1,529	167	7	192.2	366	40	384	424	3,849
2029	29,036	300	1,840	30,876	1,190	0	686	1,876	138	1,643	3,658	1,829	1,829	371	16	211.2	598	56	422	479	4,734
2030	31,906	300	1,840	33,746	1,162	0	1,068	2,230	201	1,798	4,229	2,114	2,114	365	16	232.0	613	65	464	529	5,371
2031	35,029	300	1,840	36,869	828	0	1,452	2,280	254	1,995	4,528	2,264	2,264	128	5	254.8	389	60	510	570	5,487
2032	38,457	300	1,840	40,297	715	0	1,143	1,857	211	2,079	4,147	2,074	2,074	172	7	288.4	468	51	577	628	5,243
2033	42,208	300	1,840	44,048	767	0	1,103	1,871	236	2,140	4,247	2,123	2,123	75	3	316.6	395	49	633	682	5,323
2034	46,309	300	1,840	48,149	1,189	0	642	1,831	166	2,311	4,308	2,154	2,154	593	25	347.3	966	61	695	755	6,028
2035	50,800	300	1,840	52,640	543	0	628	1,171	124	2,531	3,826	1,913	1,913	678	29	381.0	1,088	46	762	808	5,722
2036	55,352	300	1,840	57,192	1,299	0	837	2,136	143	2,618	4,897	2,449	2,449	131	6	415.1	552	57	830	887	6,337
2037	60,299	300	1,840	62,139	1,982	0	389	2,372	142	2,763	5,276	2,638	2,638	19	1	452.2	472	60	904	964	6,713
2038	65,673	300	1,840	67,513	1,291	0	0	1,291	68	3,068	4,427	2,213	2,213	16	1	492.5	510	33	985	1,018	5,954
2039	71,516	300	1,840	73,356	423	0	0	423	18	3,395	3,836	1,918	1,918	786	33	536.4	1,355	30	1,073	1,103	6,294
2040	77,863	300	1,840	79,703	292	0	0	292	12	3,762	4,067	2,033	2,033	769	33	584.0	1,386	27	1,168	1,194	6,647

Year	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	0.136	0.116	871	0	871	501	370	48	(89)	137	14	0	41	34	(89)	96	34	(89)	96
2017	0.136	0.116	1,025	0	1,025	589	436	133	39	93	40	12	28	93	28	65	93	28	65
2018	0.136	0.116	1,203	0	1,203	691	511	(440)	(441)	1	0	0	0	(440)	(441)	1	(440)	(441)	1
2019	0.136	0.116	1,390	0	1,390	799	591	(2,020)	(1,500)	(519)	0	0	0	(2,020)	(1,500)	(519)	(2,020)	(1,500)	(519)
2020	0.136	0.116	1,604	0	1,604	922	682	(2,791)	(1,878)	(913)	0	0	0	(2,791)	(1,878)	(913)	(2,791)	(1,878)	(913)
2021	0.145	0.124	1,902	76	1,978	1,170	808	(203)	(256)	53	0	0	16	(203)	(256)	37	(203)	(256)	37
2022	0.145	0.124	2,114	152	2,266	1,367	898	649	385	263	195	116	79	454	270	184	454	270	184
2023	0.145	0.124	2,347	152	2,499	1,501	998	525	309	216	158	93	65	368	217	151	368	217	151
2024	0.145	0.124	2,606	227	2,834	1,726	1,108	(1,134)	(963)	(172)	0	0	0	(1,134)	(963)	(172)	(1,134)	(963)	(172)
2025	0.145	0.124	2,891	227	3,119	1,890	1,229	(2,539)	(1,879)	(660)	0	0	0	(2,539)	(1,879)	(660)	(2,539)	(1,879)	(660)
2026	0.145	0.124	3,181	227	3,409	2,057	1,352	(161)	(207)	46	0	0	14	(161)	(207)	32	(161)	(207)	32
2027	0.145	0.124	3,498	227	3,726	2,239	1,487	629	332	297	189	99	89	440	232	208	440	232	208
2028	0.145	0.124	3,844	227	4,071	2,438	1,634	222	118	104	67	35	31	156	83	73	156	83	73
2029	0.145	0.124	4,223	227	4,451	2,656	1,795	(283)	(249)	(34)	0	0	0	(283)	(249)	(34)	(283)	(249)	(34)
2030	0.145	0.124	4,641	227	4,868	2,896	1,972	(502)	(360)	(142)	0	0	0	(502)	(360)	(142)	(502)	(360)	(142)
2031	0.145	0.124	5,095	227	5,323	3,157	2,165	(164)	(65)	(99)	0	0	0	(164)	(65)	(99)	(164)	(65)	(99)
2032	0.150	0.128	5,769	235	6,003	3,552	2,452	760	382	378	228	115	113	532	268	265	532	268	265
2033	0.150	0.128	6,331	235	6,566	3,875	2,691	1,243	675	568	373	203	170	870	473	397	870	473	397
2034	0.150	0.128	6,946	235	7,181	4,229	2,952	1,153	354	798	346	106	240	807	248	559	807	248	559
2035	0.150	0.128	7,620	235	7,855	4,616	3,239	2,132	807	1,325	640	242	398	1,492	565	928	1,492	565	928
2036	0.150	0.128	8,303	235	8,537	5,009	3,529	2,201	1,121	1,080	660	336	324	1,541	785	756	1,541	785	756
2037	0.150	0.128	9,045	235	9,279	5,435	3,844	2,567	1,361	1,206	770	408	362	1,797	953	844	1,797	953	844
2038	0.150	0.128	9,851	235	10,086	5,899	4,187	4,131	2,158	1,973	1,239	647	592	2,892	1,511	1,381	2,892	1,511	1,381
2039	0.150	0.128	10,727	235	10,962	6,403	4,559	4,668	2,027	2,641	1,400	608	792	3,267	1,419	1,849	3,267	1,419	1,849
2040	0.150	0.128	11,680	235	11,914	6,950	4,964	5,267	2,337	2,930	1,580	701	879	3,687	1,636	2,051	37,580	22,540	15,040

Calculation Sheet 2: Cash Flows for the financing on the PSMP

US Dollar, million

Debt Payment Projection											
	Year	Out Flow (US$, million): Project Cost for PSMP Electric	Loan: Repayment	Loan: Interest	Total Out Flow	In Flow (US$, million): Electric Power Revenue	Finance: Equity	Finance: Debt	Finance: Total	Total Inflow	Net Cash (USD, million)
1	2016	823	0	0	823	871	0	0	0	871	48
2	2017	892	0	0	892	1,025	0	0	0	1,025	133
3	2018	1,643	0	23	1,665	1,203	139	324	463	1,665	0
4	2019	3,410	0	128	3,538	1,390	644	1,503	2,148	3,538	0
5	2020	4,395	0	278	4,673	1,604	921	2,148	3,069	4,673	0
6	2021	2,181	32	302	2,516	1,978	161	377	538	2,516	0
7	2022	1,617	183	292	2,092	2,266	0	0	0	2,266	174
8	2023	1,974	398	285	2,656	2,499	47	110	157	2,656	0
9	2024	3,968	435	377	4,781	2,834	584	1,363	1,947	4,781	0
10	2025	5,658	435	550	6,643	3,119	1,057	2,467	3,524	6,643	0
11	2026	3,569	446	609	4,624	3,409	365	851	1,216	4,624	0
12	2027	3,097	583	628	4,307	3,726	174	407	581	4,307	0
13	2028	3,849	829	673	5,351	4,071	384	896	1,280	5,351	0
14	2029	4,734	914	763	6,412	4,451	588	1,373	1,961	6,412	0
15	2030	5,371	955	875	7,201	4,868	700	1,633	2,332	7,201	0
16	2031	5,487	1,012	976	7,475	5,323	646	1,507	2,153	7,475	0
17	2032	5,243	1,032	1,039	7,313	6,003	393	917	1,310	7,313	0
18	2033	5,323	1,130	1,080	7,533	6,566	290	677	967	7,533	0
19	2034	6,028	1,458	1,127	8,613	7,181	430	1,003	1,432	8,613	0
20	2035	5,722	1,588	1,147	8,457	7,855	181	422	603	8,457	0
21	2036	6,337	1,644	1,174	9,154	8,537	185	432	617	9,154	0
22	2037	6,713	1,619	1,187	9,519	9,279	72	168	239	9,519	0
23	2038	5,954	1,551	1,192	8,697	10,086	0	0	0	10,086	1,389
24	2039	6,294	1,756	1,177	9,227	10,962	0	0	0	10,962	1,735
25	2040	6,647	1,817	1,173	9,637	11,914	0	0	0	11,914	2,277

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	0		2016	0	0	0	0.00%	0	0	0.00%
2	0		2017	0	0	0	0.00%	0	0	0.00%
3	324		2018	324	23	162	0.29%	162	140	0.25%
4	1,827	0	2019	1,827	128	752	1.28%	914	752	1.28%
5	3,976	0	2020	3,976	278	1,074	1.71%	1,988	1,558	2.47%
6	4,353	32	2021	4,320	302	188	0.28%	2,160	1,612	2.39%
7	4,353	183	2022	4,170	292	0	0.00%	2,085	1,482	2.06%
8	4,463	398	2023	4,065	285	55	0.07%	2,032	1,376	1.78%
9	5,825	435	2024	5,390	377	681	0.83%	2,695	1,737	2.10%
10	8,292	435	2025	7,857	550	1,233	1.40%	3,929	2,412	2.73%
11	9,143	446	2026	8,697	609	426	0.45%	4,349	2,543	2.72%
12	9,550	583	2027	8,968	628	203	0.21%	4,484	2,497	2.52%
13	10,446	829	2028	9,617	673	448	0.43%	4,809	2,550	2.42%
14	11,819	914	2029	10,905	763	686	0.62%	5,452	2,754	2.47%
15	13,452	955	2030	12,496	875	816	0.69%	6,248	3,006	2.54%
16	14,958	1,012	2031	13,946	976	753	0.60%	6,973	3,194	2.55%
17	15,875	1,032	2032	14,844	1,039	459	0.35%	7,422	3,238	2.44%
18	16,552	1,130	2033	15,422	1,080	339	0.24%	7,711	3,204	2.28%
19	17,555	1,458	2034	16,097	1,127	501	0.34%	8,048	3,185	2.13%
20	17,977	1,588	2035	16,389	1,147	211	0.13%	8,195	3,089	1.95%
21	18,409	1,644	2036	16,765	1,174	216	0.13%	8,382	3,009	1.81%
22	18,576	1,619	2037	16,957	1,187	84	0.05%	8,479	2,898	1.66%
23	18,576	1,551	2038	17,025	1,192	0	0.00%	8,513	2,771	1.51%
24	18,576	1,756	2039	16,821	1,177	0	0.00%	8,410	2,608	1.36%
25	18,576	1,817	2040	16,759	1,173	0	0.00%	8,380	2,475	1.23%

Calculation Sheet 3: Cash Flows for the LRMC on the PSMP

US Dollar, million

Year	LCEP1 Capacity Cost	LCEP1 Energy Cost Fuel, Var.O&M	LCEP1 Energy Cost	LCEP1 Total Cost	LCEP2 Capacity Cost	LCEP2 Energy Cost Fuel, Var.O&M	LCEP2 Energy Cost	LCEP2 Total Cost	LCEP1's Demand & LCEP2's Investment Capacity Cost	LCEP1's Demand & LCEP2's Investment Energy Cost Fuel	LCEP1's Demand & LCEP2's Investment Energy Cost Variable O&M	LCEP1's Demand & LCEP2's Investment Total Cost
2016	0	466		466	100	519		619	100	463	0	563
2017	140	546		686	637	599		1,236	637	542	0	1,179
2018	403	622		1,025	482	659		1,141	482	618	0	1,100
2019	1,553	695		2,248	1,539	722		2,261	1,539	690	0	2,229
2020	2,460	771		3,231	2,199	957		3,156	2,199	765	0	2,964
2021	657	868		1,525	442	1,014		1,456	442	862	0	1,304
2022	316	960		1,276	264	1,071		1,334	264	953	0	1,216
2023	518	1,056		1,574	160	1,172		1,332	160	1,048	0	1,208
2024	1,392	1,199		2,591	1,445	1,278		2,724	1,445	1,190	0	2,636
2025	2,574	1,268		3,843	3,562	1,508		5,070	3,562	1,259	0	4,821
2026	1,312	1,338		2,650	1,619	1,543		3,161	1,619	1,328	0	2,947
2027	973	1,433		2,405	914	1,637		2,551	914	1,423	0	2,336
2028	1,558	1,544		3,102	1,332	1,754		3,085	1,332	1,533	0	2,864
2029	2,074	1,643		3,717	1,466	1,864		3,330	1,466	1,631	0	3,097
2030	2,516	1,798		4,315	1,737	2,023		3,760	1,737	1,786	0	3,523
2031	2,642	1,995		4,637	2,649	2,146		4,795	2,649	1,981		4,629
2032	2,158	2,079		4,238	2,085	2,267		4,352	2,085	2,065		4,150
2033	2,207	2,140		4,348	1,979	2,343		4,321	1,979	2,125		4,104
2034	2,068	2,311		4,379	2,050	2,526		4,576	2,050	2,295		4,345
2035	1,349	2,531		3,879	2,117	2,768		4,886	2,117	2,513		4,630
2036	2,341	2,618		4,959	1,994	2,851		4,845	1,994	2,600	0	4,594
2037	2,574	2,763		5,337	2,632	2,987		5,619	2,632	2,743	0	5,375
2038	1,388	3,068		4,456	1,498	3,306		4,804	1,498	3,046	0	4,544
2039	449	3,395		3,844	1,246	3,633		4,880	1,246	3,371	0	4,617
2040	310	3,762		4,072	929	3,987		4,916	929	3,736	0	4,665
Total	35,933	42,867	0	78,800	37,076	47,135	0	84,210	37,076	42,567	0	79,643
NPV	10,534	10,716	0	21,249	10,854	11,907	0	22,761	10,854	10,641	0	21,495
			10,716				11,907				10,641	

Year	Peak Demand Forecast: Peak Demand LCEP1		Hypotehtical Peak Demand LCEP2	
2016	8,214		9,502	
2017	9,554	1,340	10,610	1,108
2018	11,094	1,540	11,847	1,237
2019	12,691	1,598	13,232	1,385
2020	14,437	1,746	18,161	4,928
2021	16,756	2,319	19,739	1,578
2022	19,230	2,474	21,472	1,733
2023	21,137	1,907	23,392	1,920
2024	23,984	2,847	25,511	2,120
2025	26,097	2,113	30,646	5,134
2026	28,513	2,416	33,074	2,429
2027	31,148	2,635	35,728	2,654
2028	34,041	2,893	38,634	2,906
2029	37,210	3,170	41,823	3,189
2030	40,676	3,466	45,308	3,485
2031	44,483	3,807	49,135	3,827
2032	48,639	4,155	53,316	4,181
2033	53,187	4,548	57,883	4,568
2034	58,160	4,973	62,889	5,006
2035	63,565	5,405	68,371	5,482
2036	69,086	5,521	73,924	5,553
2037	75,090	6,004	79,954	6,030
2038	81,610	6,520	86,512	6,558
2039	88,696	7,086	93,631	7,119
2040	96,395	7,698	101,374	7,744
Total	1,013,693		1,105,668	
NPV	233,469		258,790	

MARGINAL CAPACITY COST FOR GENERATION		
Discount Captal Expenditure		
LCEP2 NPV -LCEP1 NPV	321	A
Discount Value of Savings in ennergy cost (fuel cost &O&M)		
LCEP1 NPV Fuel	10,716	
LCEP NPV O&M	0	
Total Energy Cost(1)	10,716	
LCEP1 NPV Fuel	10,641	
LCEP NPV O&M	0	
Total Energy Cost(2)	10,641	
Discounted value of Savings in energy cost (1)-(2)	75	B
A-B ($) Discounted Capital Expenditure - Savings	246	C
Discounted change in peak demand of the hypothetical case relative to the original plan		
Hypothetical Peak Demand LECP2 (NPV MW)	258,790	
Peak Demand LECP1 (NPV MW)	233,469	
Discounted change in peak demand of the hypothetical case relative to t	25,321	D
C above / D abouve (US$/kW)	9.7	
Annuities formula	0.111	
Annuities of $/kW Year	1.08	
Annual hours	8760	
Effective load factor	0.7354	
Annuities of $/kW hour with the load factor(cents/kWh)	0.02	

MARGINAL ENERGY COST (FUEL + VARIABLE O&M) FOR GENERATION		
NPV fuel + NPV Variable O&M under Hypo thetical plan	11,907	A
NPV fuel and NPVvariable O&M cost under the hypoteitical capital expenditure under origina	10,641	B
A-B	1,266	C
NPV change in peak deamnd of the hypothetical case relative to the original plan	25,321	D
C/D (US$/kW)	50.0	
Annuities of $/kW Year	5.57	
Annual hours	8760	
Effective load factor	0.7354	
Annuities of $/kW hour with the load factor(cents/kWh)	0.09	

GENERATION MARGINAL COST	$/kW/Year	$/kW/Hour
Capacity Cost	1.08	0.02
Energy,O&MCo	5.57	0.09
Total	6.65	0.103

Calculation Sheet 4: TANESCO Income Projection on the PSMP

US Dollar, million

Year	Actual 2013	Estimate 2014	Estimate 2015	Projection 2016	Projection 2017	Projection 2018	Projection 2019	Projection 2020	Projection 2021
Sales Revenue	933,525	1,296,885	1,618,420	1,915,950	2,254,353	2,645,604	3,058,062	3,528,131	4,351,578
Other Operaing Revenue	325,974	78,872	103,068	105,129	107,232	109,377	111,564	105,844	130,547
Total Operaing Revenue	1,259,499	1,375,757	1,721,488	2,021,079	2,361,585	2,754,981	3,169,626	3,633,975	4,482,126
Generation & Transmission Cost	359,971	360,293	495,810	610,356	712,681	812,799	911,728	1,015,755	1,159,207
Purchased Energy	812,396	619,204	510,858	814,279	958,100	1,124,381	1,299,676	1,499,456	1,849,421
Distribution Cost	160,896	170,000	171,775	195,500	224,250	256,500	293,750	336,000	409,200
Depreciation	84,252	90,123	105,444	134,117	157,805	185,192	220,894	352,574	423,864
Total Sales Cost	1,417,515	1,239,620	1,283,887	1,754,251	2,052,836	2,378,872	2,726,048	3,203,785	3,841,692
General Operating Expenses	228,637	321,385	100,414	134,117	157,805	185,192	214,064	246,969	304,610
Total Operating Expenses	1,646,152	1,561,005	1,384,301	1,888,368	2,210,640	2,564,065	2,940,113	3,450,754	4,146,302
Operating Income (Tsh, million)	(386,653)	(185,248)	337,187	132,711	150,945	190,916	229,514	183,221	335,823
Operating Income (US$, million)	(176)	(84)	153	60	69	87	104	83	153
Finance Cost	85,386	59,298	94,204	104,268	107,179	136,880	258,464	388,988	431,121
Non operational transaction	294,640	(223,158)	(323,266)	-----	-----	-----	-----	-----	-----
Income before Tax (Tsh million)	(177,399)	(467,704)	(80,283)	28,443	43,766	54,036	(28,951)	(205,767)	(95,297)
Income before Tax (US$, million)	(81)	(213)	(36)	13	20	25	(13)	(94)	(43)

Year	Projection 2022	Projection 2023	Projection 2024	Projection 2025	Projection 2026	Projection 2027	Projection 2028	Projection 2029	Projection 2030
Sales Revenue	4,984,613	5,497,597	6,234,620	6,861,117	7,498,775	8,196,437	8,956,851	9,791,907	10,710,386
Other Operaing Revenue	149,538	164,928	187,039	205,834	224,963	245,893	268,706	293,757	321,312
Total Operaing Revenue	5,134,152	5,662,525	6,421,659	7,066,951	7,723,739	8,442,330	9,225,556	10,085,664	11,031,697
Generation & Transmission Cost	1,282,400	1,412,450	1,596,911	1,703,448	1,810,837	1,949,038	2,108,264	2,257,812	2,473,305
Purchased Energy	2,118,461	2,336,479	2,649,714	2,915,975	3,186,980	3,483,486	3,806,662	4,161,560	4,551,914
Distribution Cost	453,475	502,425	556,325	617,100	678,425	746,350	820,325	901,450	990,000
Depreciation	434,470	449,631	524,059	680,934	828,273	850,973	919,596	996,926	1,084,494
Total Sales Cost	4,288,805	4,700,985	5,327,009	5,917,457	6,504,514	7,029,847	7,654,846	8,317,749	9,099,713
General Operating Expenses	348,923	384,832	436,423	480,278	524,914	573,751	626,980	685,433	749,727
Total Operating Expenses	4,637,728	5,085,817	5,763,432	6,397,735	7,029,428	7,603,597	8,281,826	9,003,182	9,849,440
Operating Income (Tsh, million)	496,424	576,708	658,227	669,216	694,310	838,733	943,730	1,082,482	1,182,257
Operating Income (US$, million)	226	262	299	304	316	381	429	492	537
Finance Cost	431,932	435,209	558,203	767,558	852,716	895,952	970,921	1,098,029	1,252,078
Non operational transaction	-----	-----	-----	-----	-----	-----	-----	-----	-----
Income before Tax (Tsh million)	64,492	141,499	100,023	(98,342)	(158,406)	(57,219)	(27,191)	(15,547)	(69,821)
Income before Tax (US$, million)	29	64	45	(45)	(72)	(26)	(12)	(7)	(32)

Year	Projection 2031	Projection 2032	Projection 2033	Projection 2034	Projection 2035	Projection 2036	Projection 2037	Projection 2038	Projection 2039	Projection 2040
Sales Revenue	11,709,726	13,206,972	14,444,788	15,798,065	17,280,105	18,782,331	20,414,735	22,188,165	24,116,297	26,210,926
Other Operaing Revenue	351,292	396,209	433,344	473,942	518,403	563,470	612,442	665,645	723,489	786,328
Total Operaing Revenue	12,061,018	13,603,181	14,878,131	16,272,006	17,798,508	19,345,801	21,027,177	22,853,810	24,839,786	26,997,254
Generation & Transmission Cost	2,737,663	2,959,872	3,092,471	3,351,946	3,672,471	3,848,463	4,093,906	4,523,550	4,985,502	5,500,704
Purchased Energy	4,976,634	5,612,963	6,139,035	6,714,177	7,344,045	7,982,491	8,676,263	9,429,970	10,249,426	11,139,643
Distribution Cost	1,087,350	1,345,400	1,476,530	1,620,370	1,777,540	1,936,570	2,109,860	2,297,720	2,502,320	2,724,280
Depreciation	1,155,861	1,243,542	1,328,231	1,461,255	1,519,303	1,710,473	1,828,558	1,904,146	1,968,187	2,029,329
Total Sales Cost	9,957,508	11,161,777	12,036,267	13,147,748	14,313,358	15,477,997	16,708,587	18,155,386	19,705,434	21,393,957
General Operating Expenses	819,681	924,488	1,011,135	1,105,865	1,209,607	1,314,763	1,429,031	1,553,172	1,688,141	1,834,765
Total Operating Expenses	10,777,189	12,086,265	13,047,402	14,253,613	15,522,966	16,792,760	18,137,619	19,708,558	21,393,575	23,228,722
Operating Income (Tsh, million)	1,283,829	1,516,916	1,830,729	2,018,394	2,275,542	2,553,041	2,889,559	3,145,252	3,446,211	3,768,532
Operating Income (US$, million)	584	690	832	917	1,034	1,160	1,313	1,430	1,566	1,713
Finance Cost	1,398,706	1,489,077	1,548,252	1,615,944	1,656,288	1,700,296	1,736,333	1,778,391	1,802,872	1,841,467
Non operational transaction	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Income before Tax (Tsh million)	(114,876)	27,839	282,477	402,450	619,254	852,745	1,153,226	1,366,861	1,643,339	1,927,065
Income before Tax (US$, million)	(52)	13	128	183	281	388	524	621	747	876

11.2 Suggestions for the Implementation of Power System Master Plan

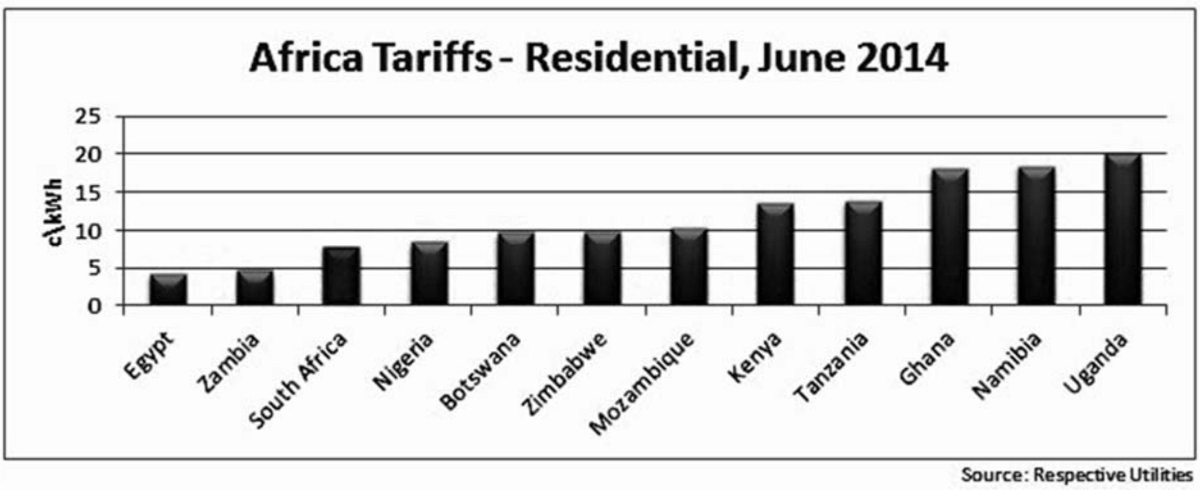
11.2.1 Suggestions for the improvement of TANESCO's financial condition

(1) Profitability

It is the good fact that TANESCO's financial condition improved greatly in 2014 due to the increased revenue of 28% and the operational cost reduction of 11%. However, the sales profit is realized at last in 2014 as the sales expenditure has exceeded the sales revenue regularly in recent years. The sales expenditure accounts for 98% of the sales revenue so the gross sales margin is realized in very low level, only 2%. Although the electric company has the role of the public utility, it should aim to realize the gross sales profit of 5%~10% in future. Also, It is necessary to reduce the sales cost to improve the profit further, but the high cost EPP (Aggreko Power Plant at Ubungo) is still remained in the energy source in 2014 after terminating the contracts with other three EPPs. Therefore, the further reduction of the cost is possible if this EPP contract is terminated in 2015. It is necessary for TANESCO to reduce the reliance on the oil and the high cost EPP and replace them with the lower cost of energy such as the hydropower and the natural gas.

(2) Tariff

Together with improving the business efficiency, the setting tariff rate to earn the adequate profit is necessary. Up to 2012, the electric tariff rate of Tanzania has been lower than the neighbor eastern African countries, so the lack of the sales profit has been compensated by the government contribution as the way of the business (Figure 11.2.1-1). The tariff rate has been increased since 2007, as the new tariff policy was set by EWURA. Changing of the tariff price, especially increasing the tariff is not implemented easily as the industry and domestic usage are affected. However, it is necessary to implement the new policy steadily that is introduced by EWURA for setting up the tariff based on the cost of energy generation, transmission and distribution.



Source: Frost & Sullivan

Figure 11.2.1-1 Tariff Rate of African countries (2014)

(3) Borrowings

Regarding long term financing of TANESCO, the current borrowings are mainly from the international donors, such funds from international donors are essential as these funds are supplied at the lower cost than the private loans and necessary for the development of national infrastructure in the future.

On the other hand, it is considerable for the government to issue the international bonds in the market as the new source of the long term financing. Issuing the international bonds in the market will diversify the financing source and find the new investors to Tanzania. Also, the investing demand from investors is strong for African countries with expected economic growth as the current long-term rate in the developed market has been historically very low due to the aggressive easing by the central government. Some African countries such as Zambia, Rwanda and Ethiopia have already issued the bonds in the international market and the next bond issue by Tanzania is expected in near future. The issue of the foreign currency denominated bonds will also strengthen the discipline for the national debt management.

11.2.2 Suggestions for Electricity Supply Industry Reform

(1) Reform Roadmap by The World Bank

The World Bank report above (”Program Document on a Proposed Development Policy Credit in the Amount SDR 65.2 Million to the United Republic of Tanzania for a Second Power and Gas Sector Development Policy Operation,” Feb. 2014) describes the following recent electricity supply industry reform movement.

- In 2007, the Government developed a Power Sector Reform Strategy, which presented a vision for the power sector in Tanzania over the medium to long-term. The reform strategy envisages the evolution of the sector from the current market structure, in which TANESCO is a single-buyer/single-seller of electricity, to eventually a more liberalized and more competitive wholesale market structure in which the producers would be able to sell directly (or through a pool or voluntary electricity exchange) to the distribution companies and large consumers. The strategy was followed by the adoption of a comprehensive Electricity Act in 2008, which takes into account many international best practices for power sector reforms as tailored to the Tanzanian environment.
- The Government realizes that it needs to increase private investments through public and private partnerships (PPPs) in this critical segment of the sector. The MEM adopted a revised PPP strategy in 2013. It adopted a policy in 2013 that future new power plants – beyond those committed ones- will be competitively tendered.
- The implementation of the Government’s policy has started with building capacity for PPP management including development of IPP/PPP projects through a competitive, transparent process.
- The Government has adopted the final report from the NKRA (National Key Result Areas) Lab on energy under the BRN (Big Results Now) initiative and started implementation of the recommendation. The progress in implementing the Lab recommendations including drafting a

time-bound Roadmap on the medium- and long-term structure of the power and gas sectors is monitored. It is expected that the Roadmap will cover such topics as TANESCO's restructuring, private sector participation, matching of objectives and targets to the updated PSMP, and expected state of the power sector in 2015, 2020, and 2035. The Roadmap will be published by the Government by June 2014 and implemented over a period of time.

(2) Reform Roadmap by MEM

The MEM's "Electricity Supply Industry Reform Strategy and Roadmap 2014 -2025," [1]which was published in June 30, 2014, indicates the following contents. The reform strategy is gradual unbundling of generation, transmission and distribution.

- The reform roadmap consists of immediate term (Jul. 2014 – Jun. 2015), short term (Jul. 2015 – Jun. 2018), medium term (Jul. 2018 – Jun. 2021) and long term (Jul. 2021 – Jun. 2025).
- The immediate term actions include Task Force establishment, capacity building program preparation, development of standard template power purchase agreement (PPA) models, designation of grid control center as Independent System Operator (ISO), business process review and TANESCO's assets and liabilities valuation and development of grid code to guide transmission and distribution companies operations.
- The short term actions include unbundling generation from transmission and distribution, designation of independent market operator and decision making decentralization (procurement, budget implementation and business plan management.
- The medium term actions include unbundling distribution from transmission, zonal office performance assessment and setting up a mechanism and rules for the operation of a retail market.
- The long term actions include unbundling distribution into several zonal companies, establishment of ESI service standards, investment in human capital and trading system, introduction of retail competition, preparation of generation and distribution companies for listing, reduction of losses from 15% to 12% and connectivity increase from 36% to 50%.

(3) Reform Roadmap by AfDB

The major donor to the government of Tanzania, AfDB, stated the followings about TANESCO in the report [Investment Plan for Tanzania, April 2013].

- First, the authorities aim at shifting the energy mix away from the expensive emergency oil-based power supply to more efficient and lower cost generation with a view to reduce the cost of electricity supply and to mitigate the risks of major shocks to the power system, such as droughts or oil price increases. The focus is presently on gas, coal and renewable energy in the near term, with coal and large hydro in the longer term.
- The second set of measures emphasizes the need to restructure sector institutions and strengthen investment planning, procurement and contracts management. This would include leveraging

[1] http://www.gst.go.tz/images/TANZANIA%20ELECTRICITY%20SUPPLY%20INDUSTRY%20REFORM%20STRATEGY%20&%20ROADMAP.pdf#search='Tanzania+ESI+Roadmap')

private investment through IPPs, procured through solicited and competitive bidding processes, and increasing market competition in power generation.

As stated above by the several international organizations, TANESCO shall be unbundled completely in the long term. Therefore, before that it is urgently necessary to make TANESCO an independent sustainable power company, namely, with profitability (no loss) and sound financial situation.

11.2.3 Suggestions for IPP entry in PSMP

(1) Promoting IPP into PSMP

IPP is a private entity to generate and sell electricity to a wholesale electricity market or to electric power companies, not retail to end users. Unlike generating sector where competition among private entities is promoted, transmission and distribution sectors are more public interest oriented because of its “unprofitability” and “openness”. In general, transmission and distribution sectors require huge initial investment while the business profit is not that attractive compared to generation sector. Adding to this, “openness”, namely fair access by the power generators or all the customers to the grid, makes it difficult for private entities run the business in these sectors.

Introduction of IPP is one of the solutions to reduce public expenditure for the power development. If the government tries to cover all the required cost by public funds, the governmental budget (or debt) for the power development will be huge. For example, investment on generation proposed by PSMP2016 from 2016 to 2020 requires US$11.6 billion which is bigger than government budget of US$10.2 billion[2] in 2015/2016. The financing by the government with the funds/supports from the international development organizations may be a solution, however the volume of such funds/supports is limited and such loan supports may need to address other prioritized sectors. Apart from that, if all the funds are borrowed by the government alone, it would exceed the standard debt balance of the budget.

Therefore, it is necessary to introduce IPP into generation sector as the electricity supply industry reform roadmap of Tanzania prescribes. IPPs reduce necessary financing loan and also government’s burden to secure the funds. Moreover, Power sector developed by IPP has the potential to make the business of electric power efficient by introducing private funds and market competition.

(2) Suggested power generation sectors by IPP in PSMP

Renewable power generation projects such as wind and solar power in PSMP 2016 are currently on going or under negotiation. If those projects are realized, the target share of renewable energy in generation mix (5%) will be achieved. Therefore, further investment by IPPs is not counted for this sector.

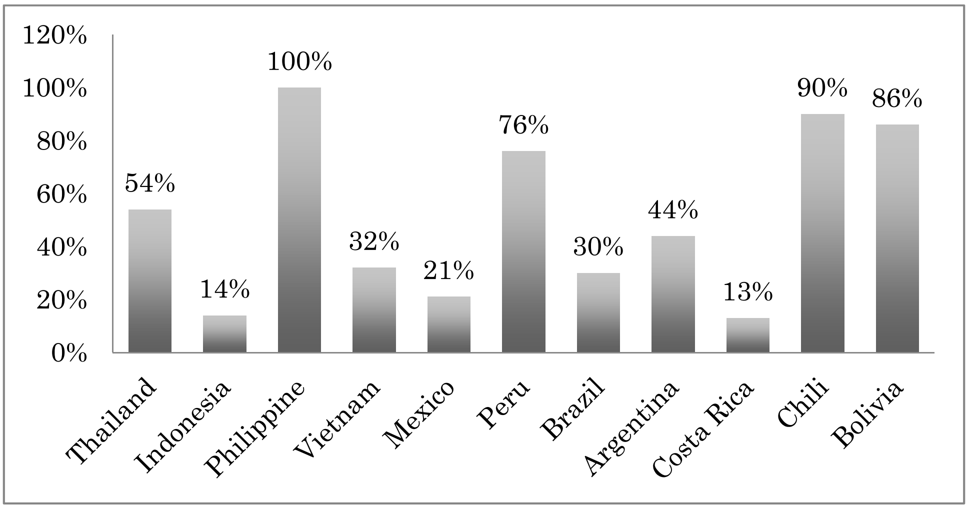
[2] Budget of Tanzania is Tsh. 22,495.5 billion in 2015/2016, around US$10.2 billion at US$/Tsh 2200.

Investment on hydro power generation is a rather risky for IPP as it requires huge initial investment and long payback period of investment. That is the reason why IPPs prefer natural and coal thermal development rather than hydro power development.

Power generation ratio is suggested in 40% gas and 35% coal in PSMP 2016. Coal fired power generation by IPP or PPP is indispensable because there is trend against supporting coal power development by the Official Development Assistance. On the other hand, development of gas fired power generation by both IPPs and a public utility is necessary to meet rapidly increasing electricity demand in short term. Negotiation with IPPs may take long time and they might not come online in a timely manner. Therefore, public investment on gas fired power in short term plays an important role.

(3) IPP ratios in Asian and South American countries

IPP ratios in Asian and South American countries are stated in the Figure 11.2.3-1 below. The government target for IPP ratio varies and depends on development policy of power system in each country.



Source: JICA Study team based on data from Japan Electric Power Information Center

Figure 11.2.3-1 IPP ratios in Asian and South American countries
(As of 2011, except Philippines 2014)

(4) IPP ratio in PSMP

In case of western countries, promoting IPP is sought for the efficiency of power sector through the competition and deregulation. In case of Tanzania, the main reason for promoting IPP in PSMP is reducing the debt borrowings for the capital expenditure, if the efficiency is obtained, it is accompanying benefit.

Promoting IPP prematurely into undeveloped power sector in developing countries often causes uncompetitive market instead of efficiency and better public utility service to the citizen. There are several cases in other countries where IPP policy is introduced without adequate electricity market system and capital market. In such cases, promoting of private investments to power generation business or selling of public generation assets to private investors have not gone smoothly.

Prevention of monopoly and inefficient market competition caused by privatization of power sector is also an important issue. Private monopoly can replace to public monopoly, if the privatization is introduced without appropriate strategies and regulations. If IPPs generate all the power for Tanzania, TANESCO might lose bargaining power for the wholesale price set by IPPs and the tariff rates may increase (due to the less competition among power generators).It is recommended, therefore, that TANESCO keep the share of its own generation facilities in the market in order to maintain such bargaining power.

Taking this aspects together with financing need of private investment into consideration, the PSMP recommends the IPP ratio should be up to 50% under the circumstances where market competition and regulation have not been well established. It is also necessary to establish independent regulatory agency in order to avoid such monopoly

(5) Suggested project return for IPP

Required Investment return for IPP which is Internal Rate of Return (IRR) of the project is suggested around 12%~16%[3] per annum in US Dollar that reflects investment risk of business and funding cost in long term at the current market condition.

(6) Financing and Incentives programs for promoting IPP into PSMP

The nature of the business for electric power sector requires long term commitment for investments in Tanzania.

Apart from achieving investment return, IPP may face associated uncertainty of business such as collection of funds, breaching agreement by local partners, and securing raw material supply. Therefore, incentive programs and supports for promoting IPP into PSMP are indispensable. Several programs are exampled in the following parts for covering financial risks and incentives for IPP, namely, 1) Guarantee, 2) Long-term finance opportunity for IPP and 3) Financial support for feasible study (F/S). These programs will mitigate financial risks and support financial costs for IPPs.

1) Guarantee

- **IDA (International Development Association) Partial Risk Guarantees (PRG) by World Bank**

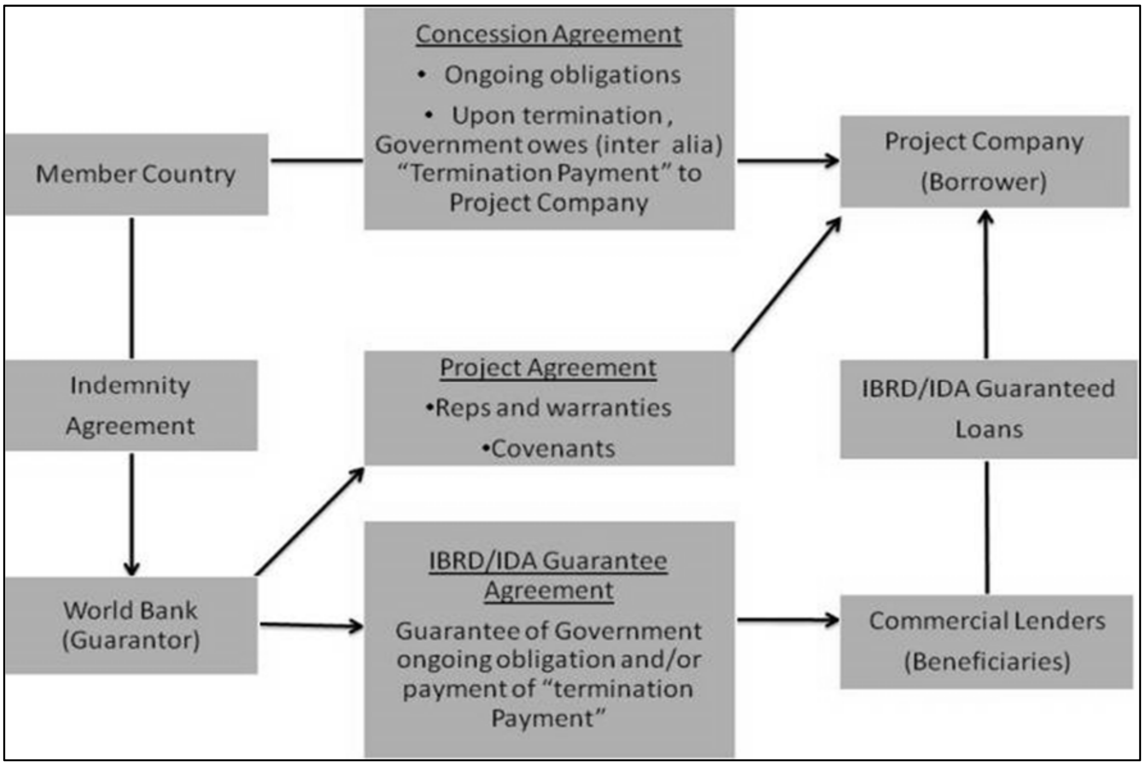
  PRGs cover private lenders against the risk of a public entity failing to perform its obligations with respect to a private project. PRGs ensure payment in the case of default resulting from the nonperformance of contractual obligations undertaken by governments or their agencies in private sector projects. PRGs typically cover outstanding principal and accrued interest of a debt

[3] This return target rate is based on the current US10 year bond yield 2.5%, borrowing spread 4~5% and investment spread 5%~8%.

tranche in full. Payment is made only if the debt service default is caused by risks specified under the guarantee.

Fees: Currently the following fees are payable by private project sponsors (or the project company) to the World Bank.

- Initiation Fee: one-time fee of 0.15% on the amount of the guarantee or a minimum of US$100,000;
- Processing Fee: one-time fee of up to 0.5% on the amount of the guarantee, to cover the cost of out-of-pocket expenses;
- Guarantee Fee: 0.75% per annum on the disbursed and outstanding guarantee amount;

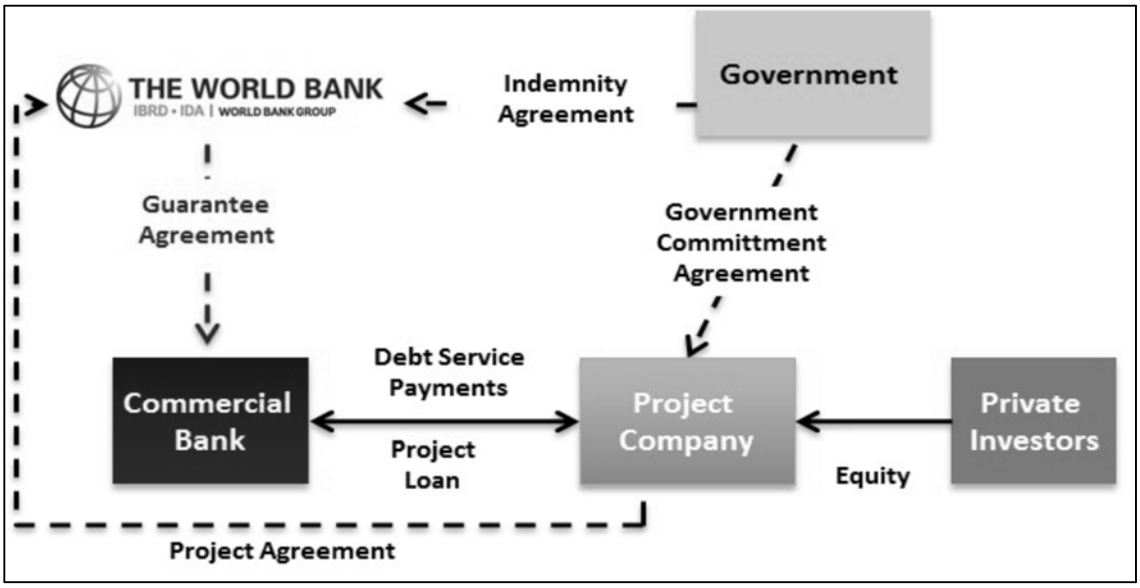


Source: World Bank

Figure 11.2.3-2 Traditional PRG structure

Examples of Contractual Structure

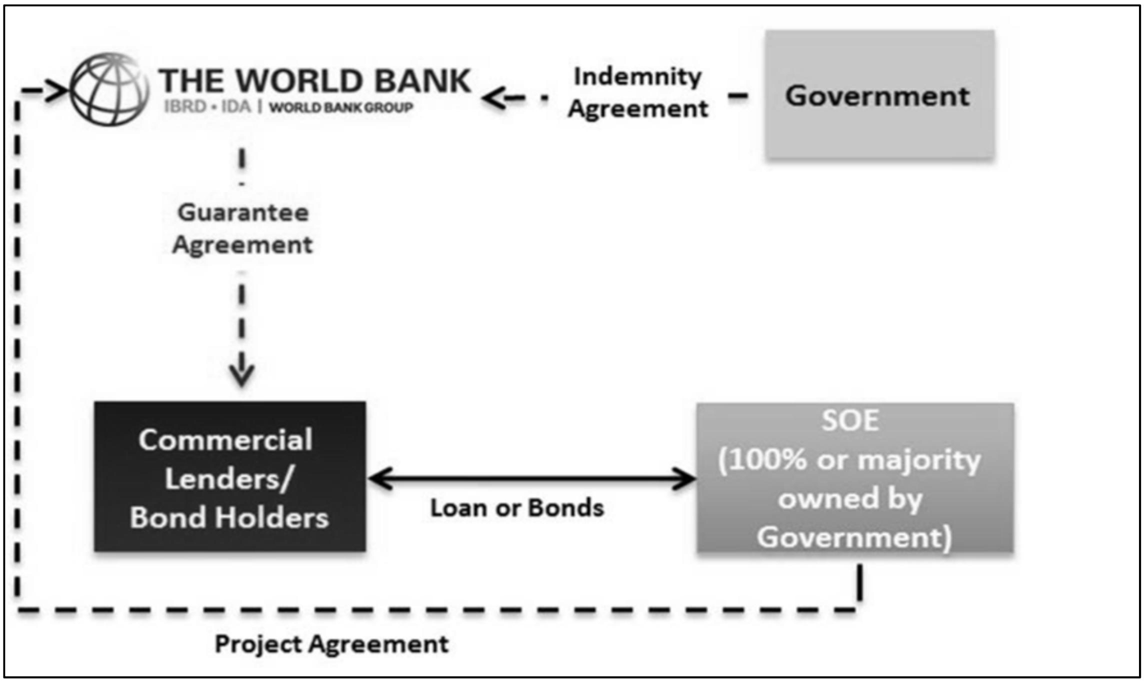
- Loan Guarantees- risk mitigation for payment or performance default by government to a private project, which triggers payment default under a commercial loan between the project and commercial lenders.



Source: World Bank

Figure 11.2.3-3 Loan guarantee PRG structure

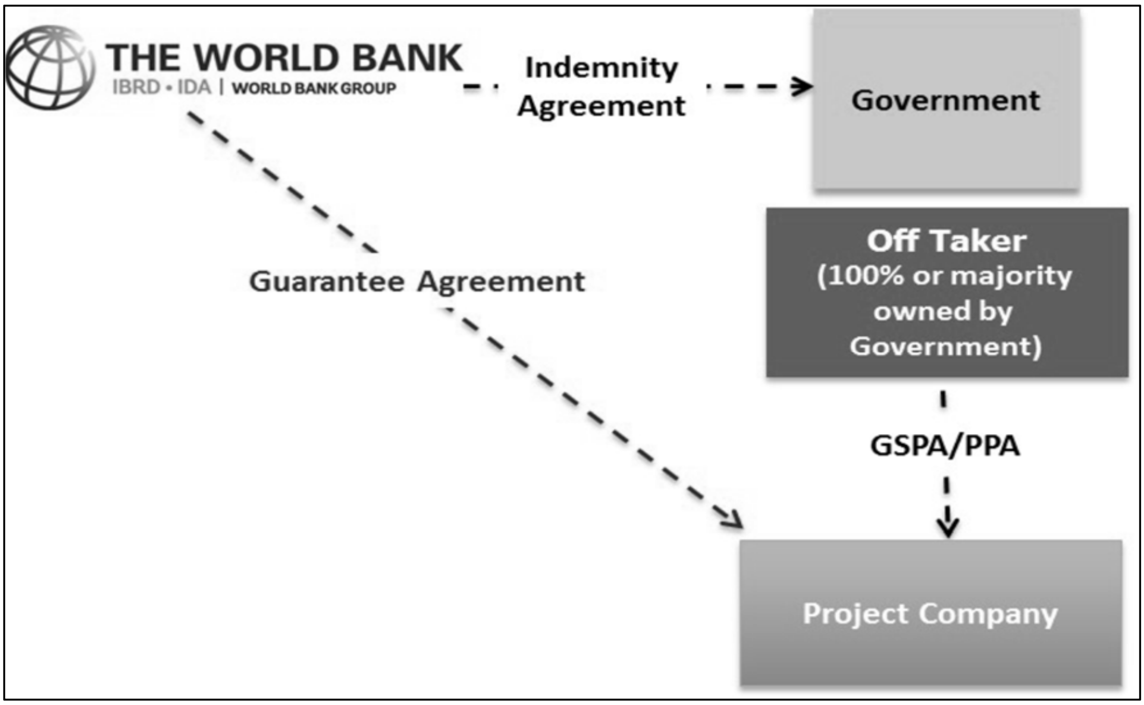
- Loan Guarantees – risk mitigation for payment default on debt service obligations to commercial lenders or bondholders due directly by government.



Source: World Bank

Figure 11.2.3-4 Loan guarantee PRG structure

- Payment Guarantees – risk mitigation for payment default by government under a contract with a private project (Figure 11.2.3-5).



Source: World Bank

Figure 11.2.3-5 Payment guarantee PRG structure

Example for Uganda

- PRG for renewable energy development program for Uganda
  PRG for Renewable Energy Development Program Project is to increase electricity generation capacity of Uganda through renewable energy based small private power producers. This component includes: based on a Government-led assessment, a key priority for attracting private sector participation in small renewable energy projects is to provide risk mitigation instruments.

➢ **Trade Insurance by Nippon Export and Investment Insurance (NEXI)**

NEXI is the official export credit agency of Japan. NEXI provides the following coverage for the private Japanese/Non-Japanese business resident having business activity based in Japan.

- Insurance for loan and overseas investment.
- Insurance period up to 30 years
- Coverage for nonperformance of contractual obligations undertaken by governments or their agencies after the end of project.
- Insurance for the obligation with sub-sovereign entity.

Example:

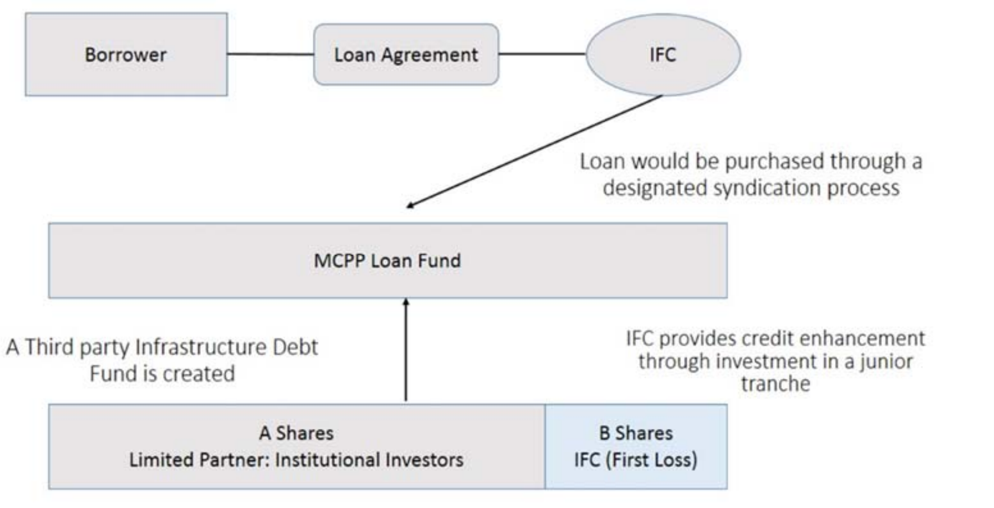
- Pumped power generation project by South Africa/ Eskom
  Eskom is South African electricity public utility. NEXI underwrote trade loan insurance for export payment of pumping turbines and motor generators for power generation exported by Japanese/Non-Japanese consortium.

2) **Long term finance**

➢ **Managed Co-lending Portfolio Program (MCPP) by International Finance Corporation (IFC)**

MPCC is a program fund jointly invested by IFC and private funds that aims to invest in the infrastructure projects in developing countries. IFC provides a first- loss tranche of up to 10% of each partner's portfolio. This is supported by guarantees from the Swedish International Development Cooperation Agency (Sida). MCPP Infrastructure was designed for institutional investors who are seeking to increase their exposure to emerging market infrastructure debt. MCPP loan to have a yield 4%~5% above London Interbank Offer Rate (LIBOR).

The target amount of funds rising is USD 5 billion. IPP may access these funds for long-term financial source.



Source: IFC

Figure 11.2.3-6 MCPP structure

Example Investors:

- The People's Bank of China (PBOC), through SAFE, its State Administration for Foreign Exchange, is the first partner in the program. SAFE is a long-standing partner of IFC and the PBOC has pledged $3 billion under the MCPP platform to be committed in the next six years.
- Germany's Allianz Group has made a US$500mn partnership agreement with the IFC to co-invest in this program. Other European insurance companies such as AXA and Prudential also show interest to invest.

3) **Feasible Study (F/S) Support**

➢ **Feasible Study (F/S) Support by JICA with Private-Sector Activities in Developing Countries**

JICA promotes public-private partnerships aims at improving the business environment in developing countries and the support infrastructure development and improvement of public services through PPP in which government and private sector share responsibilities.

JICA supports up to JPY 300million for feasible study by private entity for investing in infrastructure sector in developing countries.

Example:

- JICA supports F/S by private investor for investing Tsetsii Wind Farm-power generation system in Mongolia. IPP signed financing agreements with JICA and EBRD to construct a 50MW wind farm in southern Mongolia.
- JICA supports F/S by private investor for investing new technology Thermal-power generation system in Bosnia and Herzegovina.

➢ **Technical assistance by AfDB**

AfDB's technical assistance is primarily focused on increasing the development outcomes of its operations, raising the effectiveness of project preparation which is vital in ensuring the best developmental and poverty-reducing outcomes for projects that receive Bank financing.

Example:

- AfDB approved a US $15.3 million African Development Fund loan for technical assistance to the Government of the Republic of Mozambique. The loan will help the Government to create the skills and competencies required to deliver optimal gas and power projects as well as support the financial closure of three mega projects.

11.3 Other incentives for IPP

Following incentives for IPP to enter into the electric power market are considered.

➢ Power and Energy Purchase Agreement (PPA)

PPA secures the payment stream for a Build-Own Transfer (BOT) or concession project for an IPP. It is between the purchaser "off taker" (often a state-owned electricity utility) and a privately owned power producer.

➢ Tax exemption or reduction

Income tax exemption or reduction in certain period may attract IPPs. Customs exemption or reduction for imported equipment may be useful..

➢ Accelerated depreciation for tax accounting

It is a kind of income tax reduction method.

➢ Payment guarantee by the government

The government guarantee to IPP for nonperformance of contractual obligations with government agencies and private entities.

➢ Raw material supply guarantee by the government

The government guarantee to IPP for raw material supply for generation

➢ Viability Gap Funding (VGF)

The government subsidies are used to make up for PPP business losses.

- Local currency loan and foreign exchange risk hedging
  Local currency loan or long term foreign exchange hedging schemes provided by international donors

- Policy risk insurance (PRI)
  Political Risk Insurance (PRI) against the specific risks of transfer and convertibility, expropriation, war and civil disturbance, and breach of contract. MIGA provides PRI.