A-1. 協議議事録（M/M）

MINUTES OF MEETING
BETWEEN
THE GOVERNMENT OF TANZANIA
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
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

Japan International Cooperation Agency (hereinafter referred to as "JICA") is supporting the Ministry of Energy and Minerals in the United Republic of Tanzania (hereinafter referred to as "Tanzania") to formulate the Power System Master Plan in Dar es Salaam and Coast Regions and Review of Power System Master Plan 2012 (hereinafter referred to as "the Project").

JICA engaged a consultant who submitted Progress Report-2 of the Project in March 2015. The Tanzanian side reviewed the report and submitted comments of the report in May 2015. The consultant reviewed the comments and responded to the Tanzanian side. Thereafter, the Project Team (hereinafter referred to as "the Team") headed by Mr. Kyoji Fujii visited Tanzania from 6th July to 24th July, 2015 for the purpose of exchanging mutual opinions on how to finalize the review and update of Power System Master Plan 2012.

During its stay in Tanzania, the Team had a series of discussions and exchanged views with Task Force Team (hereinafter referred to as "TFT") formed by the Ministry of Energy and Minerals (hereinafter referred to as "MEM") of the Government of United Republic of Tanzania (hereinafter referred to as "the Tanzanian side") over the matters for the successful implementation of the Project.

As a result of the discussions, both sides agreed the matters referred to in the document attached hereto.

Dar es Salaam, 10th August, 2015

Mwihava

Eng. N. C. X. Mwihava
Acting Permanent Secretary,
Ministry of Energy and Minerals

Mr. Toshio Nagase
Chief Representative
JICA Tanzania Office

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for Mr. Kyoji Fujii
Chief Consultant
JICA Project Team

AGREED MATTERS

1. Organizational Structure

The Team and the Tanzanian side confirmed that Technical Working Groups will be formed under the Project managers for review and update of Power System Master Plan 2012 (PSMP 2012) was established as shown in Appendix 1 and 2. The Tanzanian side agreed to ensure the Working Group members be available during activities of the Team are taking place in Tanzania.

2. Timeframe

The Team and the Tanzanian side agreed to implement the review and update of PSMP 2012 in accordance with the schedule shown in Appendix 3.

3. Regional demand survey

The Team and the Tanzanian side agreed that regional demand survey to collect actual power demand and socio economic data in all regions will be conducted in order to make the review and update of PSMP 2012 be comprehensive and realistic within the agreed timeframe (Appendix-3) and the terms of reference (Appendix-4). JICA agreed to make necessary financial arrangement for the survey as per the terms of reference (Appendix-4). The survey will capture the following data;

I. population and per capita income of each district in the region,
II. planned public and private projects which will consume more than 0.5MW,
III. transformer capacity, peak demand, energy supplied and amount of load shedding at each grid substation and
IV. number of consumers by tariff category at each TANESCO's district office.

The survey will be conducted by hiring a local consultant. During the data collection in the regions, the Working Group members who accompany with the Local Consultant may instruct day-to-day survey details but issues related to the scope of the survey, will be instructed by the TFT in consultation with the Team . However, in case any additional costs may incur, the Local Consultant shall obtain a prior approval by the Team.

The results of the survey will also be utilized for the formulation of Power System Master Plan in Dar es Salaam and Coast Regions. Data collection and analysis for Power System Master Plan in Dar es Salaam and Coast Regions will be carried out in parallel with the data collection for review and update of PSMP 2012 in order to implement the Project in an efficient and effective manner. However, the preparation of the Power System Master Plan for Dar es Salaam and Coast Regions shall commence after the completion of PSMP 2012 review and update.

4. Format and output of PSMP 2012 review and update

Both sides discussed on the comments raised by the Tanzanian side and answers responded by the Team regarding the Progress Report-2. The agreed results are shown in Appendix-5. Furthermore, both sides agreed that the output of the Project regarding the PSMP will be as follows.

I. Updated PSMP will have a similar format to PSMP 2012 unless the Technical Working Group agrees to add or change some chapters or sub-chapters where necessary.
II. EXECUTIVE SUMMARY of the FULL REPORT
III. FULL REPORT which includes detailed technical information, procedures, analysis, recommendations to realize and implement the projects indicated in the updated PSMP

5. Procedure of review and update of PSMP 2012

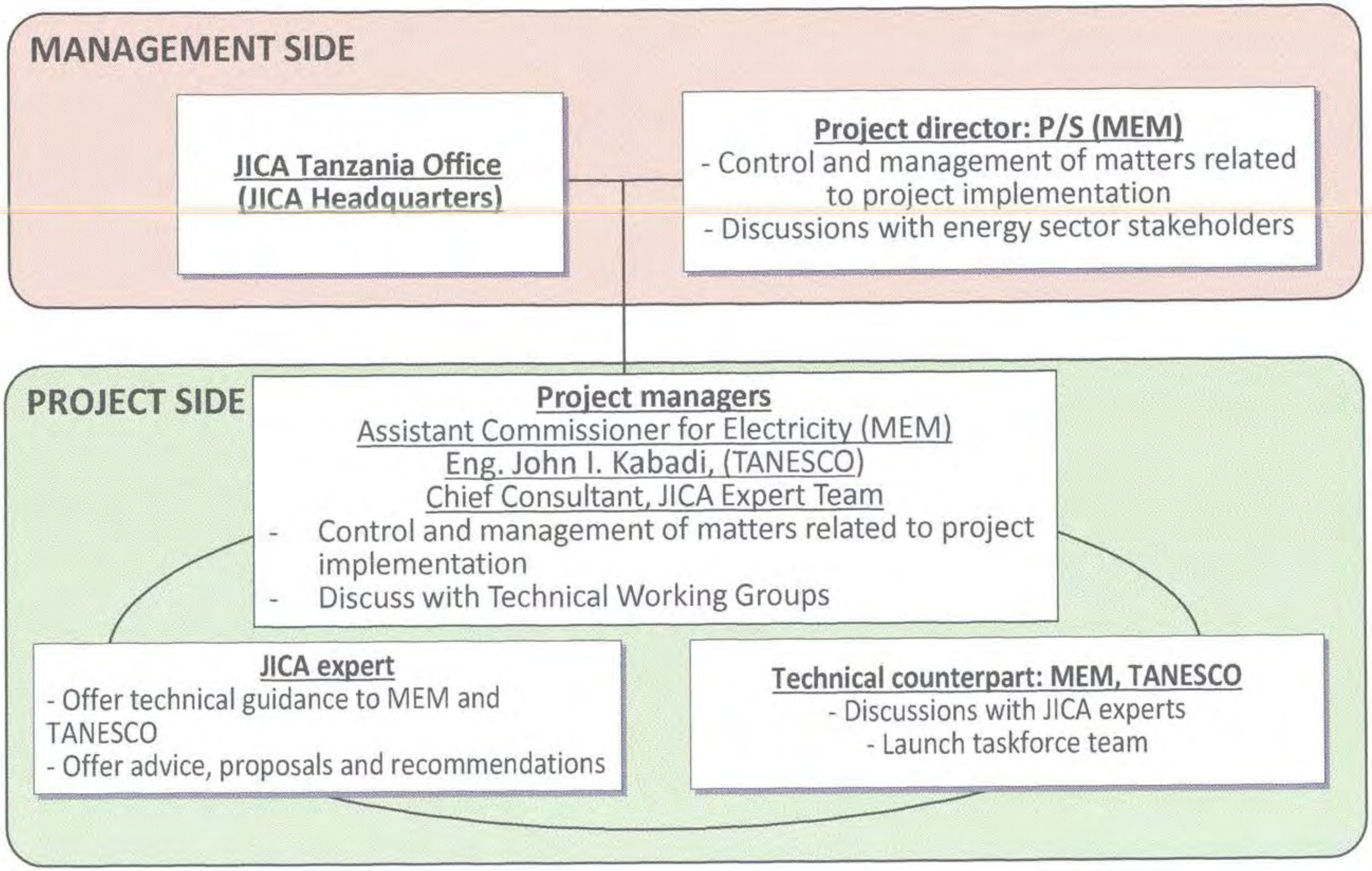
The Team and the Tanzanian side confirmed that the Technical Working Group will commence the revision of the Progress Report-2 to make the updated PSMP 2012 based on the results of the regional demand survey.

Appendix List

Appendix 1: Organizational structure
Appendix 2: Organization of Technical Working Group
Appendix 3: Schedule of reviewing PSMP 2012
Appendix-4: Terms of Reference for the regional demand survey
Appendix-5: Comments and answers to Progress Report-2

Appendix-1

Organizational structure of the Project



MANAGEMENT SIDE

JICA Tanzania Office (JICA Headquarters)

Project director: P/S (MEM)
- Control and management of matters related to project implementation
- Discussions with energy sector stakeholders

PROJECT SIDE

Project managers
Assistant Commissioner for Electricity (MEM)
Eng. John I. Kabadi, (TANESCO)
Chief Consultant, JICA Expert Team
- Control and management of matters related to project implementation
- Discuss with Technical Working Groups

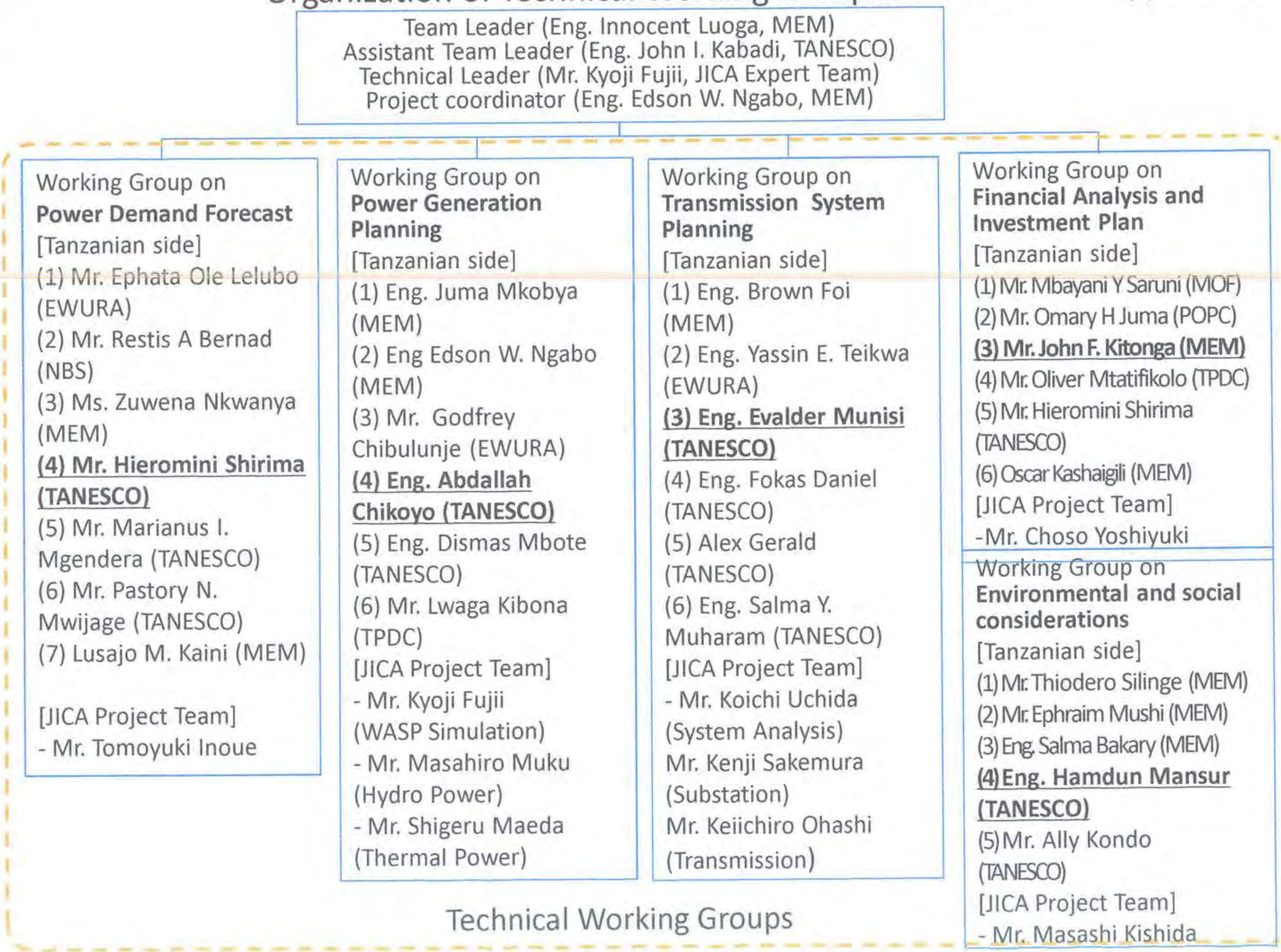
JICA expert
- Offer technical guidance to MEM and TANESCO
- Offer advice, proposals and recommendations

Technical counterpart: MEM, TANESCO
- Discussions with JICA experts
- Launch taskforce team

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

Appendix-2

Organization of Technical Working Groups for PSMP



Team Leader (Eng. Innocent Luoga, MEM)
Assistant Team Leader (Eng. John I. Kabadi, TANESCO)
Technical Leader (Mr. Kyoji Fujii, JICA Expert Team)
Project coordinator (Eng. Edson W. Ngabo, MEM)

Working Group on
Power Demand Forecast
[Tanzanian side]
(1) Mr. Ephata Ole Lelubo (EWURA)
(2) Mr. Restis A Bernad (NBS)
(3) Ms. Zuwena Nkwanya (MEM)
(4) Mr. Hieromini Shirima (TANESCO)
(5) Mr. Marianus I. Mgendera (TANESCO)
(6) Mr. Pastory N. Mwijage (TANESCO)
(7) Lusajo M. Kaini (MEM)

[JICA Project Team]
- Mr. Tomoyuki Inoue

Working Group on
Power Generation Planning
[Tanzanian side]
(1) Eng. Juma Mkobya (MEM)
(2) Eng Edson W. Ngabo (MEM)
(3) Mr. Godfrey Chibulunje (EWURA)
(4) Eng. Abdallah Chikoyo (TANESCO)
(5) Eng. Dismas Mbote (TANESCO)
(6) Mr. Lwaga Kibona (TPDC)
[JICA Project Team]
- Mr. Kyoji Fujii (WASP Simulation)
- Mr. Masahiro Muku (Hydro Power)
- Mr. Shigeru Maeda (Thermal Power)

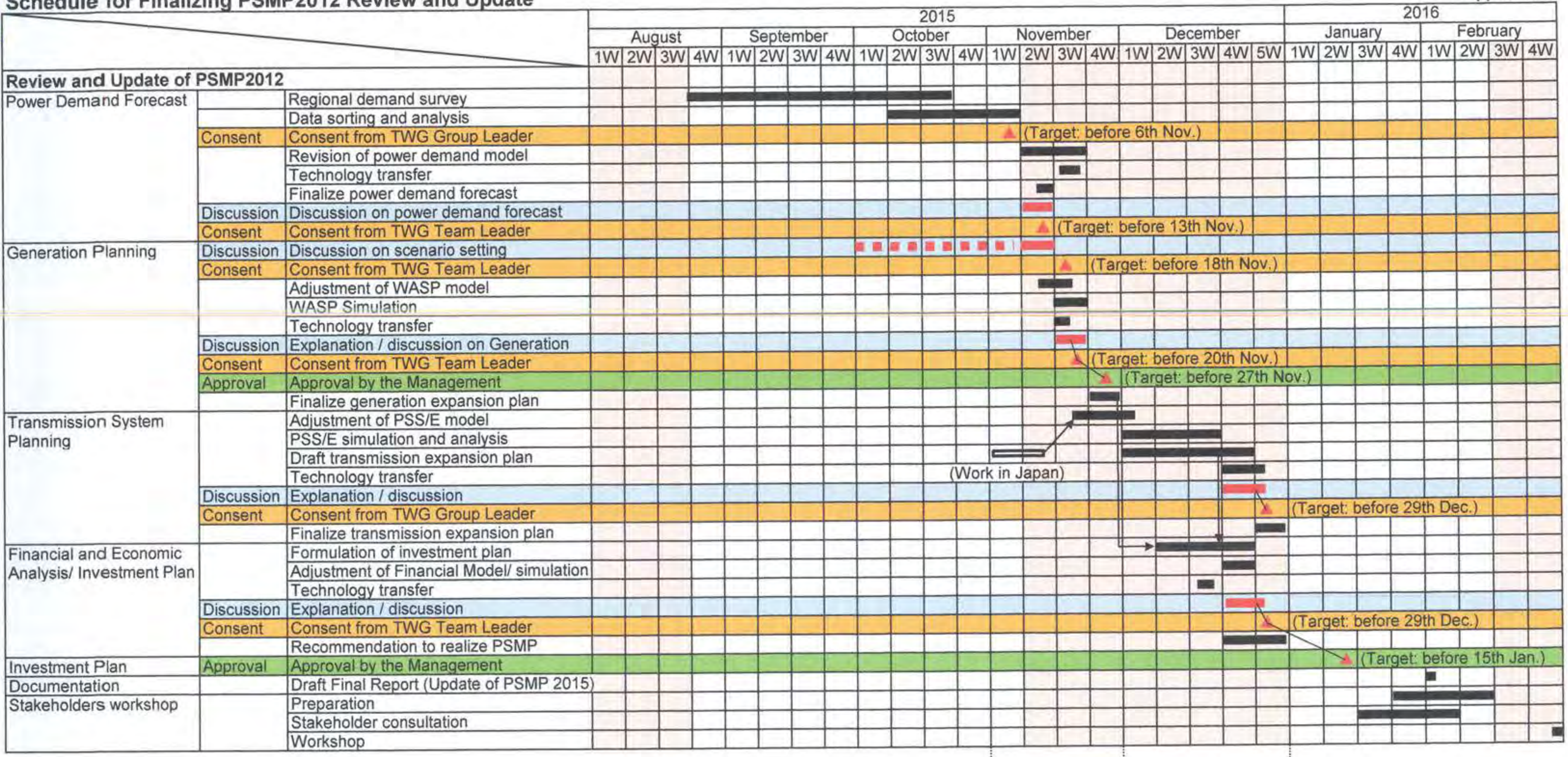
Working Group on
Transmission System Planning
[Tanzanian side]
(1) Eng. Brown Foi (MEM)
(2) Eng. Yassin E. Teikwa (EWURA)
(3) Eng. Evalder Munisi (TANESCO)
(4) Eng. Fokas Daniel (TANESCO)
(5) Alex Gerald (TANESCO)
(6) Eng. Salma Y. Muharam (TANESCO)
[JICA Project Team]
- Mr. Koichi Uchida (System Analysis)
Mr. Kenji Sakemura (Substation)
Mr. Keiichiro Ohashi (Transmission)

Working Group on
Financial Analysis and Investment Plan
[Tanzanian side]
(1) Mr. Mbayani Y Saruni (MOF)
(2) Mr. Omary H Juma (POPC)
(3) Mr. John F. Kitonga (MEM)
(4) Mr. Oliver Mtatifikolo (TPDC)
(5) Mr. Hieromini Shirima (TANESCO)
(6) Oscar Kashaigili (MEM)
[JICA Project Team]
-Mr. Choso Yoshiyuki

Working Group on
Environmental and social considerations
[Tanzanian side]
(1) Mr. Thiodero Silinge (MEM)
(2) Mr. Ephraim Mushi (MEM)
(3) Eng. Salma Bakary (MEM)
(4) Eng. Hamdun Mansur (TANESCO)
(5) Mr. Ally Kondo (TANESCO)
[JICA Project Team]
- Mr. Masashi Kishida

Technical Working Groups

Schedule for Finalizing PSMP2012 Review and Update



Review and Update of PSMP2012			
Power Demand Forecast		Regional demand survey	
		Data sorting and analysis	
	Consent	Consent from TWG Group Leader	(Target: before 6th Nov.)
		Revision of power demand model	
		Technology transfer	
		Finalize power demand forecast	
	Discussion	Discussion on power demand forecast	
	Consent	Consent from TWG Team Leader	(Target: before 13th Nov.)
Generation Planning	Discussion	Discussion on scenario setting	
	Consent	Consent from TWG Team Leader	(Target: before 18th Nov.)
		Adjustment of WASP model	
		WASP Simulation	
		Technology transfer	
	Discussion	Explanation / discussion on Generation	
	Consent	Consent from TWG Team Leader	(Target: before 20th Nov.)
	Approval	Approval by the Management	(Target: before 27th Nov.)
		Finalize generation expansion plan	
Transmission System Planning		Adjustment of PSS/E model	
		PSS/E simulation and analysis	
		Draft transmission expansion plan	
		Technology transfer	(Work in Japan)
	Discussion	Explanation / discussion	
	Consent	Consent from TWG Group Leader	(Target: before 29th Dec.)
		Finalize transmission expansion plan	
Financial and Economic Analysis/ Investment Plan		Formulation of investment plan	
		Adjustment of Financial Model/ simulation	
		Technology transfer	
	Discussion	Explanation / discussion	
	Consent	Consent from TWG Team Leader	(Target: before 29th Dec.)
		Recommendation to realize PSMP	
Investment Plan	Approval	Approval by the Management	(Target: before 15th Jan.)
Documentation		Draft Final Report (Update of PSMP 2015)	
Stakeholders workshop		Preparation	
		Stakeholder consultation	
		Workshop	

1. "Regional Demand Survey" will be commenced at the middle of August, 2015.
2. Every Technical Working Group member shall keep availability to attend discussions and technology transfer written in the schedule.
3. Every Consent will be made before the day described in the schedule.

🟥	: Field work of JICA Experts in Tanzania
Discussion	: Every TWG member shall attend the discussions written in the schedule
Consent	: TWG Team/Group Leader make a Consent before the day written in the schedule
Approval	: Approval by the Management

4. Summary of the draft report by each group shall be checked by TWG by the end of each stage
5. Every correction to the summary report shall be reflected to the Draft Final Report

TWG: Technical Working Group

1W	: Day 2~6
2W	: Day 9~13
3W	: Day 16~20
4W	: Day 23~27

1W	: Day 30~4
2W	: Day 7~11
3W	: Day 14~18
4W	: Day 21~25
5W	: Day 28~31

REQUEST FOR PROPOSAL ON REGIONAL POWER DEMAND SURVEY
FOR
THE PROJECT FOR FORMULATION OF POWER SYSTEM MASTER PLAN IN DAR ES SALAAM AND REVIEW OF POWER SYSTEM MASTER PLAN 2012

1. Introduction

Japan International Cooperation Agency (JICA), a government agency dealing with Japan's official development assistance (ODA) is now implementing the review and update of "Power System Master Plan 2012" (PSMP2012) in collaboration with Task Force Team (TFT) of the government of the United Republic of Tanzania. Yachiyo Engineering Co., Ltd (YEC) is a Japanese consultant who supports the update and review of PSMP2012 as a technical cooperation from JICA. Among various research items, TFT and YEC are now updating power demand forecasts to reflect the latest economic and social situation in the master plan. In order to facilitate an efficient study, YEC intends to hire a local consultant (hereinafter, referred to as "the Local Consultant") who will survey and collect the following data and information from the all regions in collaboration with TFT in Tanzania and requests a relevant consulting firm to submit a proposal for the survey.

2. Purpose of the Survey

The purposes of the Survey are to;

1) Obtain data and information on current and future electricity consumption from regional and district government offices, TANESCO's regional offices and electric power big consumers in the whole regions of Tanzania.
2) Sum up the data and the information for updating power demand forecasts. The future power demand and required capacity of grid substations which have 66kV or higher voltage, number of population of regions, income per capita and future power consumption of big power consumers should be summed up by region and the total power demand and capacity in the country should be calculated.

3. Scope of the work

In this context, this survey covers the following scope;

1) The Local Consultant should visit the relevant organizations in the regions, and collect and study the current and future electric power consumptions and economic data by region. The relevant organizations are mainly grid substations, regional and district government offices, TANESCO's regional offices and big electric consumers indicated by TANESCO's regional offices.

2) The Local Consultant should prepare the required transportation facility (4WD wagon is required), accommodation facility, paper, computer systems and necessary equipment and materials for the survey, scheduling on the survey and analyzing the collected data and information.

3) For information of the Local Consultant, the following documents are prepared.

Appendix 1 : Composition of survey groups to visit the regions
Appendix 2 : Questionnaire on the survey (for reference)
Appendix 3 : Staff composition for the survey team

4. Terms of Reference (TOR)

4.1 Preparatory works for the survey

1) Prepare letters explaining the purpose of the survey to regional relevant organizations
2) Prepare questionnaire and calculation forms (MS-EXCEL) for summation of the collected data
3) Prepare the timetable for visiting relevant organizations in regions
4) Make the all kinds of appointments for the survey (Ex. accommodation facilities, visiting sites and transportation facilities).

4.2 Data collection from regional organizations

1) Contact and visit representatives of the relevant organizations
2) Explain the purposes of the survey and necessary table forms for each item
3) Collect data and information in line with the questionnaire
4) Summarize data and information
5) If the required data and information are not available, the Local Consultant has to obtain reasonably estimated numbers from the organizations.
6) Make overall reports (MS-EXCEL sheet) by region

4.3 Report

The following works shall be completed by the end of the first week in November 2015.

1) Draft Data Sheet

The Draft Data Sheet shall present gathered and summarized results.

2) Final Report

The Final Report shall present gathered and summarized results.

3) Contents of the Report
   a. Complete questionnaires of all regions
   b. The total capacity, shedding and demand of substations in the country (Substation wise table)
   c. The number of customers in the country (by region and by T1+D1, T2, T3 wise table)
   d. The number of population in the country (by region wise table)

e. The average income per capita of the country (by region wise table)
f. The big project name and power consumption in the country (by region wise projects)
g. The big consumer name, power consumption and remarks in the country (by region wise consumers)

5. Schedule

The contract shall be executed as shown below.

1) The contract shall cover the work as stipulated under items from 4.1 to 4.3 as above.
2) The term of the contract shall start from the date of signing the contract (expected to be Aug 24, 2015).
3) The Local Consultant shall submit the Final Report by the end of the first week in November, 2015

Table-1 Schedule of the survey

	Aug 2015	Sep 2015	Oct 2015	Nov 2015
Bidding	▲			
Contract	▲			
Survey	■	■	■	
Reports			■	▲

6. Preparation of Proposal and Submission

The proposal shall be composed of technical proposal and financial proposal as follows;

6.1 Technical proposal

1) Profile of the Local Consultant
   Explanation shall be given within 20 lines in A4 paper.
2) Organization Chart of the firm
   The organization chart should include names of Directors, names of Departments and number of employees
3) List of the experiences in the similar field
   Describe the projects implemented by the Local Consultant within last 3 years stipulating project title, manager name and financer in the following form.

Table-2 Sample content of list of experiences

Project Title	Manager	Financed by
(Ex.) Coal demand forecast	Dr. XXXXX	Government

4) Organization Chart of the survey team

Describe staff names to be engaged in the Survey.

5) Financial Statement

Profit and loss statement of the Local Consultant for last three fiscal years

6.2 Financial Proposal

The financial proposal shall include the following items. Necessary transportation cost with fuel, accommodations and per diems for the Task Force Team (TFT) with an estimated **amount of one hundred fifty two million five hundred forty thousand Tanzanian shilling (TSH152,540,000)**, stipulated in the Appendix 3 shall also be included in the items.

Table-3 Form of financial proposal

Task	Task contents	Cost estimation
Task1	4.1 Preparatory work for the survey 1) With help from Ministry of Energy and Minerals, prepare letters explaining the survey purpose 2) Prepare questionnaire and calculation forms (MS-EXCEL) for summation of the collected data 3) Prepare the timetable for visiting relevant organizations 4) With help from TANESCO, make all kinds of appointments for the survey (Excluding accommodation facilities), visiting sites and transportation facilities.	Cost breakdown for Task1 Manpower XXXXXX Technical fee XXXXX Other costs XXXXXX ------------------------------ Total XXXXXX
Task2	**4.2 Data collection from regional organizations** 1) Contact and visit representatives of the relevant organizations 2) Explain the purposes of the survey and necessary table forms for each item 3) Collecting data and information in line with the questionnaire 4) Summarize data and information 5) If the required data and information are not available, the contractor has to obtain reasonably estimated number from the organizations. 6) Make overall reports (MS-EXCEL sheet) by region	Cost breakdown for Task2 Manpower XXXXX Transportation XXXXX Accommodation XXXXX Other cost XXXXX ---------------------------------- Total
Task3	**4.3 Report** 1) Draft Data Sheet The Draft Data Sheet shall present completely gathered and summarized results.	Cost breakdown for Task3 Manpower XXXXX Technical fee XXXXX Print cost XXXXX

	2) Final Report The Final Report shall present completely gathered and summarized results.	Other cost XXXXX ----------------------------------- Total
	Total	Total cost of Task1, Task2, and Task3

6.3 Date and mode of Submission

Technical and financial proposals shall be submitted by 16:00 (Tanzanian standard time) 29th July 2015 via e-mail to Mr. Makoto Abe (mk-abe@intl.yachiyo-eng.co.jp) of YEC together with a submission letter signed by the representative of the Local Consultant.

7. Instruction to the Local Consultant

7.1 Contact information

Prior to execution of the contract, TANESCO shall provide the addresses and contact persons of its regional offices.

7.2 Instruction

YEC may give the Local Consultant any additional instruction for the purposes of the study, as appropriate. During the data collection in the regions, Task Force Team members who accompany with the Local Consultant may instruct day-to-day survey details but issues related to contract such as payment, the scope of the survey, etc. will be instructed by YEC.

8. Others

8.1 Responsibility of the Local Consultant

The Local Consultant shall be ready to perform the survey as instructed by YEC. All copies of the completed documents, data and information shall be submitted by the Local Consultant to YEC.

8.2 Number of copy for submission documents

One (1) original documents and USB memory including all kinds of the data, the information and the reports are required for Draft Data Sheet and Final Report.

8.3 Inspection

YEC shall have the right to inspect the work being carried out by the Local Consultant. Any incomplete work shall be re-conducted on the account of the Local Consultant.

8.4 Legal Obligation

Local consultant shall sign with TANESCO a non-disclosure agreement to protect the collected information/ data.

Composition of survey groups to visit the regions

GROUP 1	Group Members	Route	Distance (KM)	Estimated distance within Region	Total Distance (KM)	No of Stations	Working Days	Travelling Days	Total Days
Mara	Names	Dar – Mara	1400	500	1900	7	14	2	16
Simiyu		Mara –Simiyu	200	500	700	5	10	1	11
Mwaza		Simiyu – Mwanza	200	500	700	5	10	1	11
Geita		Mwanza – Geita	200	500	700	4	8	1	9
Kagera		Geita – Kagera	400	500	900	5	10	1	11
		Kagera – Dar	1650	0	1650	–	–	2	2
							52		60

GROUP 2	Group Members	Route	Distance (KM)	Estimated distance within Region	Total Distance (KM)	No of Stations	Working Days	Travelling Time	Total Working Days (excluding Weekends, and Public holidays)
TABORA	Names	Dar – Tabora	1150	500	1650	4	8	2	10
RUKWA		Tabora – Rukwa	532	500	1032	4	8	1	9
KATAVI		Rukwa – Katavi	300	500	800	4	8	1	9
KIGOMA		Katavi – Kigoma	450	500	950	6	12	1	13
		Kigoma – Dar	1540	0	1540	–	–	2	2
							36		43

GROUP 3	Group Members	Route	Distance (KM)	Estimated distance within Region	Total Distance (KM)	No of Stations	Working Days	Travelling Time	Total Working Days (excluding Weekends. and Public holidays)
MKURANGA	Names	Dar – Mkuranga	45	200	245	2	4	1	5
IKWIRIRI		Mkuranga – Ikwiriri	120	200	320	3	6	1	7
LINDI		Ikwirin – Lindi	300	600	900	5	10	1	11
MTWARA		Lindi – Mtwara	120	500	620	5	10	1	11
RUVUMA		Mtwara – Ruvuma	200	500	700	4	8	1	9
		Ruvuma – Dar	1200		1200	0	0	2	2
							38		45

GROUP 4	Group Members	Route	Distance (KM)	Estimated distance within Region	Total Distance (KM)	No of Stations	Working Days	Travelling Time	Total Working Days (excluding Weekends, and Public holidays)
TANGA	Names	Dar – Tanga	354	500	854	7	14	1	15
KILIMANJARO		Tanga – Kilimanjaro	370	600	970	7	14	1	15
ARUSHA		Kilimanjaro – Arusha	80	400	480	6	12	1	13
MANYARA		Arusha – Manyara	168	600	768	6	12	1	13
		Manyara – Dar	800	0	800	0	0	1	1
							52		57

GROUP 5 ZANZIBAR	Group Members	Route	Distance (KM)	Estimated distance within Region	Total Distance (KM)	No of Stations	Working Days	Travelling Time	Total Working Days (excluding Weekends, and Public holidays)
DODOMA	Names	Dar - Dodoma	452	600	1052	5	10	1	11
SINGIDA		Dodoma - Singida	236	600	836	5	10	1	11
SHINYANGA		Singida - Shinyanga	300	600	900	4	8	1	9
		Shinyanga - Dar es Salaam	992		992		0	2	2
									33

GROUP 6 DAR ES SALAAM	Group Members	Route	Distance (KM)	Estimated distance within Region	Total Distance (KM)	No of Stations	Working Days	Travelling Time	Total Working Days (excluding Weekends, and Public holidays)
KIBAHA	Names	Dar - Kibaha	30	100	130	1	2	1	3
BAGAMOYO		Kibaha - Bagamoyo	60	100	160	1	2	1	3
DAR ES SALAAM		Bagamoyo-Dar es Salaam	64	250	314	6	12	1	13
ZANZIBAR		Dar es Salaam - Zanzibar		100	100	1	2	1	3
									22

GROUP 7	Group Members	Route	Distance (KM)	Estimated distance within Region	Total Distance (KM)	No of Stations	Working Days	Travelling Time	Total Working Days (excluding Weekends, and Public holidays)
CHALINZE	Names	Dar - Chalinze	110	100	210	1	2	1	3
MOROGORO		Chalinze - Morogoro	90	800	890	4	8	1	9
IRINGA		Morogoro - Iringa	300	600	900	4	8	1	9
NJOMBE		Iringa - Njombe	300	400	700	4	8	1	9
MBEYA		Njombe - Mbeya	400	800	1200	5	10	1	11
		Mbeya - Dar	840		840	0	0	2	2
									43

Group 8 Hydrological	Route	Route Distance	Distance (KM)	Estimated distance within Region	Total Distance (KM)	No of Stations	Working Days	Travelling Days	Total Working Days (excluding Weekends, and Public holidays)
Rufiji Basin **(Iringa)**		Dar - Iringa	502	400	902	2	2	1	3
Ruvuma and Southern Rivers Basin **(Ruvuma)**		Iringa - Songea	435	50	485	2	2	1	3
Lake Nyasa Basin **(Rungwe - Mbeya)**		Songwe - Rungwe	480	50	530	2	2	1	3
Lake Tanganyika Basin **(Kigoma)**		Rungwe - Kigoma	1690	50	1740	2	3	2	5
Lake Victoria Basin **(Mwanza)**		Kigoma - Mwanza	780	50	830	2	2	2	4
Lake Victoria Basin **(Kagera)**		Mwanza - Kagera	450	50	500	1	1	1	2
Pangani Basin **(Moshi)**		Kagera - Moshi - Tanga	1650	200	1850	3	2	3	5
Wami Basin **(Ruvu/Kibaha)**		Moshi - Morogoro	537	50	587	2	2	1	3
Dar es Salaam		Morogoro - Dar	195	15	210	1	2	1	3
									31

Appendix 2 : Questionnaire on the survey

Regional Power Demand Survey 2015

1. Visiting Substation

(1) Region		Name	

2. Data collection

(1) Substation Capacity and Demand	Description		2009	2010	2011	2012	2013	2014	2015	2020	2025
01 Substation name:											
Voltage from xx kV to xx kV	from kV to kV										
Capacity		MVA									
Peak demand		MW									
Shedding		MWh									
Energy supply		MWh									
02 Substation name:											
Voltage from xx kV to xx kV	from kV to kV										
Capacity		MVA									
Peak demand		MW									
Shedding		MWh									
Energy supply		MWh									
03 Substation name:											
Voltage from xx kV to xx kV	from kV to kV										
Capacity		MVA									
Peak demand		MW									
Shedding		MWh									
Energy supply		MWh									
04 Substation name:											
Voltage from xx kV to xx kV	from kV to kV										
Capacity		MVA									
Peak demand		MW									
Shedding		MWh									
Energy supply		MWh									
05 Substation name:											
Voltage from xx kV to xx kV	from kV to kV										
Capacity		MVA									
Peak demand		MW									
Shedding		MWh									
Energy supply		MWh									

(2) Number of customer by TANESCO district office		Category	2009	2010	2011	2012	2013	2014	2015	2020	2025
District office name :		T1+D1									
Source of supply / Substation :		T2									
		T3									
District office name :		T1+D1									
Source of supply / Substation :		T2									
		T3									
District office name :		T1+D1									
Source of supply / Substation :		T2									
		T3									
District office name :		T1+D1									
Source of supply / Substation :		T2									
		T3									
District office name :		T1+D1									
Source of supply / Substation :		T2									
		T3									
District office name :		T1+D1									
Source of supply / Substation :		T2									
		T3									
District office name :		T1+D1									
Source of supply / Substation :		T2									
		T3									
Total		T1+D1	0	0	0	0	0	0	0	0	0
		T2	0	0	0	0	0	0	0	0	0
		T3	0	0	0	0	0	0	0	0	0

Regional Power Demand Survey 2015

1. Visiting Regional government office

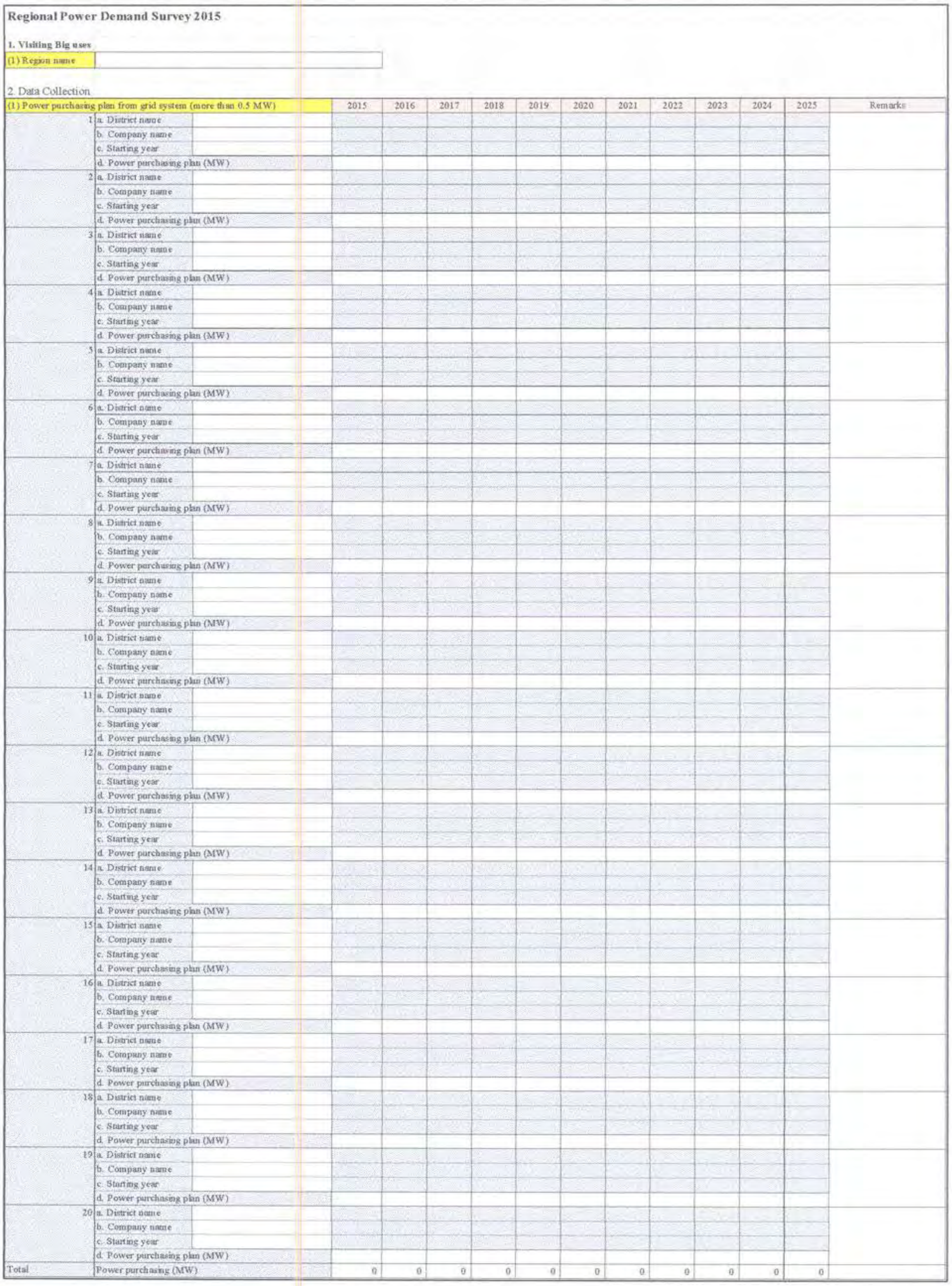
(1) Region	Name	
(2) Regional government office	Name	

2 Data collection

			2009	2010	2011	2012	2013	2014
(1) Number of population in the region								
District name :		1000person						
District name :		1000person						
District name :		1000person						
District name :		1000person						
District name :		1000person						
District name :		1000person						
District name :		1000person						
District name :		1000person						
Total		1000person	0	0	0	0	0	0

		2009	2010	2011	2012	2013	2014
(2) Average income per capita in the region	1000TSH/ person						

					2015	2020	2025
(3) Big projects (more than 0.5 MW)							
01. Project name			District				
			Starting year				
			Power demand(MW)				
02. Project name			District				
			Starting year				
			Power demand(MW)				
03. Project name			District				
			Starting year				
			Power demand(MW)				
04. Project name			District				
			Starting year				
			Power demand(MW)				
05. Project name			District				
			Starting year				
			Power demand(MW)				
06. Project name			District				
			Starting year				
			Power demand(MW)				
07. Project name			District				
			Starting year				
			Power demand(MW)				
08. Project name			District				
			Starting year				
			Power demand(MW)				
09. Project name			District				
			Starting year				
			Power demand(MW)				
10. Project name			District				
			Starting year				
			Power demand(MW)				
	Total		Power demand(MW)		0.00	0.00	0.00



Regional Power Demand Survey 2015

1. Visiting Big uses

(1) Region name	

2. Data Collection

(1) Power purchasing plan from grid system (more than 0.5 MW)		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Remarks
1	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
2	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
3	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
4	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
5	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
6	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
7	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
8	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
9	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
10	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
11	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
12	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
13	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
14	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
15	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
16	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
17	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
18	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
19	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
20	a. District name												
	b. Company name												
	c. Starting year												
	d. Power purchasing plan (MW)												
Total	Power purchasing (MW)	0	0	0	0	0	0	0	0	0	0	0	

Appendix 3 : Staff composition for the survey team

Group	Local consultant	Task Force Team(TFT)
1	Driver 1 person Researcher 1 staff (Name)	Member from TFT 2 persons 1 staff from MEM, EWURA, REA, etc. 1 staff from TANESCO
2	Driver 1 person Researcher 1 staff (Name)	Member from TFT 2 persons 1 staff from MEM, EWURA, REA, etc. 1 staff from TANESCO
3	Driver 1 person Researcher 1 staff (Name)	Member from TFT 2 persons 1 staff from MEM, EWURA, REA, etc. 1 staff from TANESCO
4	Driver 1 person Researcher 1 staff (Name)	Member from TFT 2 persons 1 staff from MEM, EWURA, REA, etc. 1 staff from TANESCO
5	Driver 1 person Researcher 1 staff (Name)	Member from TFT 2 persons 1 staff from MEM, EWURA, REA, etc. 1 staff from TANESCO
6	Driver 1 person Researcher 1 staff (Name)	Member from TFT 2 persons 1 staff from MEM, EWURA, REA, etc. 1 staff from TANESCO
7	Driver 1 person Researcher 1 staff (Name)	Member from TFT 2 persons 1 staff from MEM, EWURA, REA, etc. 1 staff from TANESCO
8	Driver 1 person Researcher 1 staff (Name)	Member from TFT 2 persons 1 staff from MEM, EWURA, REA, etc. 1 staff from TANESCO

I. SPECIFIC COMMENTS

A. General

Chapter	Page	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
1	General	The report does not reflect the ToR Introduction should highlight the need for updating the PSMP 2012 update with regard to economic changes and other factors for national development, should be re-casted with the counterpart team	(1) TOR If you have any other specific point which TOR is not reflected in the study, please let us know. A copy of the Record of Discussions, which outlines the scope of the Project, is attached for ease of your reference. (2) Introduction Agreed. It will be revised to reflect the comment from the Tanzanian side, in collaboration with TFT.	Data collection for demand forecasting and update of the PSMP 2012 is needed. Interconnection shall be taken into consideration. The structure of updated PSMP2015 will be similar to the PSMP 2012 and any change from the original format shall be agreed by Joint Task Force

Chapter	Page	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
				Team.
	1-4	The schedule should be removed and put in the appendix	Agreed. The schedule to be removed from the main report and put in the appendix.	Agreed
2	General	The information described in this chapter should be in chapter 1.	Chapter 1 is an introduction which explains the background of PSMP update while chapter 2 describes economic and social situation in Tanzania which is to be the basic conditions of analysis and planning. Therefore, it is recommended to have chapter 2 independently.	The introduction part of updated PSMP2015 will be at least similar to the PSMP 2012.
3	General	The chapter is elaborating more about TANESCO instead of guiding us toward the formulation PSMP 2015 update	Chapter 3 describes policies and organizations related to electricity sector in Tanzania. If detailed explanation on TANESCO's financial situation is not suitable to be placed in this chapter, it will be moved to Chapter 11.1.1 Financial Situation of TANESCO. Since TANESCO's financial deficit has been the most critical challenge in electricity sector, the Consultant considered that it would be better to mention the	The format of updated PSMP2015 will be at least similar to the PSMP 2012.

Chapter	Page	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			challenge in Chapter 3.	
4	General	Recast with the counterpart involved during updating the PSMP 2015 for more details	Noted. It is strongly requested that MEM ensures all Task Force Team (TFT) members be available whenever consultant members are in Dar es Salaam. Also, please inform the Consultant of the names, organizations and contact information of TFT members so that they can be added to the counterpart list. The Consultant will submit their field work schedule in advance so that MEM would be able to inform all the TFT members to be ready for the collaborative work. It would be preferable to have a project office at MEM's building for ease of communication with MEM's counterparts and collaborative work with TFT members.	The Chapter will be re-casted based on the latest data which will be obtained through the regional demand survey.
5	General	Recast with the counterpart involved during updating the PSMP 2015 for more details Tables more preferable than words. Figures, diagrams and pictures should be	The first comment is the same as comment No. 4. Tables and figures will be used as many as possible. It is recommended that the figures, diagrams and pictures co-exist with sentences for easy	To be consulted with TPDC, MEM, NDC, STAMICO, NBS, TGDC, REA, Ministry of

Chapter	Page	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
		shifted to Appendix	understanding.	Agriculture, Ministry of Natural Resources, TAREA.
6		Recast with the counterpart involved during updating the PSMP 2015 for more details	The comment is the same as comment No. 4.	Summary of Chapter 6 to be moved to introduction.

B. Detail

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
7-1	Per Capital Income	Should be included in the factors affecting power demand	GDP and population are included as explaining variables in energy model and their trend is similar to that of per capita income. Details of power demand forecast model will be explained on the occasion of technical transfer session to be held in July 2015.	Agreed as explained by the Consultant.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
7-2	Industrial / Transport Policy	The heading does not match the items below it	Agreed. It will be revised	OK
7-2	i. Energy Demand Block: ii. Economic Block Item 5, figure 7.1.2-2	i. Item 3 heading: Word Energy should be replaced by Source ii. Item 3: Also word 'Power' should be removed. iii. Item 6: The last word Energy should be rechecked. iv. Coal and Renewable have been forgotten.	i. It can be said "Final energy demand by types of energy" instead of "energy" or "source". In technical term, "source" has a different meaning. Our report shows electricity and fossil energies. In the report, "Power demand means "Electric power demand" and "Energy demand" means "Fossil energy demand". ii. "Power" is a category of energy which consists of final energy demand. Therefore, it cannot be removed. Fossil fuel such as coal, oil, natural gas, etc. Is called "primary energy" and power is called secondary energy because it is converted from primary energy. Final energy demand is the sum of such different types of energy. iii. The same above, it is not changed iv. They are included in the "Energy Demand Forecast Block" in the	i. "Final energy demand by types of energy sources" will be used instead of "energy" or "source". ii. Agreed with the explanation of the Consultant iii. Agreed with the explanation of the Consultant iv. Coal and renewable are included in the energy demand block.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			model as follows. **Energy demand forecast block** (3) Final energy demand by energy - Coal - Natural gas - LPG - Gasoline - Jet fuel - Kerosene - Diesel - Fuel oil - Power - Renewable energy	
7-2	i. Table 7.1.2-1	i. Should be removed and put it into appendix	i. Agreed. The table will be put into appendix.	i. To be deleted.
7-3	i. Table 7.1.3-1	i. More clarification is required and labeling should start at 1.	i. Labeling will be revised. Clarification will be provided when the consultant visits Dar es Salaam in July.	i. "7.1.3 Procedures of the demand model" to be moved to appendix
7-3	i. Demand by fuel	i. Formula should be reviewed and clarification should be given.	i. Clarification will be provided when the consultant visits Dar es Salaam in July	i. Agreed with the explanation of the Consultant
7-4	i. Table 7.2.1-1	i. Population outlook, please indicate the source and use NBS Data on Population.	i. NBS's data will be added.	i. Agreed
7-5	i. Table 7.2.1-2	i. Table should be reviewed.	i. Agreed. It will be reviewed	i. To be reviewed by consulting NBS

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
7.7	i. Table 7.2.1-5	i. The same scenario case should be reflected on the explanation above	i. Please explain what the intention of the comment is. Real GDP assumption in Table 7.2.1-5 is consistent with power demand scenarios.	i. Agreed with the explanation of the Consultant
7-8	i. Table 7.2.1-7	i. Inflation rate should be revised to reflect the reality.	i. Inflation rates from 2015 to 2020 are revised. The values are 5.0% per year.	i. The source of the prediction is the Central Bank of Tanzania and the prediction is accepted.
7-8	i. Table 7.2.1-8	i. Table should be reviewed.	i. Agreed. To be revised	i. WTI price prediction will be review by the relevant authority in Tanzania such as EWURA. ii. Detailed information, methodologies, etc. will be moved to Supplemental Document for ease of follow up.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
7-9	i. Section: 7.2.2 last Paragraph	i. More clarification is required.	i. Agreed. To be revised, more explanation will be added.	i. Simple explanation of the methodology is enough for PSMP. Most of the section will be moved to Supplemental Document.
7-9	i. Table 7.2.2-1	i. Table heading should explain if it is GWh or MWh.	i. The unit is GWh and the heading to be revised.	i. Agreed
7-10	i. Catch Up Rate	i. Potential power demand should be defined and the same "Catch Up Rate".	i. Agreed. To be revised	i. Agreed
7-10	i. Figure 7.2.2-1	i. Should be replaced with readable version.	i. Agreed. To be revised	i. Agreed
7-11	i. Table 7.2.2-3	i. Table should show which country the data reflect.	i. Agreed. Power ratios of different countries are referred. For example, the trend of power ratio for Tanzania in the near future will be similar to that of Africa (average). However, it will become close to more developed countries, like	i. Agreed. Most comparison should also consider sub-Sahara African countries.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			Asian countries, as development continues. With the assumption above, the data basically are decided by auto correlation analysis between reference countries and Tanzania. However, each sector has the maximum values. Those maximum values are decided by our experiences. The main countries are shown in the table 7.2.2-2	
7-11	i. Table 7.2.2-4	i. Table should show the country it refers.	i. Agreed. T-loss decreases to 2.5% and D-loss decreases to 10%. This is the target of many developing counties in Asia and Africa. For Tanzania, the current loss rates are so high. Therefore, the future loss rates become at 14.0% in 2045.	i. Agreed. T/D loss-reduction rate will be confirmed by the relevant authorities (EWURA and TANESCO). Electricity Supply Industry Reform Strategy and Road Map will be referred to check the target of T/D loss-reduction.
7-12	i. Table 7.2.2-5	i. Replace the word "loss rate"	i. Agreed. To be revised	i. Agreed.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
		by "Load factor".		
7-13	i. Section 7.3.1 Paragraph 1	i. Replace "Power demand" by "Energy demand".	i. In the demand forecasts, we study electricity, fossil energies and bio energies. "Energy demand" means fossil and bio energies. Therefore, "Power demand is used for "Electric power demand".	i. The title of the section is as it is. The title of the "Table 7.3.1-1 Power Demand Forecasts (Dispatched power) "will be replaced by "Table 7.3.1-1 Electric Energy Demand Forecasts (Dispatched power) ".
7-13	i. Figure 7.3.1-1	i. Replace " Power demand" by "Energy demand".	i. In order to distinguish general energy such as fossil energy, bio energy etc. with electric energy, the former is called "Energy" and the latter is called "Power".	i. The title of the "Figure 7.3.1-1 Power demand forecasts" will be replaced by "Figure 7.3.1-1 Electric Energy demand forecasts
7-14	i. Sentence ii. Table 7.3.2-4	i. The value in MWh is energy but not power ii. Tariff T7 and T8 were not	i. Same as above ii. To be revised	i. The word "power demand" will be replaced by "electric energy

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
		defined in the glossary		demand". ii. Agreed. The definition of T7 and T8 will be added to the table. The tariff category will be confirmed by relevant authorities. Detailed information will be moved to Supplemental Document. Explanation on relation of Tariff categories and industrial sectors which is used for demand forecast will be included and moved to Supplemental Document.
7-18	i. Figure 7.4.2-1, section 7.4.2	i. The word JICA study team should be removed and replaced by PSMP 2015.	i. To be revised	i. Agreed. The word JICA study team will be removed and replaced by PSMP 2015

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
7-19	i. Section 7.5.1, Methodologies, bullet (B)	i. Regional power demand should include commercial demand.	i. In regional demand forecasting, there are two sectors as follows: Industry demand includes all kinds of industries, such as Agriculture, Manufacturing, Commercial and Services. Another sector is Residential.	i. Agreed.
7-19	i. Table 7.5.1-1, bullet (A) ii. Bullet E	i. Why to use "Elasticity" rather than "NBS Forecast" ii. Bullet D should also take forecasted of actual regional power consumption.	i. NBS does not have regional future population. Therefore, we have to estimate regional future population using by Elasticity between actual regional population growth rate and country population growth rate. ii. National power demand is divided into regions with reference to the regional contribution of industrial GDP in order to forecast regional power demand. Also, (E) Power demand for Future big projects is taken into consideration to adjust regional allocation of power demand.	i. Agreed. It is to be confirmed through NBS. ii. Actual regional demand data will be collected through regional demand survey and the results will be incorporated into regional demand forecast.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
7-20	i. Table 7.5.2-1	i. Power demand in each regional should be by yearly and it should stated ii. power demand forecast (dispatched power) should be yearly	i. The all kinds of forecasted data are yearly. Please refer " [Supplement to Main Report] S-1. Power Demand Forecast Data " for yearly data of regional demand forecast. ii. Same as above	i. Agreed. All kind of forecast in the document is supposed to be checked by TANESCO. ii. Agreed
7-21	i. electrification	i. 36% is not the electrification rate but it is accessibility to electricity. The electrification rate of Tanzania is 24% ii. Therefore the calculation in this paragraph should be reviewed.	i. It is suggested to use access base electrification rate which is a commonly used indicator in the world.	i. 36% is access to electricity and 24% is connectivity to electricity. The word "electrification rate" will be replaced by "access to electricity".
7-21	i. Table 7.5.2-3 ii. Table 7.5.2-4	i. All tables should be reviewed.	i. The same as above.	i. Same as above
7-22	i. Table 7.5.2-7	i. Outline the big project by 2020	i. The original data were collected from TANESCO. TFT is requested to provide the necessary information to update the table.	i. The data will be verified through the regional demand survey.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
7-23	i. Table 7.5.2-8	i. Data should be reviewed.	i. During the formulation of PSMP2012update, regional demand survey was conducted by the joint team of MEM and TANESCO. The same kind of survey was planned for PSMP2015 by MEM and TANESCO, but not realized due to budgetary constraints of MEM - "2015 PSMP BUDGET ESTIMATES" is attached for ease of reference. It is recommended that the Tanzanian side to allocate necessary budget for FY2015-16, if possible, to complete the survey by the end of September 2015.	i. The data will be verified through the regional demand survey.
7-24	i. Table 7.5.2-9	i. The table is not clearly understood. More clarification is required.	i. The total power demand of gold mining subsector is estimated by elasticity to GDP growth rate of 0.1 referring the past trend. The total power demand of gold mining subsector is distributed into regions referring regional gold production. Therefore, Table 7.5.2-9 shows both gold production by regions and	i. The table will be updated once the regional demand survey is completed.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			regional demand of gold mining.	
7-24	i. Table 7.5.2-10	i. Zanzibar should be included. ii. Also data of 2013 should be included.	i. The data of Zanzibar will be added to "Table 7.5.2-10 Actual power demand by region". ii. Please provide the data for 2013 if available.	i. Agreed. The data of Zanzibar will be added. The word "region" will be replaced by "load center". ii. Agreed.
7-27	i. Section 7.6.1, Paragraph 1	i. Word "Primitive" should be removed. ii. Also comparison should be reviewed, and Tanzania should be compared with other developing countries rather than developed countries.	i. To be revised accordingly. ii. "Figure 7.6.1-1 Actual primary energy consumption per capita "includes Ghana, China and Malaysia for comparison with similar countries.".	i. Agreed. ii. Agreed.
7-27	i. Table 7.6.1-1	i. Two tables connected and not clearly understood.	i. Agreed. To be revised	i. Agreed. To be revised. To be moved to Supplemental Document.
7-28	i. Policy Mentioned	i. Mention the policy that shows reduction of wood and	i. The National Energy Policy (Feb. 2003) Policy Statement	i. Agreed.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
		charcoal.	44. Promote application of alternative energy sources other than fuel wood and charcoal, in order to reduce deforestation, indoor health hazards and time spent by rural women in search of firewood.	
7-28	i. Table 7.6.2-1	i. Irrelevant (can be removed)	i. As described in the National Energy Policy, application of alternative energy sources other than fuel wood and charcoal is to be promoted. The table suggests some examples and solutions how to reduce wood-origin fuel. Also, these are assumptions which are used for calculating future energy demand in wood and charcoal. For these reasons, it is suggested not to remove the table.	i. The table will be moved to Supplemental Document.
7-30	i. Table 7.6.3-1	i. Base year should be mentioned.	i. Actual data in the past (2000 – 2011) which were used for energy model formulation were collected from IEA and MEM. Those data are the basis for demand forecast. If specifically mentioned, 2011	i. The table will be revised indicating 2011 as base year. The table will be moved to Supplemental

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			would be the base year because it is the latest actual data which can be obtained.	Document.
7-29	i. Table 7.6.3-2	i. Remove GoT on the right hand side and replace it with Zanzibar, Power for street light and power for gold mine	i. Agreed. To be revised	i. Agreed.
7-29	i. Table 7.6.3-3	i. The title of table should be mentioned and indicate title of column.	i. Agreed. To be revised	i. Agreed
7-31	ii. Note after figure 7.6.3-5	i. The first note is not true. ii. In second note: the sentence after the word "future" should be removed.	i. Agreed. Sentences on government to be deleted. ii. Agreed. To be revised	i. Agreed. ii. Agreed.
7-32	i. Paragraph one	i. Contribution of final energy demand (Biomass, wood and charcoal) is 81% please provide source of information	i. The final energy demand and contribution of each energy type from 2015 to 2045 is the forecast by the Consultant. The final energy consumption by the types of energy is forecasted with division of final energy consumption by the energy contribution ratios in the sectors. The	i. Agreed. REA will be consulted.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			contribution ratios are changed year by year, usually woods and charcoal, fixed fuels, liquid fuels, gas fuels and electricity are taken in turn as energy consumption.	
7-33	i. figures	i. Label the pie chart example 1 up to five	i. Agreed. To be revised	i. Agreed.
8-1	i. Table 8.1.1-1	i. Existing thermal power stations should be updated accordingly and the text (misspelling)	i. It is described based on the information from TANESCO. Please provide us the latest information. If there is any misspelling, it will be corrected.	i. Agreed.
8-2	ii. Section 8.1.2	i. All Text should be reviewed. ii. Sentence after word " TANESCO" should be removed.	i. The section describes current situation of hydro power plants in Tanzania based on the information from TANESCO. If the review is necessary, please let us know which point is to be revised/corrected. ii. To be removed	i. Agreed ii. The paragraph will be rephrased.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
8.4	i. Section 8.2	i. Starts from page 8.4 to 8.9 rephrase it. Do not report progress but report the actual plan based on methodologies, criteria and assumption then indicates candidates of projects of thermal based on methodologies and criteria used	i. Section 8.2 describes on-going and planned power development projects. Progress of them is very important in order to make PSMP a realistic one.	i. Agreed. Summary of the progress will remain in the main document and other will be moved to Supplemental Document.
8-4	i. Section 8.2.1	i. All text should be rephrased and reflect current BRN status either consult HMDU (Head of Ministerial Delivery Unit) for clarification	i. Same as above. What does HMDU stands for? Please let us know how can we contact HMDU?	i. Agreed. To be rephrased.
8-4	i. Table 8.2.1-1	i. Should be deleted as it is no relevant.	i. The table is inserted to describe the status of key power development projects under BRN initiative. If it is outdated, please provide us with the latest one.	i. Agreed. To be deleted.
8-5	i. Table 8.2.1-1	i. Delete the table (because it report progress of BRN projects)	i. Same as above.	i. Agreed. To be deleted.
8-4 –	i. Text	i. In all these pages, the text should be rephrased and	i. Section 8.2 describes ongoing and planned power	i. Agreed. Summary of the progress will

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
8-9		actual planning, methodologies and criteria should be used.	development projects. Progress of them is very important in order to make PSMP a realistic one.	remain in the main document and other will be moved to Supplemental Document.
8-10	i. Section 8.2.2	i. Hydro power estimated in Tanzania is 45,000 MW and it's not 38,000MW	i. Please provide a report of source of 45,000 MW. Hydropower potential will be revised based on new source.	i. Agreed. To be revised according to the data from MEM.
8-11	i. Table 8.2.2-1	i. Should be updated i.e. table should just show Project, Capacity and Commissioned Year (remarks, and status should be removed).	i. Section 8.2 describes ongoing and planned power development projects. Progress of them is very important in order to make PSMP a realistic one. ii. Table 8.2.2-1 shows potential projects identified in previous studies (i.e. these are existing plans) and the project information in Table 8.2.2-1 is the latest in Feb. 2015. iii. The information in the column of "status" and "remarks" will be used in Section 8.3.4 (Table 8.3.4-3).	i. The table will include information such as project , capacity expected commissioning years and other information will be moved to Supplemental Document.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			iv. In addition, the commissioned year of some projects were not planned by the previous study and will be set in section 8.3.4 of Chapter 8 (but not yet set in this progress report).	
8-12	i. The whole pages	i. Page 8-12 up to page 8-19 delete it. It is not necessary	i. It is proposed that project explanation be put as an appendix.	i. Agreed. The section (from 8-12 to 8-19) will be moved to Supplemental Document.
8-12 – 8-19	i. Project Explanation. ii. Tables in these pages.	i. Should be deleted. ii. Tables should put as an Appendix.	i. It is proposed that project explanation be put as an appendix. ii. Agreed.	i. Agreed. Same as above.
8-20	i. Tables	i. Remove table 8.2.2-2(1) to 8.2.2-2(5) and put it under appendix	i. Agreed. To be put under appendix.	i. Agreed. The tables will be moved to Supplemental Document.
8-25	i. Evaluation for Average Generations Costs.	i. Generations costs should be removed either use the technical word that proves that hydro is cheaper than thermal	i. Please understand a fact that some of planned hydro projects are more expensive than actual purchase cost	i. Summary table of generation cost will remain in the main document while

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
		power.	from some existing thermal IPP plants. The generation costs of hydro are variable by site/project and they depend on construction cost and annual energy generation. Generation costs are the only indicator which proves the economic benefit of hydro power plants.	detailed calculation will be moved to Supplemental Document.
8-26	i. Table 8.2.2-3	i. Should be reviewed especially Plant factor of Lower Kihansi which is 6%.	i. Plant factor of Upper Kihansi in Table 8-2-2-3 is 52%. That of Lower Kihansi Expansion is 6%. Please refer to page 4-4 of "Power System Master Plan 2009 Update, SNC-LAVALIN International". According to this report, installed capacity is 120MW and annual generation is 69GWh. So, plant factor is calculated as follows: 69,000MWh/ (120MW x 24hour x 365days) = 6.6% In Table 8.2.2-3, annual energy generation capability that considers outage rates	i. Agreed. To be consulted with TANESCO

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			and station use rates is used as annual energy generation.	
8-26	i. Figure 8.3.2-1	i. Load Curve: it should be of yearly and not specific day.	i. The Figure 8.3.2-1 compares typical daily load curves of a week day and holidays to explain that Tanzania has evening peak. Annual load duration curves are shown in Figure 8.3.2-5 Load duration curves in Tanzania.	i. Agreed. Daily load curve will be removed.
8-28	ii. Section 8.3.2	i. Use evening peak rather lighting peak time	i. Agreed. To be revised.	i. Agreed.
8-29	i. Figure 8.3.2-1	i. Load duration curve in 2013 should annually not daily	i. Annual load duration curve is shown in Table 8.3.2-5.	i. Agreed. Daily load curve will be removed.
8-31	i. Figure 8.3.2-5	i. Clarification is required and load duration curve in Tanzania should be explained.	i. Load duration curve is made from hourly system loads of a year by sorting from highest to the lowest. It explains the shape of annual load and used for defining the amount of peak, intermediate and base load power plants. Load duration curve is widely understood in electric power	i. Description of peak demand and annual electricity consumption for each year will be added to explain the difference of load duration curves from 2011

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			industry. If load duration curve is not understood by TFT, basic technical lessons will be provided to them.	to 2013.
8-32	i. LOLP (Section 8.3.2.2)	i. LOLP analysis should be done to obtain the real figure. Please find it by doing analysis/calculation rather than assuming	i. In order to calculate actual Loss of Load Probability, please let us know annual loss of load hours for the last five years which is only caused by insufficient generation capacity.	i. Agreed. Actual LOLP will be calculated based on the data from TANESCO. Then reasonable assumption for future LOLP will be made.
8-34	i. Table 8.3.2-2	i. Review the table. But the row for Mchuchuma I to IV should be 600MW. Remove the number of units (150x4 units)	i. Agreed. To be revised.	i. Agreed.
8-34	i. Section 8.3.2.5 last paragraph	i. Explain in details. It is not clear understood	i. The paragraph to be removed	i. To be removed
8-35	i. Japan reference	i. Word "In Japan" should be removed. ii. Mention the technology only.	i. Agreed. ii. Agreed.	i. Agreed. To be rephrased. ii. Agreed. To be rephrased.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
8-35	i. Paragraph 4	i. Ultra super critical pressure coal fired thermal power station; do not specify Japan technology; instead use Ultra super critical pressure only	i. Agreed.	i. Agreed. To be rephrased.
~~8-36 – 8-37~~	~~i. Technology~~	~~i. The pages should be removed.~~	~~i. Agreed.~~	~~i. Agreed. To be moved to Supplemental Document.~~
8-42	i. Table	i. Scenario 2 is the best than all, however more clarification is required on this table. ii. Also renewables should be shown/explained.	i. The consultant considers that the risk of hydro power such as climate change, opposition from communities to be resettled, environmental impact, etc. which might lower the advantage of hydro should be carefully considered. High dependence on hydro is vulnerable to climate change, and transition from hydro based generation to thermal based generation mix is proposed to allow more reliable supply of power. ii. Renewable cannot be a firm source of energy other than geothermal so conventional	i. It will be agreed later. After knowing the share of gas, coal, hydro and renewable, future generation mix will be finalized. ii. Same as above.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			sources of generation are compared in this section.	
8-43	i. Section 8.3.3	i. Should be removed.	i. Optimization process is necessary to select the plan which is most desirable, realistic and realizable).	i. Agreed. To be moved to Supplemental Document.
8-47	i. First paragraph	i. Delete the paragraph	i. Progress of ongoing and planned projects is very important in order to make PSMP a realistic one.	i. Agreed. (To be checked tomorrow)
8-48	i. Table 8.3.4-1	i. Revisit the table on coal projects. Also column financing, contract, f/s and remarks should be removed. ii. Column of the project should have the title i.e. Plant or Project name. iii. Sources should also be reviewed.	i. Agreed. ii. Agreed. iii. Sources of the information are MEM, NDC, STAMICO and TANESCO	i. Agreed. ii. Agreed. iii. Agreed. Revisit the source of information. The source of information will be indicated. The table should include name of project, capacity and expected commissioning year only.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
8-49	i. Paragraph 1	i. Remove the paragraph.	i. Progress of ongoing and planned projects is very important in order to make PSMP a realistic one.	i. Agreed. To be removed.
8-50	i. Last Paragraph, section 8.3.5	i. The last sentence starting with " against……." Should be removed.	i. Agreed.	i. Agreed. To be removed.
8-51	i. Generation type	i. Rephrase the last paragraph. ii. "Candidate site" Provide more detail and necessary information on possible site for construction combined cycle of gas turbine	i. Please let us know the reason why and how it should be rephrased ii. TANESCO has conducted the survey and it has detailed information. It can be included in the report or appendix if necessary	i. Agreed. "Section 8.3.5 Priority project of power development plan" will be moved to Supplemental Document ii. Agreed. Same as above
8-51	i. Candidate Site: last paragraph	i. Should be removed either prove by your own analysis on the possible site for construction gas turbine	i. Agreed. To be removed	i. Agreed. Same as above.
8-52-8.54	i. Pages	i. Should be deleted. However last paragraph in page 8-54	i. Agreed.	i. Agreed.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
		should remain.		
8-55	i. Paragraph 1	i. Lake Malawi should read Lake Nyasa.	i. Agreed.	i. Agreed.
8-55	i. Paragraph 4	i. Should be removed as it is giving President Obama Speech which is unnecessary to be here.	i. Agreed.	i. Agreed.
8-55	i. Paragraph 3, issues concerning environmental…..	i. Should be removed.	i. Agreed.	i. Agreed.
8-56	i. Issues concerning O&M	i. The paragraph should be removed here and rephrased and put it as a challenge.	i. Agreed. This section will be described as a challenge.	i. Agreed.
8-56	i. Hydro Power Generation facilities.	i. The first paragraph on development plan should be reviewed to reflect 2015 – 2045. ii. Include all sources of power not only hydro power	i. The planning period of PSMP2012update was 25 years and PSMP2015 followed it. It was agreed between the Tanzanian side and the Japanese side in October 2013 during the discussion for Detailed Planning Survey for the	i. The planning period for the PSMP2015 is 25 years, from 2015 to 2040. ii. All generation sources will be summarized after concluding

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			Project. ii. Section 8.3.6.2 of page 8-56 to 8-61 is issues and recommendations for hydro power development. For thermal power development, please find section 8.3.6.1 (i.e. page 8-54 to 8-56).	generation scenario.
8-57	i. Paragraph 6 & 7	i. Should be removed.	i. There is concern that it will take much time to obtain Environmental and Social Impact Assessment (ESIA) approval on hydro power plants from the National Environment Management Council (NEMC), and the start of construction will be delayed. Paragraphs 6 & 7 are necessary to attract attention on such risks.	i. The paragraph will be deleted but there will be foot notes to attract attention to take necessary measures for some hydro power projects to be implemented in a timely manner.
8-58	i. Last paragraph	i. Rephrase the last paragraph on improvement of system for operation and maintenance	i. Please let us know why Last paragraph should be rephrased and viewpoint of rephrasing.	i. The paragraph will be rephrased to address the challenges for implementing hydro power projects.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
8-59	i. Paragraph	i. Should be rephrased. ii. Hydro power plant development is for all investors not for TANESCO only	i. Please let us know which paragraph should be rephrased and viewpoint of rephrasing. ii. Noted. We understand that TANESCO is not an only investor and operator for hydro power plants. It is expected that newcomers in power generation business such as private companies/investors will be able to operate and maintain hydro plants. Still, the Consultant assumes that number of plants operated by new comers will be much lower than those operated by TANESCO because (1) hydro development takes quite a long time and (2) it will be difficult to secure operators and maintenance staffs for hydro power plants in Tanzania other than TANESCO. More than half of future hydro development projects are planned by	i. *"Chapter 8.3.6 Issues and Recommendations in Realization of Power Development Plans"* will be rephrased to summarize some challenges and recommendations for project realization.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			RUBADA but it does not have the experience of construction, operation and maintenance of hydro power plants.	
9-1	i. Figure 9.1-1	i. Replace with readable version. Also we recommend TANESCO diagram to be used.	i. Agreed. The Figure will be replaced with TANESCO diagram.	i. The network diagram which shows current transmission lines and substations will be replaced by the new one.
9-1	i. Paragraph 2	i. Rephrase the paragraph.	ii. Please let us know how the paragraph should be rephrased?	i. The paragraph will be rephrased to simply explain the current transmission diagram.
9-2	i. Paragraph 2	i. Replace Sumbawanga with Rukwa. ii. Peak demand should be in yearly(Highest demand in a year) do not use January peak demand	i. Agreed. To be replaced. ii. The table shows the system peak demands in a month (not only January, but also every month throughout from January to December) are shown in Figure 9.1-2.	i. Agreed. ii. Agreed. Annual peak demand will be compared.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
9-3	i. Figure 9.1-3	i. The Hydro peak demand increased in 2014, so should be shown.	i. What we so far have had is the data right up to April 2014 from January 2009. Please provide us with full data from May 2014 to date so that we can fully reflect the actual situation in 2014.	i. The Figure and paragraph will be re-casted
9-4	i. Table 9.1-3	i. Fill the gap.	i. Agreed.	i. Agreed to fill the gaps. To be moved to Supplemental Document.
9-6	i. Table 9.1-4	i. On the heading the word " Made by study team" should be removed or replaced by PSMP, 2015 study. ii. Please find unknown data	i. Agreed. ii. There is no "code" name available for XLPE cables, we are afraid. Code names such as Wolf, Hawk, etc. come from BS standards they are only for ACSR conductors.	i. Agreed to change the heading. To be moved to Supplemental Document.
9-6	i. Table 9.1-4	i. Cross section, it is not 241 but 240.	i. Agreed.	i. Agreed. To be moved to Supplemental Document.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
9-8	i. Design criteria	i. Rephrase the paragraph. And the word " several countries' aids" should be removed.	i. Agreed.	i. Agreed. The paragraph will be rephrased.
9-9	i. Figure 9.1-5	i. Should obtain the real data from TANESCO on transmission and distribution losses and not obtain it from Controller and Auditor General.	i. Agreed.	i. Agreed.
9-10	i. Paragraph 1: Transmission and Distribution Loss	i. Provide the challenges and methodologies to reduce power losses rather than putting the stories.	i. Please understand that the paragraph shows the present situation. The solution would be proposed at the time of second year of the PSMP study.	i. Agreed. The challenges and methodologies to reduce power losses will be described.
9-10	i. Protection system	i. The whole paragraph should be removed.	i. Agreed.	i. Agreed.
9-11	i. Figure 9.2-1	i. Replace this figure with the updated and readable version. ii. Please come up with your proposal on Transmission Network Diagram according to your analysis.	i. Agreed. ii. Our proposal is shown in section 9.2.4 on page 9-16	i. Agreed. To be updated and replaced by a readable one. ii. Agreed. Proposed transmission network based on

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
				system analysis will be inserted.
9-11	i. Last Paragraph	i. Rephrase the paragraph.	i. Agreed.	i. Agreed. The last paragraph of page 9-11 will be removed.
9-12	i. Table 9.2-1	i. Replace with readable version and update the information.	i. Agreed.	i. Agreed. The table should include information such as voltage, path (from~to), length and year to be commissioned.
9-12	i. 9.2.3. Future Development Plan.	i. Replace the word ''clause'' with ''section''	i. Agreed.	i. Agreed. Table 9.2-2 will be moved to Supplemental Document.
9-13	i. Proposed schemes in period of 2016 to 2020.	i. Update the generation projects which should come in between 2016 to 2020.	i. Details of generation expansion plan will be provided later.	i. Agreed. Transmission and generation expansion projects for short term from 2015 to 2020, medium term from 2021 to 2030 and

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
				long term from 2031 to 2040 will be proposed based on system analysis.
9-13	i. Table 9.2-3	i. Replace with the readable table.	i. Agreed.	i. Agreed. Table 9.2-3 should include relevant information such as voltage, path (from~to), length and year to be commissioned and the detailed information will be moved to Supplemental Document.
9-14	i. Table 9.2-4	i. Replace with the readable table. ii. Please correct the names of the project ''spelling''	i. Agreed. ii. Please let us know the correct "spelling".	i. Agreed. Table 9.2-4 should include relevant information such as voltage, path (from~to), length and year to be commissioned and the detailed information will be moved to

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
				Supplemental Document.
9-14	i. Table 9.2-5	i. Proposed transmission system should match with the Generation plan.	i. Agreed	i. Agreed. The transmission system will be consistent with generation expansion plan once the plan is completed.
9-15	i. Last paragraph	i. The standard capacity for 400/220kV transformer is not only 250MVA there is also 500MVA	i. Agreed	i. Agreed. Figure 9.2-2 will be moved to Supplemental Document.
11-1	i. Table 11.1.1-1	i. Should be removed and summarize the financial situation of TANESCO in one paragraph.	i. Please provide with us the detailed income statements for looking up the trend in profitability of TANESCO.	i. Chapter 11 will be re-casted to simply describe necessary finance and financing options to realize PSMP projects.
11-1 – 11.16	i. TANESCO sales and expenditure	i. Should be removed/deleted here, it is not necessary	i. Improvement of the financial status of TANESCO is critical for enabling the power utility	i. Same as above

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
		information for PSMP.	to make necessary investments for the expansion and reinforcement of power systems based on the updated PSMP. We, therefore, consider that it is necessary to have detailed figure and analysis of sales/expenditure and other financial data for analyzing financial condition of power sector which is currently represented by TANESCO. In addition, in order to attract foreign direct investment on power sector in Tanzania, improvement of TANESCO's financial situation is indispensable.	
11-17	i. Paragraph 2 ii. Table 11.1.2.1-1	i. Business entity should be deleted and rephrase from Investment Paragraph. ii. Table should be rephrased especially in areas which shows 0 investment on generation in the year 2015 and moved to appendix iii. The total amount should be in	i. If business entity is not appropriate, how about power sector entities? ii. The investment data come from each expert in charge of generation and transmission in TANESCO. If necessary, the table can be moved to appendix. If unnecessary, Japanese yen column will be	i. Same as above

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
		USD rather than Japan Yean	deleted. iii. Agreed.	
11-18	i. Table 11.1.2.1-2	i. Items should be in English. The data contradicting between IPP's and TANESCO Investments. ii. Note there is no project specified for TANESCO only and for IPPs only. Please do not specify investment for TANESCO and IPPs	i. Agreed. Table 11.1.2.1-2 will be revised, especially Japanese part. In addition, the data are scrutinized. ii. No projects are specified to TANESCO or IPPs. There are two alternative assumptions to compare the effect of introducing IPPs. One is only TANESCO invests necessary generation plants. The other is a half of thermal generation is shared by IPPs and the remaining generation including a half of thermal generation is invested by TANESCO. This share can be changed through the discussion with the Tanzanian side.	i. Same as above
11-19	i. Revenue	i. TANESCO revenue should be removed or either should be the revenue generated from year 2015-2045 according to	i. If TANESCO revenue as expression is not appropriate, just revenue granted is OK, but revenue from the users at the distribution stage is what	i. Same as above

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
	ii. Table 11.1.2.1-3	the analysis.	it means.	
11-19	i. Paragraph (Operation costs, excluding Depreciation)	i. Operation cost: EPP & IPPs are supposed to decrease up to zero it is not correct.	i. The existing EPPs and IPPs, in particular, expensive generations, are supposed to be finished when the contract term ends. If suitable IPPs remain, they are included in the half of thermal generation alternative as new plants.	i. Same as above
11-20	i. Life time of Generation Plant	i. Revise Life span of coal and hydro or justify the specified data.	i. The data are based on the experience of consultant, but if you have data in Tanzania, please provide us with them.	i. Same as above
11-20	i. Transmission, Substation and Meters Life time	i. Revise Life time of Transmission, Substation and Meters.	i. The data are based on TANESCO's existing depreciation asset data, but if you have specific data in Tanzania, please provide us with them.	i. Same as above
11-21	i. Loan and equity	i. Ratio for loan and equity: 80%:30% is not true	i. Agreed. 80%:20% is correct. It is a simple mistyping.	i. Same as above

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
11-23	i. TANESCO's Financial Estimates in table 11.1.2.2-1	i. Financial estimate should be the whole projects analyzed and not of TANESCO ii. Please simulate the model for new investment/projects	i. The first alternative is that the whole projects are implemented by TANESCO. ii. It is difficult to simulate only new investment projects because the revenues are users' tariff revenues. In order to separate new projects, it is necessary to set generation tariffs and transmission tariffs as well as generation costs and transmission costs including salaries.	i. Same as above
11-24	i. Table 11.1.2.2-2	i. Should be removed or either should be of project analyzed.	i. Future tariffs should reflect the investment costs and also future operational costs. And it is important to estimate the future situation. The projects are not independent and relate to revenues (tariff level).	i. Same as above
11-24 – 11-26	i. Section 11.1.3	i. ESIR should be summarized and put it in Introduction part.	i. Agreed. It will be revised.	i. Same as above
11-27	i. Table 11.1.3-1	i. Just provide the results, no	i. If unnecessary, only the	i. Same as above

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
		need of table.	results will be described.	
11-28 – 11-31	i. Recommendation	i. Should be removed/deleted from here because it is not necessary.	i. It is necessary to suggest/ recommend for the improvement of TANESCO's financial condition by specifying the perspective which is sound financial situation of TANESCO or future transmission / distribution companies. Improvement of the financial status of TANESCO is critical for enabling the power utility to make necessary investments for the expansion and reinforcement of power systems based on the updated PSMP.	i. Same as above
10-1 - 10-55	i. Strategic Environmental Assessment	i. In PSMP, we recognize Environmental Social Impact Assessment (ESIA), however it should be summarized into legal framework, administrative, effects of the projects (generation, transmission and distribution) on the environmental in terms of emission and remedies.	i. PSMP is not a project level plan but a policy level plan or power sector development plan. Therefore, based on the Environmental Management Act 2004, and SEA Regulation 2008, revising PSMP is subjected to Strategic Environmental Assessment (SEA), not ESIA. ESIA will be implemented in	i. Agreed. The chapter will be summarized into 3-4 pages to simply describe legal framework, administrative, effects of the projects, and mitigation

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			implementation of the PSMP comprised of various projects The Tanzanian legal and regulatory requirements of SEA are provided in Section 104 and 105 of Environmental Management Act. The screening application document for SEA was sent from MEM to the Vice President Office (VPO) in July, 2014 and a confirmation note acknowledging that MEM needs to continue to undertake a SEA for updating PSMP was given in July 2014. Thus, MEM is responsible for conducting SEA for the new PSMP. The JICA project team assists MEM in conducting SEA for the new PSMP. So far, SEA had been implemented in accordance with Tanzanian SEA legislation by IRA in cooperation with MEM and JICA team. However, power generation plan and other related plan including optional scenarios had not been	measures.

Page	Issues	Comments from the Tanzanian Side	Answers and comments from the Consultant	Results of discussion
			concluded with MEM, SEA has not been completed. Once it is concluded, the SEA is going to be modified and the summary of the SEA result would be incorporated into the new PSMP.	

II. GENERAL OBSERVATION

Comments from the Tanzanian side	Answers from the Consultant	Results of discuss
1. The report should focus on updating the existing PSMP 2012 Update.	1. The report was developed based on the analysis of the existing PSMP 2012. Please refer to Chapter 6 for details. Comprehensive approaches and analyses are necessary to formulate a power system master plan. The Consultant has reviewed PSMP 2012 and recognized that the methodologies applied to PSMP2012 need to be improved. For example; (1) Power demand forecast: power demand forecast model is to be derived from final energy demand model, therefore, final energy demand forecast is required. Also, regression analysis for demand forecast model should include not only ordinary least square (applied to PSMP2012) but other function such as logarithmic function. (2) Generation expansion plan: A least cost generation expansion tool such as WASP (Wien Automatic System Planning Package) needs to be applied to seek the most economical option. Also, scenario comparison is necessary to understand pros and cons of alternatives. (3) Transmission system planning: PSS/E was used for PSMP2012 Update and the same software is used for PSMP2015. Transmission system model needs to be updated to incorporate the changes afterward. Short circuit calculation which was not done in PSMP2012 should be conducted to evaluate the breaking capacity of switchgears. With the points mentioned above, new methodologies are applied to PSMP2015 and this cannot be done by only updating 2012Update.	1. Agreed as discussed.
2. This report should follow the ToR and update the existing PSMP 2012 Update	2. Same as above	2. Agreed, same as

A-2. 参考資料/入手資料リスト

調査名：タンザニア国全国電力システムマスタープラン策定・更新支援プロジェクト

番号	名　称	形態 文書･ビデオ･ 地図･写真等	ｵﾘｼﾞﾅﾙ･ｺﾋﾟｰ	発　行　機　関	発　行　元
1	Power System Master Plan 2012 Update	文書	コピー	Ministry of Energy and Minerals	Oct. 2012
2	THE PROJECT ON IMPROVING THE RELIABILITY OF ELECTRIC POWER SUPPLY IN THE CITY OF DAR ES SALAAM	文書	コピー	Ministry of Energy and Minerals	Mar. 2012
3	National Account Tanzania_Mainland_2001-2012	文書	コピー	National Bureau of Statistics	Oct. 2013
4	DOING BUSINESS IN THE EAST AFRICAN COMMUNITY 2013	文書	コピー	The world bank & IFC	2013
5	EWURA Annual Report 2013	文書	コピー	Energy and Water Utilities Regulatory Authority	Jun. 2013
6	THE NATIONAL GRID　2014	文書	コピー	TANESCO	2014
7	Corporate Business Plan - 2014	文書	コピー	TANESCO	Dec. 2013
8	SREP Tanzania Investment Plan - FINAL	文書	コピー	Ministry of Energy and Minerals	May 2013
9	Tanzania SPPA Main Grid　JUNE 2009	文書	コピー	Ministry of Energy and Minerals	Jun. 2009
10	THE TANZANIA FIVE YEAR DEVELOPMENT PLAN	文書	コピー	President's office , Planning commission	Jun. 2012
11	THE TANZANIA LONG TERM PERSPECTIVE PLAN (LTPP),	文書	コピー	President's office , Planning commission	Feb. 2012
12	STATUS OF DEEP EXPLORATION WELLS UP TO MARCH 2012	文書	コピー	The Tanzania Petroleum Development Corporation	2012
13	EXPLORATION ACTIVITY	文書	コピー	TPDC	May 2014

STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) FOR UP-DATING THE NATIONAL POWER SYSTEM MASTER PLAN (PSMP), 2012

FINAL REPORT

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December 2016

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Abbreviations

BRN	Big Results Now
CO_2	Carbon Dioxide
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
EWURA	Energy and Water Utilities Regulatory Authority
GDP	Gross Domestic Product
GHG	Green House Gas
GWh	Gigawatt Hour
HIV/AIDS	Human immunodeficiency virus infection and acquired immune deficiency syndrome
IAEA	International Atomic Energy Agency
IPTL	Independent Power Tanzania Limited
ITCZ	Inter-tropical Convergence Zone
JICA	Japan International Cooperation Agency
MDGs	Millennium Development Goals
MEM	Ministry of Energy and Minerals
MW	Megawatt
NDC	National Development Corporation
NGOs	Nongovernmental organizations
NLUPC	National Land Use Planning Commission
NO_x	Nitrogen Dioxide
NSGRP –	National Strategy for Growth and Reduction of Poverty
PMO – RALG	President's Office – Regional Administration and Local Government
PSMP	Power System Master Plan
REA	Rural Electricity Agency
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SEA	Strategic Environment Assessment
SIDP	Sustainable Industrial Development Policy
SO_x	Sulphur Oxide
TANESCO	Tanzania National Electrical Supply Company
ToR	Term of Reference
TPDC	Tanzania Petroleum Development Corporation
URT	United Republic of Tanzania
WASP	Wien Automatic System Planning
WB	World Bank

Executive Summary

Background

The Government of Tanzania is aiming at transforming its economy into an industrialized and middle-income level by 2025. Currently, most of the people are in rural areas engaged in subsistence agriculture and levels of poverty are still high in the rural areas and relatively high in urban areas. However, Gross Domestic Product (GDP) growth rate has been impressive in the recent past. The real GDP grew by 6.9 % in 2012 compared with 6.4 % in 2011 and is projected to grow by 7 % in 2016. Income per capita is projected to grow from an average US$ 640 in 2015/15 to US$ 3,000 in 2025.

Sectors that are expected to trigger that growth leading to industrialization by 2025 include industries, manufacturing, mining, transportation and agriculture. With agriculture, programmes such as the SAGCOT that was initiated in 2010 are expected to lead to agricultural growth and the emergence of agro-industries. Tanzania has earmarked areas of agricultural growth in and around the Rufiji Basin.

In addition, another Government's effort to transition the country's economy is the Big Result Now (BRN). The BRN is a political agenda aimed at comprehensive system of implementation focusing on six priority areas of the economy namely; energy and natural gas; agriculture; water; education; transport; and mobilization of resources. The BRN initiative aims at adopting new methods of working under specified timeframe for delivery of proposed targets.

Thus under these conditions, reliable and affordable energy supply is a key to achieving the intended changes. Despite the endowment of enormous resources for power generation (e.g., gas, coal, wind, hydro, solar, biomass, uranium as well as importation), some challenges exists including mobilization of adequate financial resources to implement the proposed power projects and inadequate requisite human resources skills and knowledge for developing the existing power resources. Thus, the majority of Tanzanians still depend on biomass for their energy supply and use. Efforts to develop reliable and affordable energy supply have constituted the main focus of the Government of Tanzania since independence. The traditional sources have been fossil fuel, and hydropower until early 2000, when gas from Songo Songo Island was included in the national grid for provision of electricity in Tanzania. By 2014, the total installed capacity was 6,033.98 Gwh out of which, the grid generation capacity mix consisted of hydro (43% of the total), oil (13% of total), natural gas (43.5%) and the rest was made up of biomass.

Therefore, in order to meet the desired goal of becoming middle-income industrialized country, the government has in 2014/15 initiated several energy development projects aimed at increasing energy supply in the country. The main objective of energy development in Tanzania is to boost power generation capacity from 1,583 MW in April 2014 to 10,000 MW by 2025 and to get to over 18,000MW by 2040, with subsequent expansion of transmission and distribution infrastructure. In addition, the government is revising the Energy Policy of 1992 to align it with the current and future energy needs and development in the country and has also initiated the revision of the Power System Master Plan of 2012.

Power System Master Plan, 2012

The Power System Master Plan (PSMP) of 2012 (hereinafter, referred to as "PSMP-2012") reflects and accommodates recent development in the economy, including development in the gas sub-sector as well as government policy changes and guidelines. The guidelines include, among others Vision 2025, MKUKUTA and the Five Year Development Plan (FYDP). The FYDP aims to increase per capita electricity consumption from 81kWh in 2011/12 to 200kWh by 2015/16 through increased generation capacity alongside accelerated electrification program. Electrification level is also planned to increase from the current 18.4 percent to 30 percent by 2015/16. This implies connecting 250,000 new customers per annum for five years from 2013 to 2017. The overall objective of the PSMP were to re-assess short-term (2013 – 2017), mid-term (2018 - 2023) and long term (2024 - 2035) generation, transmission plans requirements and the need to fuel the economy to a middle-income level by 2025 as well connecting presently off-grid regions. Others are looking at options for power exchanges with Ethiopia (through Kenya), Zambia, Uganda, Rwanda, Burundi and Mozambique so as to increase the supply of reliable power to Tanzania.

The PSMP-2012 was first developed and approved in 2008 to provide a new plan to guide the development of the power system in Tanzania for the next 25 years. The Plan was updated in 2009 by reviewing the progress and challenges encountered during the first year of implementation. The Plan was again revised taking into account new development and socio-economic demands of energy. Revision of load forecast based on the current situation and updated expectations;

The PSMP-2012 is now undergoing extensive revisions taking into account new demand and projection for socio-economic development towards industrialization. Tanzania has maintained a mixture of energy resources, but the plan now is to maintain a 75%; 20% to 5% ratio for thermal, hydro and renewables respectively. Under the thermal component, the plan is to have 40% of energy from gas and the rest from coal, hydro and renewable energy source. Renewable sources include solar, geothermal, wind and biomass. Drought, low rains and availability of abundant gas, coal and geothermal potentials have resulted in the tilt towards more thermal power.

The revision of the PSMP-2012 has considered development of alternative expansion generation plans covering five scenarios (as discussed below) based on consideration of various options including cases of load forecast in which the scheduling of projects in each plan takes into account a reserve margins on firm capacity. In view of the above, Tanzania will need a total of 3,400MW in the medium term (2013-2017) and 8,990MW by 2035. Meeting these demands will require financing of about USD 11.4 billion during the medium term period and another USD 27.7 billion will be needed to cover the period to 2035. When inflation and interest during construction are added, total investment required rises to over US$ 41 billion dollars in the long run.

Several energy development projects such as the Mtwara gas pipeline, Kinyerezi 1- IV with a combined total of 990 MW, Mtwara 600 MW, Rusumo 80 MW; thermal power at Kiwira (200 MW; Mchuchuma 600 MW and Ngaka 400 MW; Arusha – Singida, 400 KV and Iringa – Dodoma- Singida –Shinyanga (400KV) and several others are earmarked and some are implemented or in various stages of implementation. The critical challenge however is the availability of financial resources to implement all the planned projects that were included in the PSMP-2012. Although the PSMP-2012 was developed with environmental considerations, the lack of clear monitoring programme makes it difficult to judge the consequences of the chosen technologies thus, in this revision a more coherent and clear way of mainstreaming environmental issues into the plan was adopted in the form of a Strategic Environmental and Social Assessment (SESA).

Strategic Environmental Assessment (SEA).

Strategic Environmental Assessment (SEA) is designed to assist strategic decision-making, with the purpose to improving the quality of policies, plans and programmes and to contribute towards sustainable development. In the case of the Power System Master Plan (PSMP), the SEA plays a pivotal role in ensuring that energy sector planning becomes effective in integrating economic, social and environmental aspects. In fact, linking energy sector planning with SEA is an attempt to introduce sustainability considerations into decision-making.

Therefore, the key objective of this SEA is to mainstream sustainability issues in the Power System Mater Plan of Tanzania. Several of sustainability criteria are discussed in the main report for this SEA and they include prevention of environmental degradation, promotion of environmental services, prevention of health impacts, effect on natural resources and impact on climate change. Stakeholder engagement, field visits, scenario development and literature reviews formed the main focus and approaches for this SEA.

Proposed Development Scenarios

The revision of the PSMP-2012 has considered five scenarios based on consideration of various options including availability of energy resources (gas, coal, hydro, renewables), implication, scheduling for the development of various alternatives, cost implications and environmental implications of each scenario. For all five scenarios renewable energy sources have been given the same contribution of 5% while other sources are given different proportions.

Scenario 1

In this scenario the contribution of gas is 50% while coal contributes 25%, hydro 20% and renewable sources 5%. In this power expansion scenario the contribution of coal is kept constant at 25% until 2040 while maintaining substantial contribution from gas powered sources at 50%. The contribution of 5% from renewable sources is expected to come from wind, geothermal and solar. Using the WASP (Wien Automatic System Planning Package) software, engineers ranked scenario 1as first on environmental aspects, third in cost and energy balance respectively and second best in terms of overall ranking among five scenarios.

Scenario 2

Scenario 2 is based on 40% contribution by gas, 35% coal, and hydro and renewable sources being maintained at 20 % and 5% respectively. This power source mix is expected to operate from 2015 to 2040 projection period. However the introduction of full swing gas and coal will begin to be realized by the year 2024 while significant contribution by renewable sources will be achieved by 2025. By the year 2025 the planned geothermal source will reach 100MW, while the contribution by wind sources will be 50 MW and 75 MW by 2017 and 2018 respectively

Power source mix scenario 2 has been developed into two variants: Variant A is project that works under normal circumstances and variation B is an accelerated scenario. The assumption held under scenario 2 - variation A, is that the plan begins with gas source as major contributor to the power mix, supported by hydro source at least for the year 2015 and 2016, while contribution of renewable source starts 2017. By 2020 significant contribution from Gas source will be backed up by contributions from hydro and renewable source with coal contributing little since most of the coal fired plant from Mchuchuma and Ngaka will be at their construction phases. By the year 2026 the contribution of coal and renewable source will increase and will continue to grow (especially coal) significantly to reach the projected contribution by 2040.

Under the accelerated variant (Scenario 2 – B), it is assumed that there will be deliberate accelerated investment initiatives from public and private sector in energy projects to make sure that installed power capacity is achieved much earlier than projected by normal scenario. Under accelerated scenario the contribution by renewable sources and coal begins much earlier by 2017 as compared to 2020 under variation A. However, under this assumption, issues such as availability of land for the projects, availability of experts to smoothly construction and running of the projects, continued economic activities that require power to create the assumed power demand and presence of private investors ready to invest in power projects in Tanzania are critical pre-requisite. None of these assumptions are guaranteed and the on going global oil price crisis adds more complications into this assumption because some international oil companies that would also invest in gas are still studying the markets. In terms of cost and power balance this scenario is ranked number one, while it is ranked number two environmentally. Overall scenario 2 is ranked number one, and the PSMP Task Force Team, which comprised of MEM staff and JICA engineers and several working groups such as demand forecast group; power generation planning and power systems group proposed it for adoption in the PSMP as power source mix for the programme from 2015 to 2040 for Tanzania.

***Scenario** 3*

This scenario is based on the assumption that gas will contribute 35% of the total while coal will contribute 40 and hydro and renewables remain at 20% and 5% respectively. In the first two years (2015/2016) the scenario is predominantly gas fired, hydro and little contribution from diesel fired plants. The contribution from diesel will diminish gradually, being replaced by renewable sources, which begin to feature in the scenario by 2017, while coal contribution begins by 2020. The introduction of coal-fired thermal will start by contributing 5%, and increasing dramatically to 40% by 2040. Analysis by using WASP software, found this scenario the best in terms of energy source balance. However the scenario is the most expensive in terms of costs, it ranks third in term of environmental performance thus coming up third in overall ranking.

Scenario 4

This scenario demands large allocation from coal (50% of the total) while gas is projected to contribute 25% and hydro and renewables remaining at 20% and 5 % respectively. The projection from this scenario is that in the first two years the power source mix will come from gas by 65 -70%, diesel fired plant 4%, and hydro over 35%. The first contribution from renewable sources will begin in 2017 and continue to grow gradually to reach the projected 5%. The share contribution from coal will begin at 2020 with 10% increasing to 30% by 2022 and eventually stabilizing at 50% by 2040. By the year 2033 most of the diesel powered engines will be phased out thus, paving way for coal, gas, hydro, and renewable operating at projected levels.

According to WASP software, scenario ranked second in terms of cost by fifth in terms of environmental aspects and fourth overall ranking. Increased share contribution of coal to 50% and reducing gas to only 25% will have huge implication in terms of environmental consequences and water demand. Compounding these environmental consequences the issues of climate change and acid rain might as well emerge thus impacting even other sources like hydro sources that are predominantly rainfall dependant and thus subject to risk of drought. In addition to these constrains environmental cost of using large share of coal and gas will significantly raise the cost of implementing this scenario.

Scenario 5

In this scenario, the contribution of gas is 50% of total while that of coal is 35% and hydro is 10% and renewables maintain the same 5 %. Contribution by renewable sources are planned to commence in 2017 with coal contributing 15% by 2020 and increasing to 25% by 2021 (assuming the Mchumhuma and Mbeya coal projects are operational). Introducing coal and renewable sources reduces the share contribution from diesel-powered plants to near zero and by the year 2032 all diesel-powered plants will be phased out and the projected development to prevail to 2040.

This scenario is ranked fifth in overall ranks and fourth in cost and environmental aspect respectively. This scenario will have significant environmental implications in terms of GHG emission levels from coal and gas, significant water use for coal and gas and it will be expensive to mitigate environmental impacts due to significant use of gas and coal.

Environmental and Social Implications of proposed Scenario 2

Based on a WASP software, the PSMP Task Force Team has proposed Scenario 2 to be considered for development in the PSMP 2016 Update. As noted above, this scenario will be made up of 40% gas, 35 % coal, 20% hydro and 5% renewables.

Generally, all the five proposed scenarios put emphasis on the higher contribution of gas and coal (>75%) while hydro and renewables contributes relatively less (<25%). The contribution of hydro and renewables is largely the same in all five scenarios. Gas tops the contribution (50%) in Scenarios 1 and 5, and is lowest (25%) in Scenario 4. Coal on the other hand tops contribution (50%) in Scenario 4 and is lowest (25%) in Scenario1. With coal being the worst poluting source followed by gas, scenarios 5, 4 and 3 are the worst environmentally because they have the highest contributions of emissions (Carbon Dioxide, Sulfur Dioxide, Nitrogen Oxide, particulate matter, heavy matter) and high deamd on water use for cooling purpsoes leading to smog, acid rain and toxin to the environment and directly affecting humans via numerous respiratory, cardiovascular, and cerebrovascular effects.

A further comparative analysis of the remaining scenario 1 and 2 shows that, while scenarios 2 is estmated to cost less than scenario 1 by almost US$ 740 million, most of the environmemtal parameters show higher values in scenario 2 than in scenario 1. For example,the amount of both annual total and unit GHG emissions for Scenario 2 are significantly higher than those of scenario1 (by > 2,500,000 tons CO_2 eq/annum and >0.050 kg CO2 eq/kwh, respectively) in the year 2040. Furthermore, the annual total GHG emission breakdown by fuel type shows that coal in scenario 2 emits relatively more GHGs (about 10,000,000 tons CO_2 eq) per annum than in scenario 1 in the year 2040.

Similarly, by 2040, scenario 2 will emit higher annual Sulfur Dioxide emission (SOx) than scenario one by almost 70,000 tons and the same for annual Nitrogen Dioxide emission (NOx) in which scenario 2 will emit 67,000 tons by 2040 as opposed to 53,000 tons from scenario 1. Annual coal ash amount is higher in scenario 2 than in scenario 1 by almost 350,000 tons by 2040. Therefore, relatively lower cost shown in scenario 2 (i.e. $45,099 Million) compared to scenario 1 ($45,838 Million) would definitely be due to compromised environmental quality by foregoing expensive mitigation costs and choosing scenario 1 due to cost factor alone.

The more general social implications of both scenario 1and 2 would include health risks associated with gaseous emissions resulting to diseases. Other impacts are climate change, acid rain, excessive pressure on water resource, change in vegetation cover due to clearing for transmission lines, loss of land due to establishment of various power generation stations and transmission lines, impact on bird movements and impact on marine resources arising from release of hot water from gas powered plants that are located along the coast of Tanzania. More intensive health implications will be associated with the use of coal and especially where coal use is more than any other energy source in a particular scenario. In Scenario 2 coal will contribute 35% of the total generation as opposed to 25% in Scenario 1. Other impacts are increased energy generation that may trigger growth of industries and spur employment opportunities, increased economic growth and improved social wellbeing.

Transmission Lines

Despite the challenges in generation and measures adopted in the PSMP in the form of energy mix in order to guarantee long term reliable power supply, there are significant issues in terms of transmission of the generated power to reach energy users. Tanzania is a large country with relatively low population densities in many areas. The principal demand centres are located far away from main generation areas (mostly in the south of Tanzania). This means the cost and losses in transmission are expected to be high as energy is transported to various end users.

Proposal regarding transmission line sunder the revised PSMP have been provided but they indicate major concern on issues related to land take to allow establishment of way leave for transmission line. Since there are diversity of sources with varying generation capacity there will also be transmission lines for 400 kV; 220 kV and 300 kV, which demand way leave between 60 m to 90 m size and others for 33Kv or 11 kV for distribution purposes. Other issues of concern with regards to transmission line are potential bird collisions. Presence of multiple transmission lines closer to important bird areas like Kilombero valley, south coast corridor from Mtwara to Dar es Salaam and southern highland areas interfere free flying zone particularly for migratory birds. In addition to loss of biodiversity due to clearing of vegetation there will be land scape issues where multiple transmission lines will distort the scenic quality of the areas traversed by crossing transmission lines.

Conclusions and Recommendations

Conclusions:

The PSMP-2012 required upadating in view of the fast pase of development Tanzania has been experiencing since then and the desired goal of becoming an industrialized country by 2025. Demand to meet the ever increasing development needs and targets lead to the revision of the Power System Master Plan so that the country could not only achieve reliable energy but also afforable and possibly environmentally friendly energy supply.

Five energy development balance and mix were considred taking into account, energy balance, cost and environmental implications. Based on a WASP software of analysis for such large scale development scenarios, the PSMP Task Force Team proposed the adoptuon of Scenario 2 for development of the PSMP. This scenario is projeted to consist of 40% gas;35% coal; 20% hydro and 5 % renewables and would cost an estimated US 45,099 million to establish.

The detailed environmental analaysis however, shows thst scenario 1 is more environmentaly friendly than scenario 2. This scenario will consist of 50% gas; 25% coal; 20% hydro and 5% renewables and would cost an estimated US$ 45,838. The higher cost in this scenario is attributed to adoption of more environmentally friendly solution that minmizes effect of emissions as opposed to scenario 1 that has externalized those environmental costs.

Also, it has been noted that the PSMP-2012 did not have a coherent and comprehensive monitoring and evaluation program, which makes its diffocult to measure the effect of the program. Other impacts that have also been highoughted in this SEA include health risks associated with gas emissions that may lead to human diseases. Others are climate change, acid rain, excessive pressure on water resource, change in vegetation cover due to clearing for transmission lines, loss of land due to establishment of various power generation stations and transmission lines, impact on bird movements and impact on marine resources arising from release of hot water from gas powered plants that are located along the coast of Tanzania.

Recommendations

Based on the analysis above the following recommendations are made:

1. Gas being environmentally relatively better than coal, and in order to adequately protect the environment, the people and ensure sustainability of the PSMP, scenario 1 is recommended instead of scenario 2, if externalized environmental cost is considered.
2. Each power generation and transmission project must be subjected to detailed and participatory Environmental and Social Impact Assessment,
3. National and international standard on emission levels sould be applied to protect the people and the environment,
4. The best affordable and environmentally friendly technologies for power generation and transmission should be adopted as means to safeguard the environment and the people,
5. Where land will be acquired for establishment of power generation plants, transmission lines of substations, fair and timely compensation to the affected persons should be provided.
6. Capacity developmeng measures to the Environmental Unit of the Ministry of Energy and Minerals and TANESCO for the implementation of the SEA recommendations should be designed, funanced and implemented
7. A robust Monitoring and Evaluation system for the implementation of the PSMP and this SEA should be established, funded and implemented.
8. As a matter of policy, there should be a deliberate programme to show when and how the country will gradually switch to more use of cleaner renewable energy sources.
9. Coal based power plants must be cited close to reliable and sustainable sources of water for cooling.
10. The citing of thermal electricity plants should avoid prime biodiversity areas including wetlands and natural forests.
11. All waste water from thermal power plants should be collected,and thoroughly treated before discharging into receiving water bodies.
12. Fly ash and other wastes should be disposed in surveyed landfills or abandoned mines, while some amounts are recycled into useful products, such as cement and building materials.
13. With regard to management of water for hydropower generation, there is need for policy changes that will allow MEM to manage strategic cachtment areas that feed into the power supply. This sort of decision will require detailed assessment of the challenges the current arrangement imposes on power generation.
14. Design measures that will reduce land acquisition for transmission and other utilities muts also be built in the PSMP.
15. Deliberate policieis need to be put in place to ensure large population is accessing electrictiy. This will not only improve livelihood but also reduce the use of biomass as sourec of energy and miminize deforestation.

1. Background on Tanzania and current PSMP 2012

1.1 The Land and the People

Land: Tanzania, located just south of the Equator with about 947,303 km^2, is the 13th largest country in Africa and the 31st largest in the world. It borders Kenya and Uganda to the north; Rwanda, Burundi and the Democratic Republic of Congo to the west; and Zambia, Malawi and Mozambique to the south. Tanzania is located on the eastern coast of Africa and has an Indian Ocean coastline approximately 800 km. long. It also incorporates several offshore islands, including Unguja (Zanzibar), Pemba and Mafia. The country is the site of Africa's highest and lowest points: Mount Kilimanjaro at 5,895 metres above sea level, and the floor of Lake Tanganyika at 352 metres below sea level, respectively. Mountain ranges and plateaus in the west and southwest, and the Maasai Steppe in the northeast divide the interior.

Population: According to the 2012 Population and Housing Census, the country is estimated to have a population of about 44,928,923 people with an annual average inter- censual growth rate of 2.7 (URT, 2013). Out of that about 1.3 million people were in Zanzibar. The average household size is estimated at 4.8 overall and 4.8 and 5.1 in mainland Tanzania and Zanzibar respectively (ibid). The population density is estimated to be 51 persons per sq.km overall and, 49 and 530 persons per sq. km in mainland Tanzania and Zanzibar respectively (ibid).

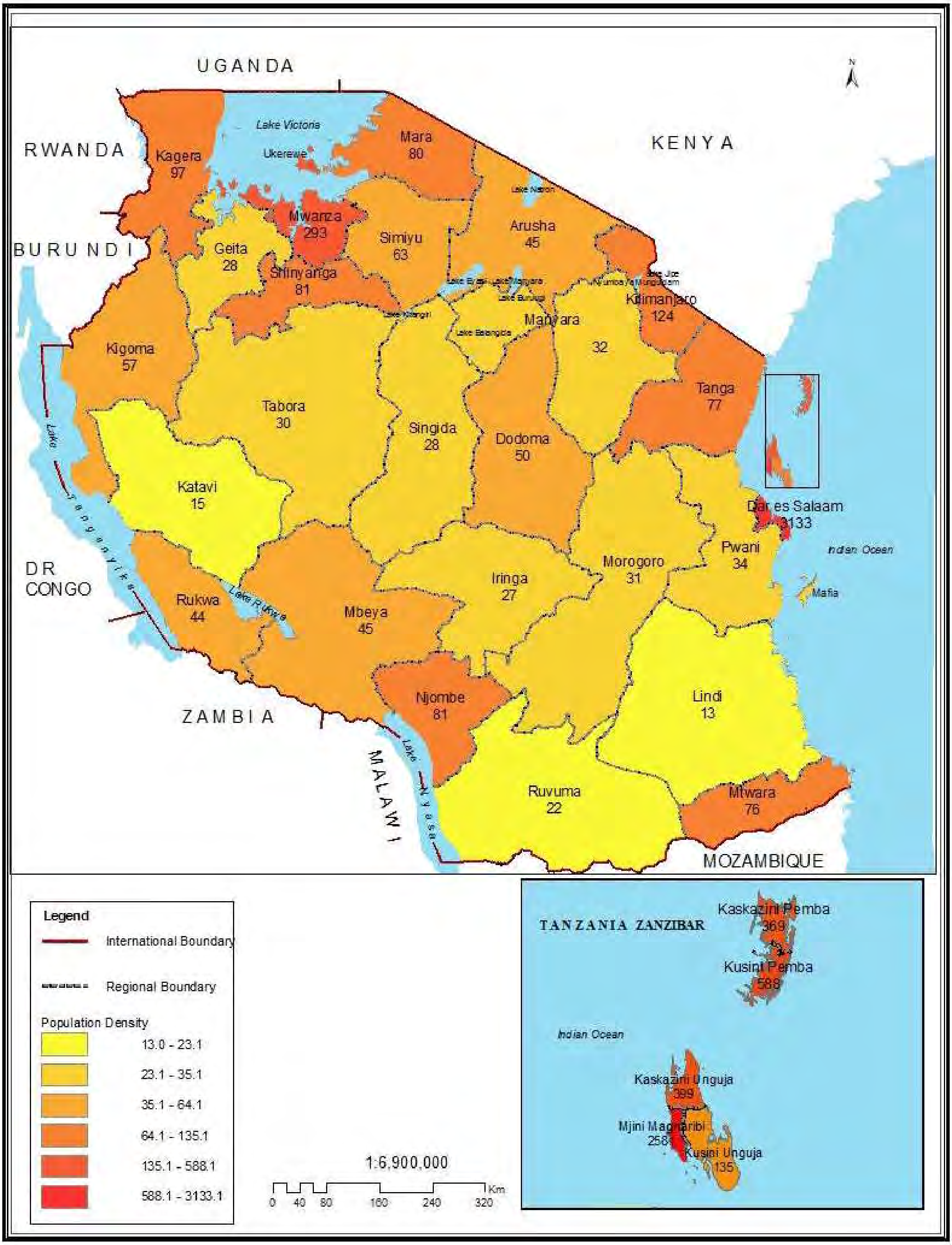
Table 1: Trends in Population size and growth, 1967 - 2012

AREA	VARIABLE	CENSUS YEAR				
		1967	1978	1988	2002	2012
Tanzania	Total Population	12,313,469	17,512,610	23,095,882	34,443,603	44,928,923
	Inter-censual Increase		5,199,141	5,583,272	11,347,721	10,485,320
	Size relative to 1967(1967=100)		100	142	188	280
	Average annual growth rate (% p.a.)		3.2	2.8	2.9	2.7
	Doubling time (years)		21.7	25.0	24.3	26.1
Tanzania Mainland	Total Population	11,958,654	17,036,499	22,455,207	33,461,849	43,625,354
	Inter-censual Increase		5,077,845	5,418,708	11,006,642	10,163,505
	Size relative to 1967(1967=100)		100	142	188	280
	Average annual growth rate (% p.a.)		3.22	2.8	2.9	2.7
	Doubling time (years)		21.5	25.1	24.3	26.1
Zanzibar	Total Population	354,815	476,111	640,675	981,754	1,303,569

AREA	**VARIABLE**	**CENSUS YEAR**				
		1967	**1978**	**1988**	**2002**	**2012**
	Inter-censual Increase		121,296	164,564	341,079	321,815
	Size relative to 1967(1967=100)		100	134	181	277
	Average annual growth rate (% p.a.)		2. 7	3.0	3.1	2.8
	Doubling time (years)		26.0	23.3	22.7	24.4

Source: National Bureau of Statistics (NBS) and Office of Chief Government Statistician (OCGS), Zanzibar 2013

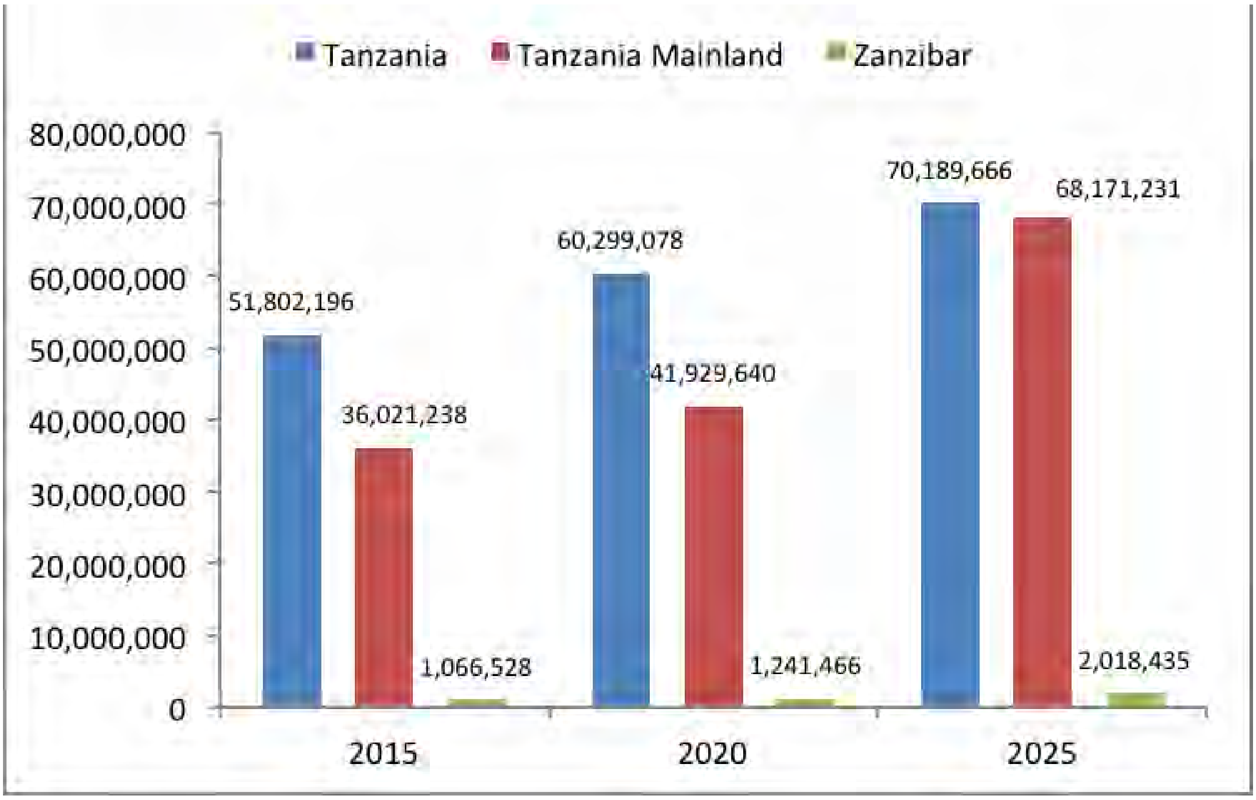
The majority of the people in Tanzania reside in rural areas however, urbanization and urban growth is increasing, with Dar es Salaam, the main commercial city having more than 5 million people, or almost 10 % of the nation's population. In terms of population density, Dar es Salaam had the highest at 3,133 people per km^2 followed by Mwanza (293), Kilimanjaro (124) and Kagera (97). Tanzania is sparsely populated with population density of 51 persons per square kilometre with variation across regions. Dar es Salaam and Mjini Magharibi are densely populated regions with population densities of 3,133 and 2,581 persons per square kilometer respectively. Lindi had the lowest population density in the country, at 17 people per km^2. Most of the urban towns such as Tanga, Bagamoyo, Kilwa, Lindi and Mtwara are growing fast, with Lindi, Kilwa and Mtwara growing faster as a result of increasing activities related to gas, oil exploration and the construction of several large scale infrastructures in those regions.



Map 1: Map of Tanzania showing population density distribution

Source: National Bureau of Statistics 2016

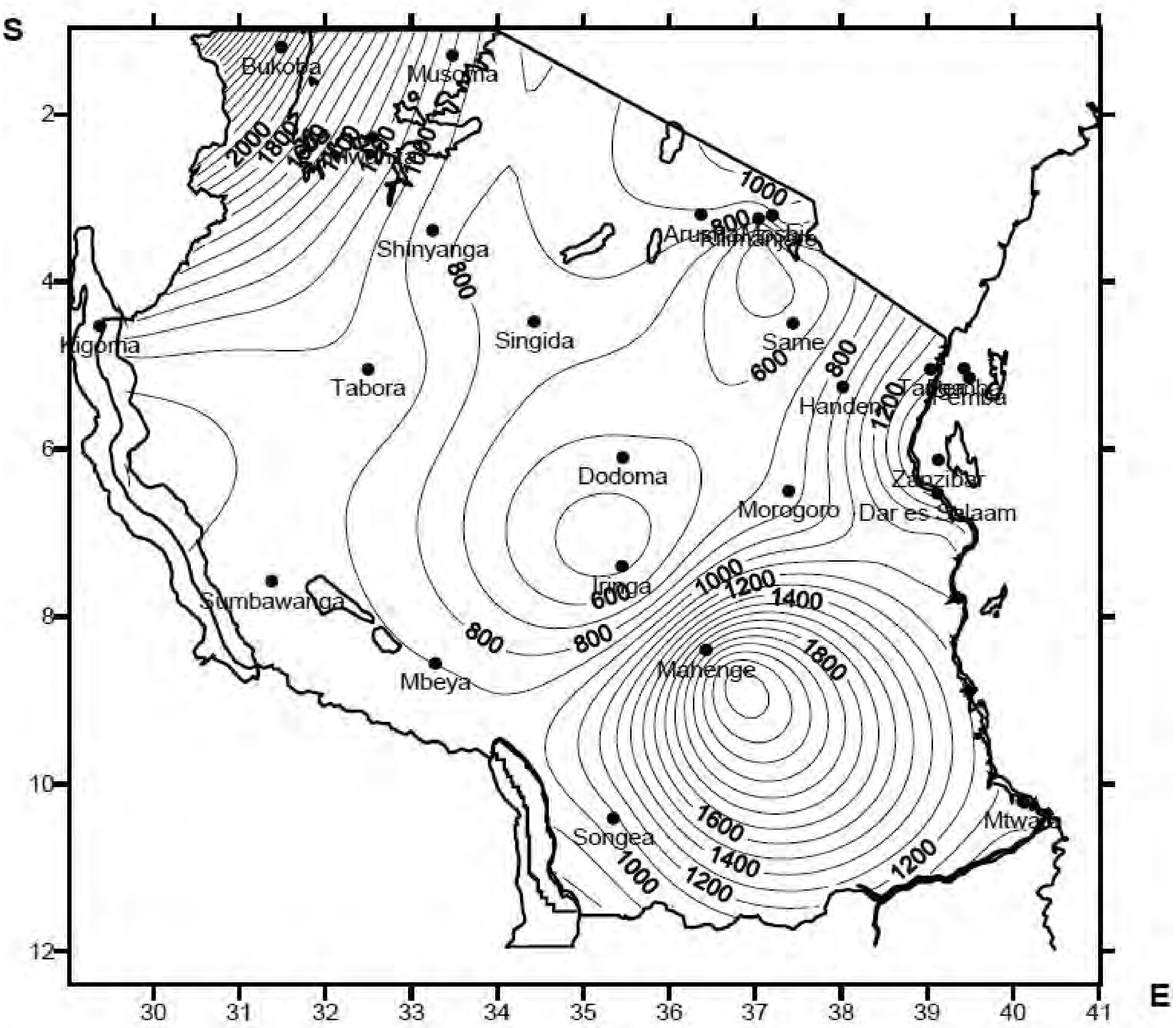
Figure 1: Projections of Future Population of Tanzania



(Source: National Bureau of Statistics 2016)

1.2 Climate

Tanzania is characterized by two main rainfall patterns, which influence many of the livelihood activities in the country. The rainfall patterns are namely the long rains and the short rains, which are associated with the southward and northwards movement of the Inter-tropical Convergence Zone (ITCZ). The long rains (*Masika*) begin in mid March to end of May, while the short rains (*Vuli*) begin in the middle of October and continue to early December. The northern part of the country including area around Lake Victoria Basin, North-Eastern Highland and the Northern Coast experience bimodal rainfall regime, whereby the first maximum occur in the period of March, April and May while, the second maximum in the period of October, November and December. Central, South and Western areas have a prolonged unimodal rainfall regime starting from November continue to the end of April. Annual rainfall varies from 550 mm in the central part of the country up to 3,690 mm in some parts of southwestern highlands. The average duration of the dry season is 5 to 6 months. However, recently, rainfall pattern has become much more unpredictable with some areas/zones receiving either minimum or maximum rainfall per year. This changes, that are associated with global warming and climatic changes are causing dramatic alterations in farming, cropping patterns and type of crops, making farming activities less and less reliable.

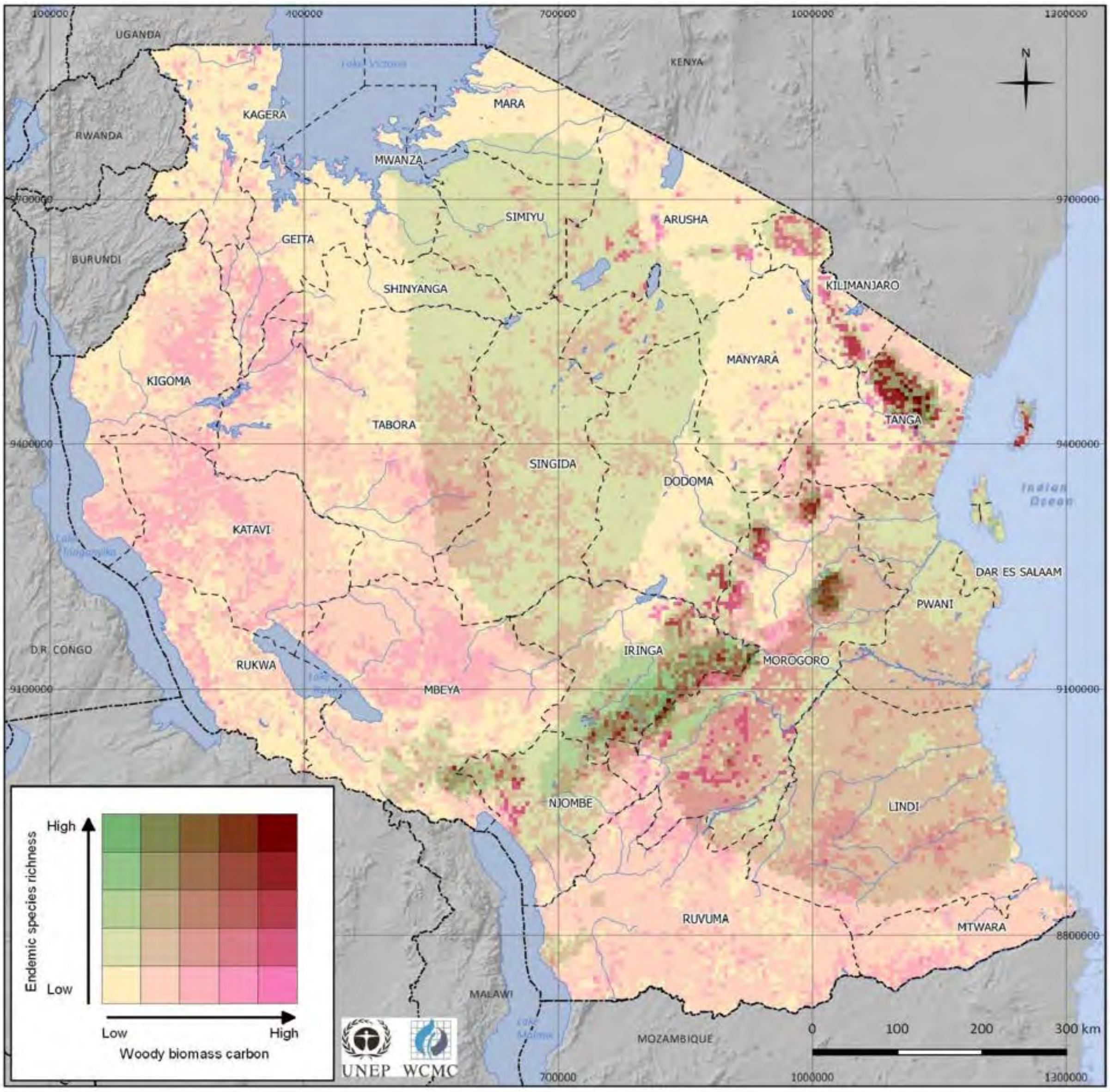


Map 2: Spatial distribution of mean annual rainfall 1970 - 2000

Source: Tanzania climate strategy 2012

1.3 Land Cover, Land Use and Resource

Biodiversity: Tanzania is one of mega-biodiversity countries in the world with abundance biodiversity resources. Several endemic species are found in Tanzania, thus making the country unique and attractive for tourism and scientific research. The region with high level of endemism includes the Eastern Arc mountain ranges, coastal forests and montane forest covering Mountainous areas. Observation from map 3 indicates the zones with high species endemism and IUCN threatened status corresponding much to the Eastern Arc mountain regions.



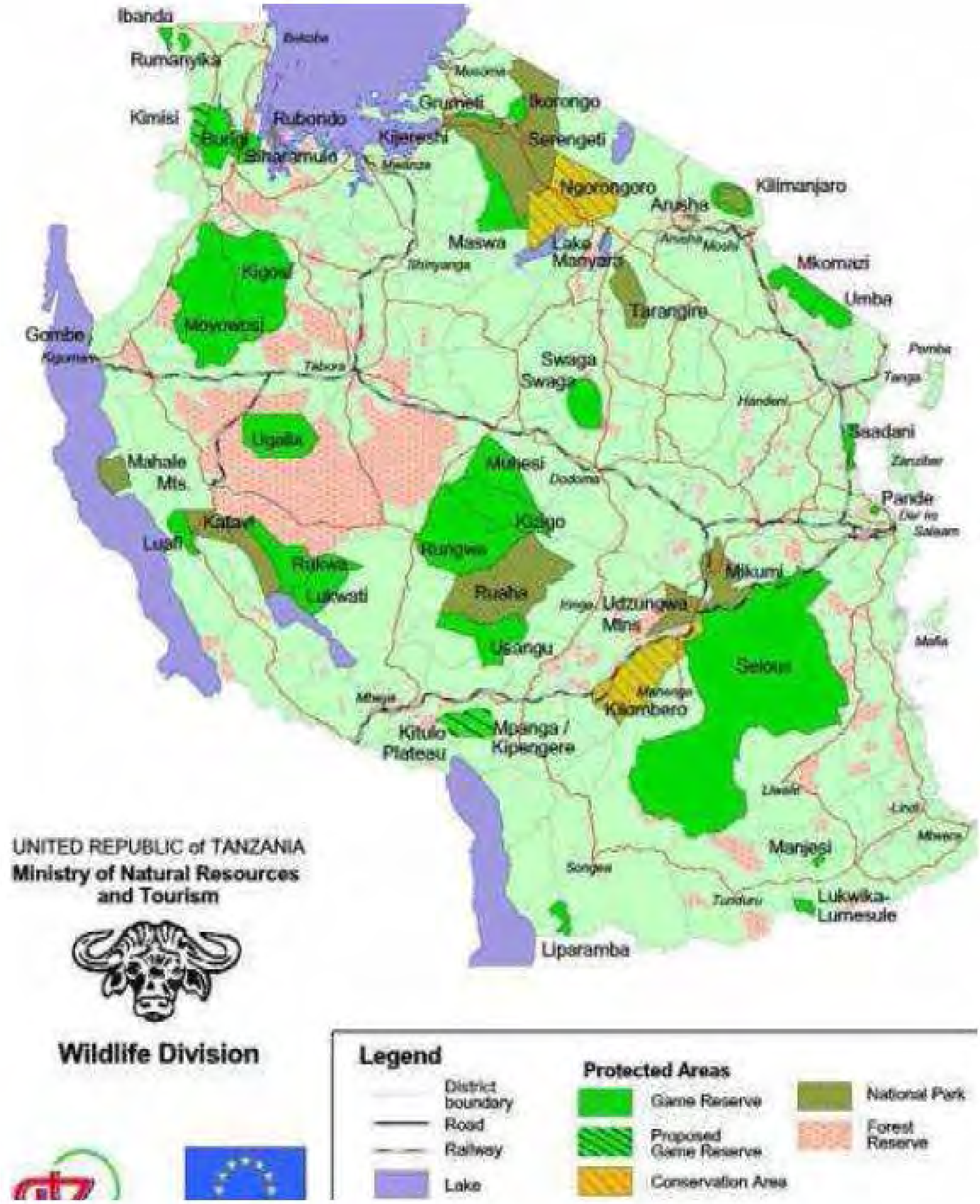
Data sources:
Endemic species: IUCN. 2014. The IUCN Red List of Threatened Species. Version 2014.2. http://www.iucnredlist.org. Downloaded on 1st August 2014.
Woody biomass carbon: NAFORMA 2013: NAFORMA woody biomass. 5km preliminary dataset based on field data.

Map projection: WGS84 / UTM Zone 36S
Map prepared by: UNEP-WCMC
Date: August 2014

Map 3: Regions with high species endemism and IUCN threatened categories

Source: WWF-REDD+ Pilot Project 2015

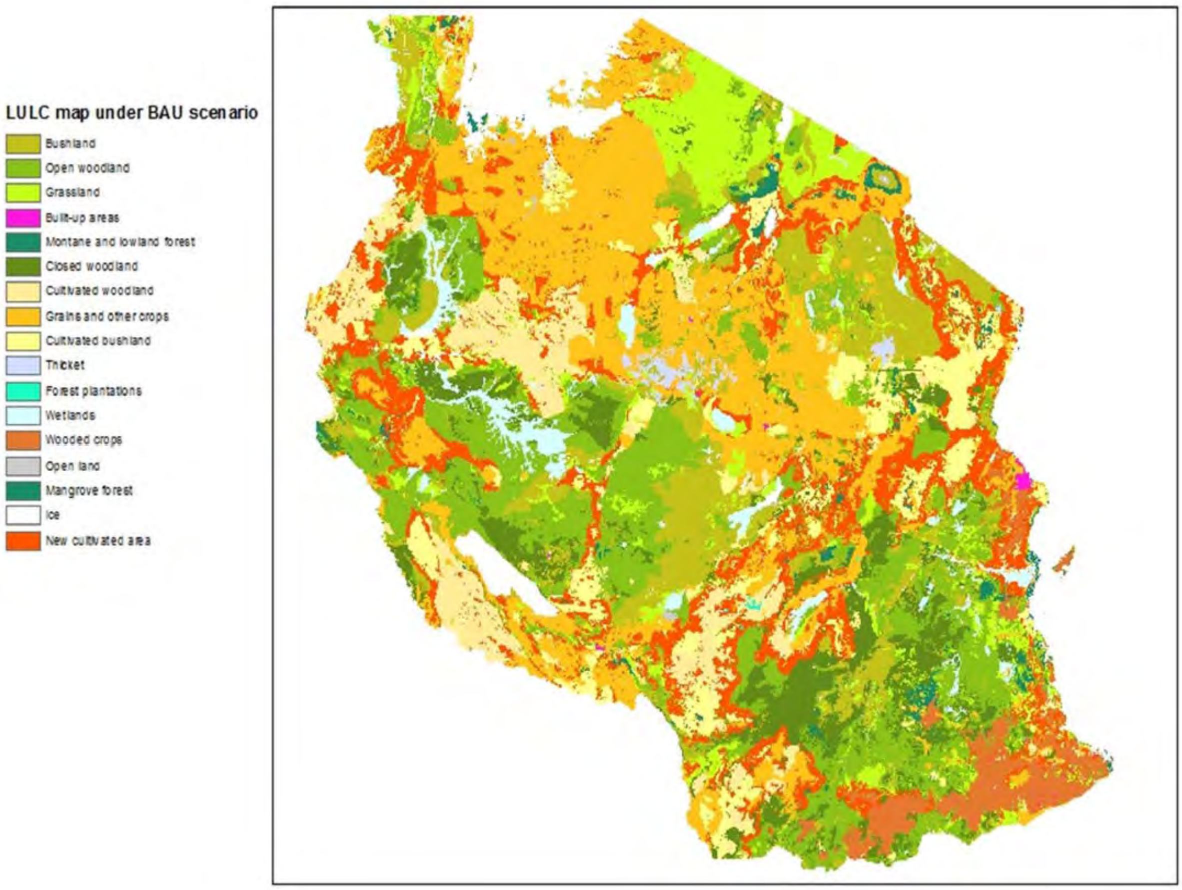
Over 40 % of the country in covered by protected areas such as National Parks, Game Reserves, Forest Reserves, Wildlife Management Areas, Nature Reserve as well as Marine Parks and Reserves. These areas constitute core gene pools and source of biodiversity and an attraction for tourism, a major economic activity for Tanzania.



Map 4: Tanzania protected areas (National Parks, Game Reserves, Forest reserves)

Source: URT 2009

Forest: Forest areas have concentrated around the north-eastern where the Kilimanjaro and Meru Mountains are located and in the coast, southern and northern highland areas as well as the vast miombo woodland areas found on the central, south and southwestern side of the country. Commercial tree plantations make up less than 0.5 per cent of the total wooded areas (Grant, 2009). Both illegal and unregulated utilization of the forest and wildlife resources have increased in recent years, affecting elephants and rhino populations as well as forest resources. Illegal timber harvesting and timber trade have resulted in the depletion of some valuable timber species such as the black wood and loss of revenue to the government.



Map 5: Land use land cover (Forest Cover) map of Tanzania

Source: NAFORMA 2015

Water bodies: Tanzania is also home to several fresh water bodies such as lakes and rivers. Three of Africa’s Great lakes are partly within Tanzania; to the north and west are Lake Victoria, Africa's largest lake, and Lake Tanganyika, the continent's deepest lake, known for its unique species of fish. Others are Lake Nyasa to the southwest also having abundant ornamental and endemic fish species; Lake Natron, to the northeastern, the main flamingo breeding site in East Africa. There are also several other lakes, such as Lake Ngozi in Mbeya and Rungwe Districts, Mbeya Region, a potential geothermal site and Lake Rukwa in western Tanzania.

Beside the lakes, there are also several important rivers that provide water for a number of socioeconomic activities including generation of electricity, for irrigation, domestic and industrial uses as well as fresh water fisheries and environmental services. These rivers include the Rufiji, Ruaha, Kilombero, Ruhudji, Wami, Iyovi, Ruhuhu, Ruvuma, Mchuchuma, Malagarasi, Mara and Kagera Rivers. Others are Pangani, Kihansi and Wami Rivers. Most of these rivers are important for the generation of hydropower electricity.

Many of the rivers start on highland areas where increasing human activities in these catchment areas including agriculture and conversion of the mountain grasslands into forest areas are causing major alteration on the flow of water into the rivers. Siltation and low water flows are becoming major problems that are likely to affect availability of water for hydropower generation and other uses due to poor catchment management. For example, generation of electricity at the Mtera Dam and from Kidatu Hydropower Station, that rely mostly on Ruaha River and Iyovi and Lukosi Rivers respectively has often been affected by low flows of water. It was the energy crisis in the early 2000 and then from 2004 to 2006 that led to the engagement of Independent Power Producers (IPP) such as IPTL, Richmond, DOWANS and many others because inflows into the hydropower stations was very low. Also, the same crisis led to the eviction of pastoralist from the Usangu valley in order to allow to the flow of water into the Ruaha River.

Map 6: Main River Basins of Tanzania

Source: Hydropower Vulnerability Report 2014

Heritage: Tanzania is a country, which encompasses an extraordinary history and an abundance of natural wonders. The country is well endowed with abundant significant cultural heritage resources, which range from the Pliocene period about four million years ago to present time (http://www.mnrt.go.tz/sectors/category/antiquities). These resources are categorized into seven groups as follows:-

i. Archaeological or Paleontological sites such as Olduvai Gorge, Laetoli Footprint, Isimila Stone Age site, Engaruka Ruins;
ii. Historical sites such as Kaole Ruins, Kunduchi Ruins, Kilwa Kisiwani Ruins, Songo Mnara Ruins;
iii. Historical towns such as Bagamoyo, Kilwa Kivinje, Mikindani;
iv. Traditional Settlements such as Kalenga in Iringa and Bweranyange in Kagera;
v. Historic Buildings like Colonial Administrative Buildings (BOMAs) in many Districts in Tanzania;
vi. Sites with special memories like Colonialists Cemetery, Cemeteries of World War I and II and Defensive Walls;
vii. Natural Features and Structures such as Mbozi Meteorite, Amboni Caves and Kondoa Rock Art Shelters to name only a few.

The Division of Antiquities as a Government Institution is responsible for conservation, preservation, protection and management of these cultural heritage resources. The cultural heritage resources are legally protected through Antiquities Act of 1964 (Act No.10 of 1964 Cap 550), which is the principal, legislation and the Antiquities (Amendment) Act of the 1979 (Act No. 20 of 1979) as well as Rules and Regulations of1981, 1991, 1995 and 2002.

Original map courtesy of the authors

Map 7: Natural and Cultural Heritage sites in Tanzania

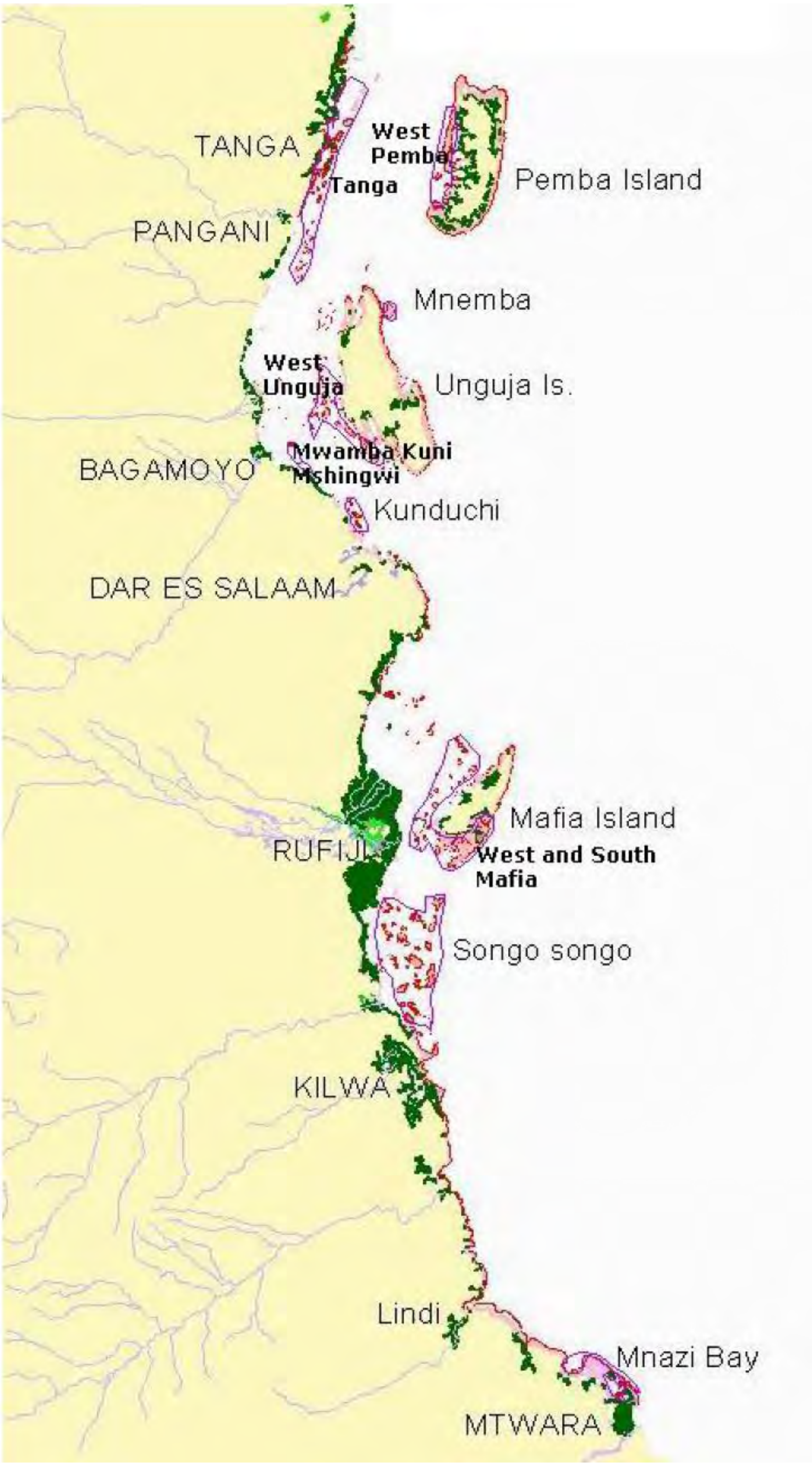
Source: http://www.mnrt.go.tz/sectors/category/antiquities

Coastal area and Fishery: Tanzania has a coastal line of about 900 km from Tanga to Mtwara encompassing the islands of Unguja, Pemba and Mafia and an Exclusive Economic Zone (EEZ) extending into the Indian Ocean. The sea offers a variety of social and economic opportunities including fisheries, sea transport and tourism as well as in recent years, off shore oil and gas exploration and mining. Despite having such abundant opportunities, Tanzanians have note fully benefitted from marine and aquatic resources and instead, these are continuously being degraded.

For example, poor fishing gear and equipment limits the ability of coastal and other people to venture into deep waters for fishing purposes thus continue to fish along the seashore and getting fewer fish. Extractive activities such drilling for gas and oils as well as use of dynamite in fishing are posing serious threats to marine resources, and in particular its effect on breeding sites and coral reefs. In the lakes and rivers, pollution caused by various anthropogenic activities incusing industries, mining and the use of mercury and cyanide are affecting fresh water fisheries.

Map 8: The Distribution of Coral reefs in Tanzania

Source: Muhando and Rumisha 2008



Map 9: Coral reefs Priority areas in Tanzania

Source: Muhando and Rumisha 2008

Agriculture: Over 30 % of Tanzania's land is suitable for agriculture but only a fraction is used due to problems such as inadequate infrastructure that support agriculture (water availability, farm services, markets, machinery and agro-processing industries). Major food crops include maize, sorghum, cassava, millet, wheat and rice. Cash crops include tea, coffee, tobacco, cashew nuts and sisal. Other crops are vegetables, fruits, beans, groundnuts etc (See Map 10 below).

Looking at a map of the existing and planned location of hydropower facilities in Tanzania, it is obvious that many of them are downstream of the main agricultural production areas (see Map 10 below). For example, existing hydropower dams are on the Pangani River, whose catchment is actually Mount Kilimanjaro and Mount Meru in Arusha and Kilimanjaro. Pangani River drains into the Indian Ocean, thus supplying water for agriculture production up stream, where sugar cane plantation and paddy farms at Lower Moshi are the main crops; others are maize, horticulture, coffee, beans and legumes. Sugar and paddy are some of the largest irrigation plantations found in the Pangani Basin upstream of the Nyumba ya Mungu and Hale Hydropower stations.

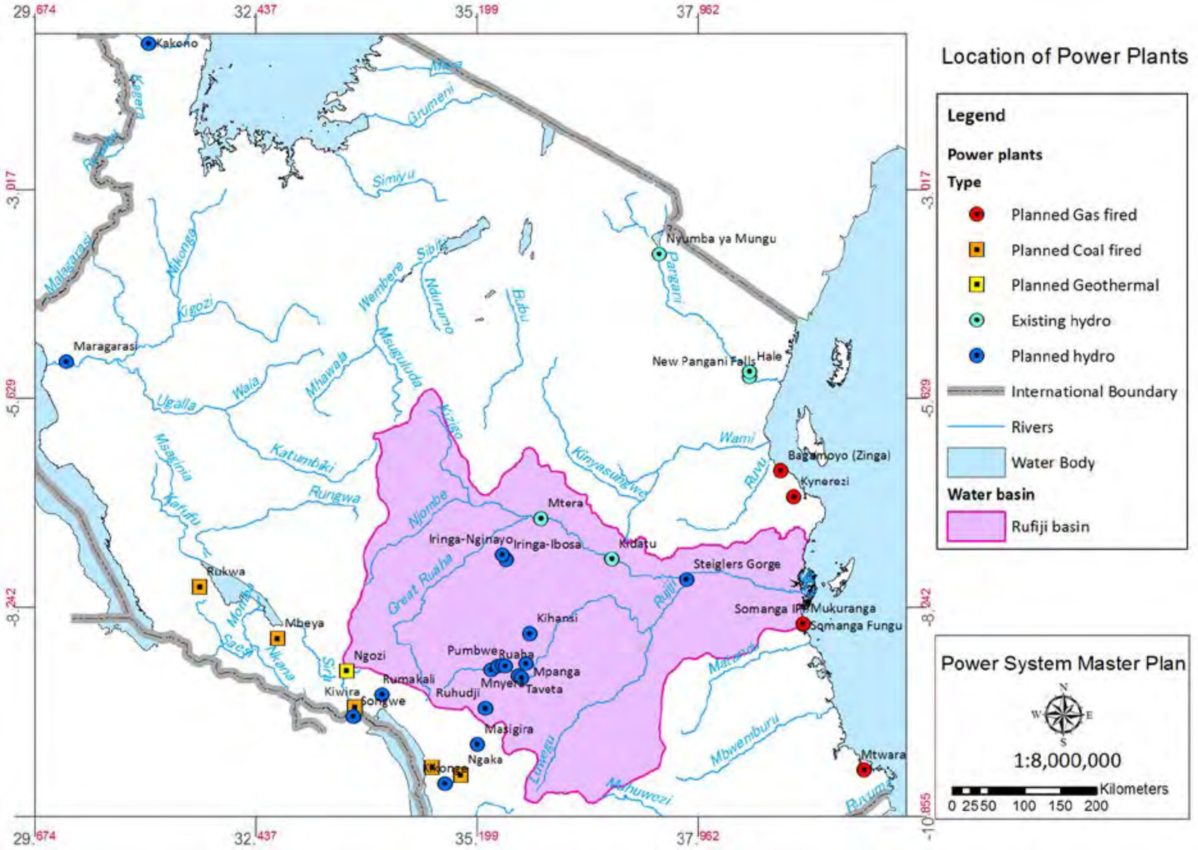
Map 10: Map showing Agricultural Crop distribution around Tanzania

Source: www.kilimo.go.tz

Similarly, the existing largest hydropower plants are located in the Great Ruaha River, and Njombe River (for Mtera and Kidatu) and Rufiji River for Kihansi (see Map 11 below). The catchment for these rivers is upstream of the power plant stations and in rich agricultural areas for tea, maize, pyrethrum in Njombe, paddy and maize in the Usangu valley, and maize in the upland areas of Mbeya, Njombe, Iringa and Dodoma regions, which is the catchment of the Rufiji and Ruaha Rivers.

The same is the case for the planned hydro-dams in the proposed new PSMP. Over 80 % of the planned new hydro-dams are located in the Rufiji Basin (Map 11), a very rich agricultural area and a large part of the Southern Agricultural Growth Corridor of Tanzania (SAGCOT – see Map 12 of the area). The SAGCOT area extends far beyond the Rufiji Basin to include areas that are also the main sources of water for Mtera, Kidatu and Kihansi power stations. The SAGCOT is a national strategy for expanding agricultural production for a variety of crops including paddy, maize, vegetables, livestock and establishment of agro – industries. Inevitably water demand for SAGCOT programs will have to be provided in tandem with and taking into account other needs such as for hydropower generation and environmental flows.

Other planned hydropower programs are outside the Rufiji Basin but also located in major rivers hat are feeding into the agriculture sector and thus balancing the need for power generation against agricultural production will become crucial in the success of this PSMP. The projected contribution of hydropower in the new PSMP is 20% of all power generation types. To be able to get as much water to generate 20% of all the generation will require considerable and careful planning of how water balance among several users will be maintained and above all, it will require putting in place measures to ensure the catchments are well protected to continue to provide water not just for power but for agriculture, domestic uses and environmental services.



Map 11: Location of Planned Hydrro Plants in the New PSMP

Source JICA PSMP study team 2016

Map 12: SAGCOT area in Tanzania

Mining: Tanzania is also rich in mineral resources. The country is the 4th largest gold producer after South Africa, Ghana and Mali. Gold, copper, silver, diamonds and coal are mines from various parts of the country. Most of the gold and diamond mining is taking place around the Lake Victoria area, thus exerting too much demand for power supply. Other minerals include uranium inside the Selous Game Reserve and at Bahi, in Dodoma Region. There is also, over 1.5 billion tons of coal, over 1.2 billion tons of iron ore deposits in Mbeya, Ruvuma and Njombe Regions. Plans to mine coal and iron ore at Liganga and Mchuchuma are underway and the coal will feed into power supply to fuel the envisaged industrialization.

Several gemstones are also available in many places in the country, including the most popular tanzanite that is found only in Arusha Region, Tanzania. Oil and gas exploration has continued in several parts, focusing more along the coast, off shore and in the rift valleys. Gas deposits have been discovered on the east coast and on off shore areas and are now being used to generate electricity. More such discoveries that were done in recent years have provided basis for the consideration of improved power supply that can fuel the economy in the years to come.

Map 13:Mineral Map of Tanzania

Source: Extracted and Modified from http://www.mapsofworld.com/tanzania/tanzania-mineral-map.html Sept 2016

1.4 The Economy and Development

GDP Growth: The Government of Tanzania is aiming at transforming its economy into a middle-income level by 2025. Currently, most of the people are in rural areas engaged in subsistence agriculture and levels of poverty are still high in the rural areas and relatively high in urban areas. However, Gross Domestic Product (GDP) growth rate has been impressive in the recent past. According to the Economic Survey report (URT, 2013), the real GDP grew by 6.9 % in 2012 compared with 6.4 % in 2011. This growth was associated with improved transport and communication infrastructure, improved industrial production, following improved power supply as well as the use of alternative power sources in industrial production. Also, good weather helped to produce more from the agriculture sector. Recent estimates shows, GDP declined from 7.6 % in 2014 to about 6.8% in the early 2015.

Figure 2: GDP trends 2010 to 2015.

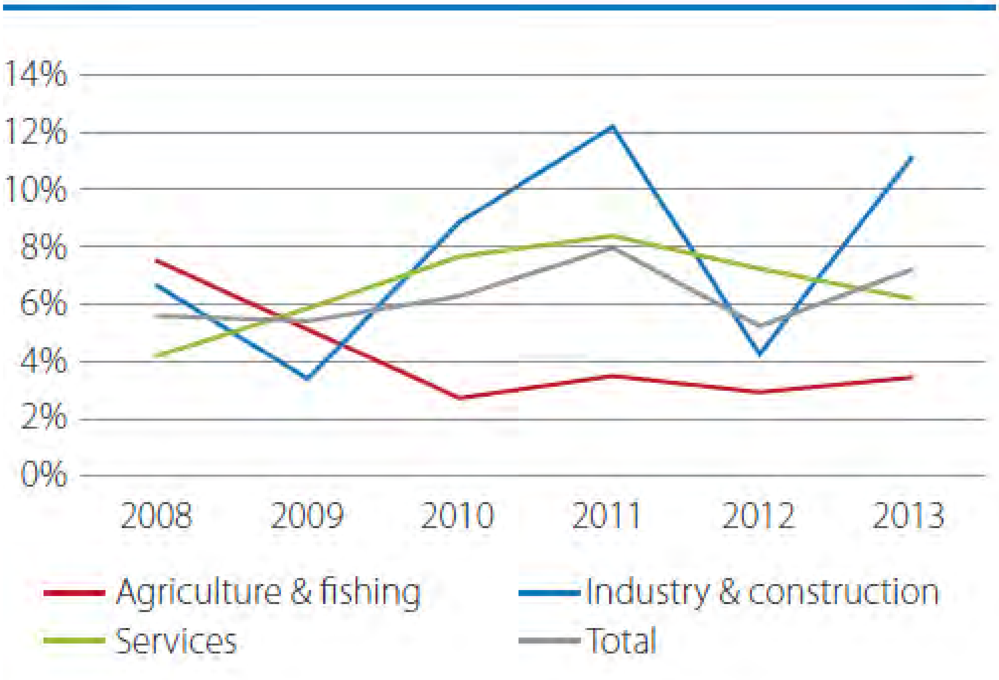
Source: National Bureau of Statistics 2016

Industries: Based on the 2012 Economic Survey report, industry and construction activities grew by 7.8% in 2012 compared with 6.9% in 2011. This growth was attributed to improved performance in all sub-economic activities except construction. However, the share of industry and construction economic activities to GDP increased to 22.1 % in 2012 from 21.9% in 2011 (URT, 2013).

The growth of manufacturing sub-activity was 8.2% compared with 7.8% in 2011. This was a result of increased industrial production, particularly food, cement, beverages and iron following improved power supply. The share of this sub-activity to GDP was 8.4% in 2012, the same as in 2011 (ibid).

Mining sub-activity grew by 7.8% in 2012 compared with 2.2% in 2011. This growth was a result of increase in gold and diamond production, improved construction industry (quarrying and mining) (ibid).

Figure 3: Sector Real Growth rate in Tanzania



Source National Bureau of Statistics 2014

Development Plan and Initiatives: The Five Year Development Plan (2011/12-2015/16) which is aimed implementing Tanzania Vision 2015 have generated five crucial element aimed at enhancing economic growth momentum; among of them are (i) large investments in energy and transport infrastructures (ii) Strategic investments to expand the cotton textile industries; high values crops; cultivation under *Southern Agricultural Growth Corridor of Tanzania* (SAGCOT) (iii) institutional reforms for an effective implementation, monitoring and evaluation of the plan.

The SAGCOT initiated in 2010 is an agricultural partnership designed to improve agricultural productivity, food security and livelihoods in Tanzania. SAGCOT has the potential to make a huge impact by bringing together government, private sector, development partners and the farming community to pool resources and work together towards improved and increased agriculture. By addressing the entire agricultural value chain, the SAGCOT approach will go beyond raising agricultural productivity and ensure the necessary infrastructure, policy environment and access to knowledge to create an efficient, well-functioning agricultural value chain.

Another Tanzania Government's effort to transition the country’s economy is the Big Result Now (BRN); The BRN initiative is a comprehensive system of implementation focusing on six priority areas of the economy i.e.: **i) Energy and natural gas; (ii) Agriculture; (iii) Water; (iv) Education; (v) Transport; and (vi) Mobilization of resources.** The BRN initiative aims at adopting new methods of working under specified timeframe for delivery of proposed targets.

Thus the current economic growth and several initiatives laid down by the government are expected to result into increased development. Reliable and affordable energy supply is a key to achieving the intended changes.

1.5 Energy Development in Tanzania

The vast majority of Tanzanians still depend on biomass for their energy supply and use. Efforts to develop reliable and affordable energy supply have constituted the main focus of the Government of Tanzania since independence. Various sources of energy have been developed and are continuing to be developed to enable the country overcome its energy deficiency and improve economic and social wellbeing of the people. The traditional sources have been fossil fuel, and hydro generation until in the early 2000, when gas from Songo Songo Island was included in the national grid for provision of electricity in Tanzania.

The Tanzania grid generation capacity mix by 2014 comprised of hydro, Oil, Natural Gas and Biomass with a total installed capacity of 6,033.98 GWh out of which 2,613.60 GWh, equivalent to 43.3% of total grid generation capacity were hydro, 785.52 GWh equivalent to 13.0% were Oil, 2,625.81 equivalent to 43.5% were natural gas and 9.05 GWh equivalent to 0.2% are Biomass which are mainly from TANWATT and TPC.

The number of Tanzanians connected to electricity increased from about 10 % in 2005 to 24 % in 2014. Similarly, access level has increased to 36% by March 2014 and is projected to reach 75% at household level by 2035. The installed capacity has to-date increased by 78% from 891 MW in 2005 (URT, 2012).

The GDP for Tanzanians is projected to grow from an average US$ 640 in 2015/15 to US$ 3,000 in 2025. In order to achieve this middle-income growth level, generation and distribution of sustainable and affordable energy must be guaranteed. The government has in 2014/15 initiated several energy development projects aimed at increasing energy supply in Tanzania. These include 7 projects for energy generation; 7 projects for transmission and 14 projects for distribution. The main objective of energy development in Tanzania is to boost power generation capacity from 1,583 MW in April 2014 to 10,000 MW by 2025, with subsequent expansion of transmission and distribution infrastructure. In addition, the government is revising the Energy Policy of 1992 to align it with the current and future energy needs and development in the country (URT, 2012).

1.5.1 Energy generation, distribution and transmission and status in the current PSMP

1.5.1.1 Power transmission in the current PSMP

TANESCO owns transmission and distribution lines of different voltage capacities all over the country (see Figure 3 below). The transmission system is comprised of 2,732 km of 220 kV, 1,538 km of 132kV and 546 km of 66kV.TANESCO imports power from Uganda via 132kV and from Zambia through 66 and 33kV lines. Currently, it noted that portions of line, the Iringa – Dodoma – Singida 220kV line, the Chalinze – Hale – Arusha 132kV line and Ubungo – Kunduchi – Ras Kilomoni 132kV line and 132kV marine cable from Ras Kilomoni (Mainland) to Ras Fumba (Zanzibar) had exceeded their thermal limits therefore they could not transfer all the respective demanded power (URT, 2012).

This situation has resulted in the introduction of the 400kV Iringa – Shinyanga backbone project, the 400kV Dar es Salaam – Tanga – Arusha and the reinforcement of 132kV line to Ras Kilomoni and 132kV marine cable to Zanzibar projects (URT, 2012). The proposed increase in power generation in Mbeya, Iringa and Dar es Salaam regions has necessitated the reinforcement of the 220kV lines to these areas so that power can be evacuated to the load centers. To this effect, 400kV lines from Dar es Salaam – Morogoro – Dodoma, Dar es Salaam – Chalinze – Tanga – Arusha and Iringa – Makambako – Mbeya are planned for construction (URT, 2012).

Several issues pertinent to transmission are considered in the current PSMP. These include development of new interconnectors, drivers of grid development, costs and technologies etc. (URT, 2012). In addition to technical issues considered in the transmission line, the more pertinent and complex social and environmental issues also have been considered. These include land acquisition for the transmission lines, towers and substations leading to resettlement of affected persons, issues related to loss of biodiversity due to clearance for the lines, impact on bird life and movements are some of the key issues addressed in this revised PSMP.

1.5.1.2 Renewable Energy Sources in the current PSMP

Two main renewable sources – namely hydropower and geothermal have been considered in the Power System Master Plan. The main hydropower includes the existing ones as stated above as well several variable candidate hydro that include Malagarasi Stage III (2024), Mpanga (2032), Iringa –Nginayo (2027), Iringa-Ibasa (2026), Mnyera- Ruaha (2026). Mnyera- Pumbwe (2030). Others are Mnyera- Kwanini (2030), Mnyera- Kisigo (2029), Mnyera- Taveta (2031), Songwe-Manolo (2028), Songwe – Softe (2035), Lower Kihansi (2031), Upper Kihansi (2033), Kakono (2028), Masigira (2032, Ruhudji (2033), Rumkali (2033), Kikonge 2(2034) and Stieglers Gorge (2036). Other renewable sources, although not the main focus of the PSMP for now include:

- Mufindi - Biomass - 30 MW -expected to be ready by 2015
- Sao Hill - Biomass – 30 MW – expected to be ready by 2015
- Solar 1 60 MW - expected to be ready by 2016
- Solar 11 60 MW – expected to be ready by 2017
- Wind 1 50 MW – expected to be ready by 2016

- Wind 11 50 MW – expected to be ready by 2017

However, it is important to note the complexity in planning and developing biomass integrated timber industry to generate energy. Electricity is not the core business of such industries and therefore, for these industries to generate more electricity; they would require massive investments to be able to generate enough by-products without affecting the environment (URT, 2012).

The Singida Wind projects are likely to generate 50 MW each when they start.

The other renewable source that is considered in the PSMP 2012 is geothermal energy. Currently, there are about 50 geothermal potential sites in the country, with an estimated geothermal potential of more than 650MW. The three most promising sites for geothermal energy include:

a) Lake Natron in Arusha region
b) Lake Ngozi, Songwe River basin in Mbeya Region
c) Luhoi Spring site, with potential of 50 – 100MW located in Lower Rufiji Valley, Utete District.

To start with, Tanzania will focus at the Lake Ngozi site for the development of geothermal which is planned to start supply 100 MW by 2025 and to grow to 200MW by 2026. Given the importance of using Tanzanian resources, the government has established Tanzania Geothermal Corporation and invited several private sector companies to invest in exploration and generation of geothermal energy. Currently, Tanzania's geothermal potential is estimated to be about 650 MW.

1.5.1.3 Power transmission in the current PSMP

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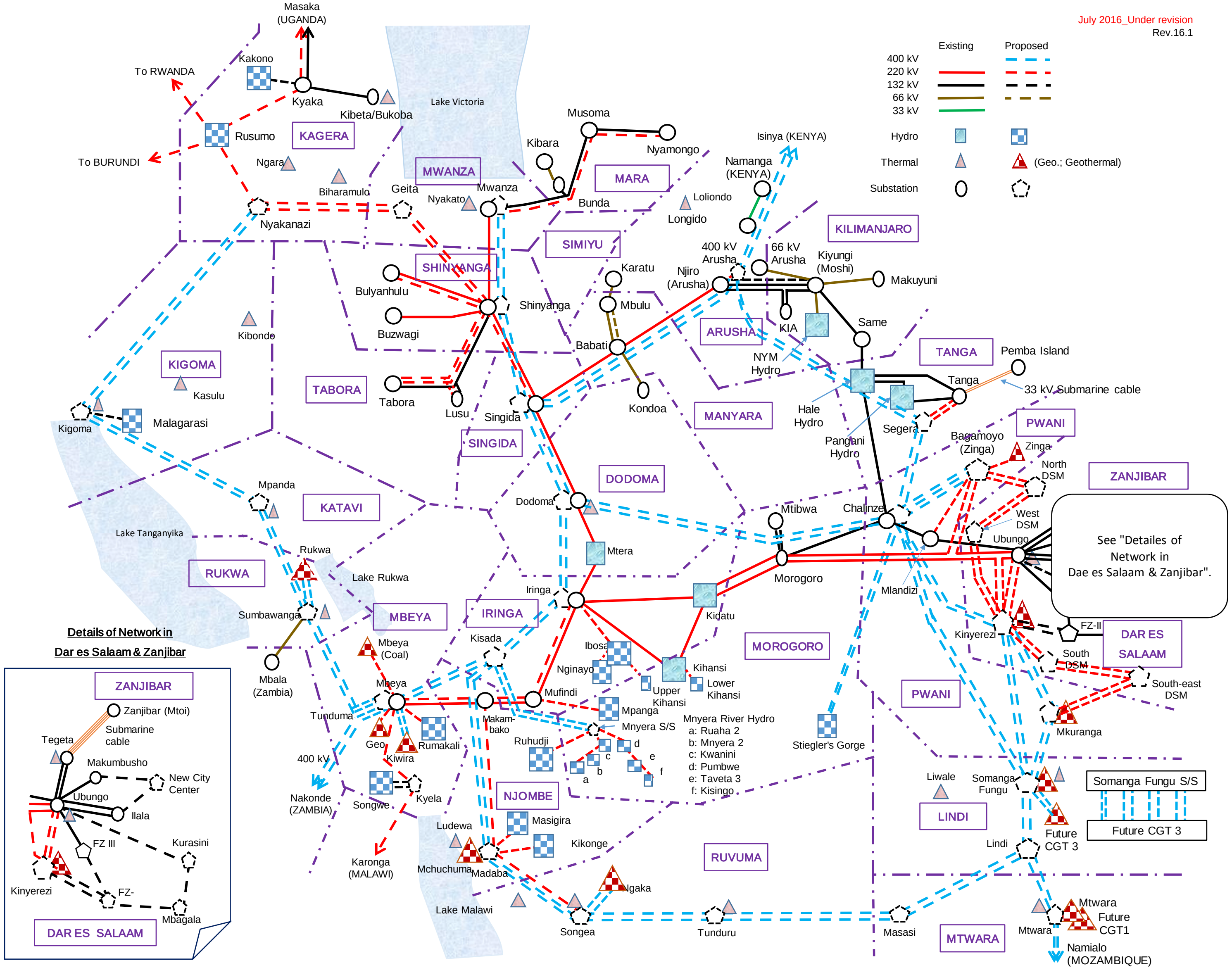

Map 14: Proposed Transmission Line Development Plan Based on Scenario 2 (as of July 2016)

1.5.1.4 Power Distribution Networks

The distribution system network voltages are 33kV and 11kV, which serve as the distribution backbone stepped-down by distribution transformers to 400/230 volts for residential, light commercial and light industrial supplies. Heavy industries are supplied at 11 kV and 33 kV. Until December 2012, there were more than 1,037,859 customers linked by these distribution lines. in which 335,322 are in Domestic Low Usage Tariff (D1), 700,048 are in General usage Tariff (T1), 2,096 are in Low voltage Maximum Demand (MD) usage tariff (T2), 391 are in High Voltage Maximum Demand (MD) usage tariff (T3), 1 as the Bulk sales to Zanzibar (T5), 1 as the Bulk Sales to Kahama Mining (T8) (URT, 2012). The total length of the 33kV lines is 12,602 km, 11kV lines are 6,392 km and 400/230 Volts lines are 26,565 km. Total number of transformers in the distribution system is more than 12,000. All of these facilities are critically in poor condition. However, distribution networks (including 33 and 11kV, LV lines and distribution substations) in Dares Salaam, Kilimanjaro and Arusha are being rehabilitated. (URT, 2012)

In other regions, rehabilitation initiatives are also playing a great role in minimizing the distribution system losses and new network extensions are also being carried out where it is appropriate. In other 7 regions the same activities are being carried out under the MCC project. On the other hand, though with its limited resources, TANESCO under its routine activity programs carries out planned and unplanned maintenance works on the distribution system (URT, 2012).

1.6 The Power System Master Plan – Salient Features

The Power System Master Plan (PSMP) of 2012 (URT, 2012) reflects and accommodates recent development in the economy, including development in the gas sub-sector as well as government policy guidelines. The policy guidelines include, among others the desire by the government to accelerate economic growth through the Vision 2025, MKUKUTA and the Five Year Development Plan (FYDP). The FYDP targets to improve key infrastructure networks, including power infrastructures to attain low cost energy service that will allow more inflow of foreign direct investment (FDIs) to Tanzania (URT, 2012).

The FYDP aims to increase per capita electricity consumption from 81kWh in 2011/12 to 200kWh by 2015/16 through increased generation capacity alongside accelerated electrification program. Electrification level is also planned to increase from the current 18.4 percent to 30 percent by 2015/16. This implies connecting 250,000 new customers per annum for five years from 2013 to 2017 (URT. 2012).

The overall objective of the PSMP were to re-assess short-term (2013 – 2017), mid-term

(2018 - 2023) and long term (2024 - 2035) generation, transmission plans requirements and the need to fuel the economy to a middle-income level by 2015 as well connecting presently off-grid regions. Others are looking at options for power exchanges with Ethiopia (through Kenya), Zambia, Uganda, Rwanda, Burundi and Mozambique so as to increase the supply of reliable power (URT, 2012).

The Power System Master Plan (PSMP- 2012) was first developed and approved in 2008 to provide a fundamentally new plan to guide the development of the power system in Tanzania for the next 25 years. The Plan provided a detailed assessment of load demand projections, available options for meeting the demand and requirements for a new higher voltage backbone transmission system for the country (URT, 2012). The Plan was updated in 2009 by reviewing the progress and challenges encountered during the first year of implementation. The Plan was again revised and covered the following main components:

a) Revision of load forecast based on the current situation and updated expectations;
b) Re-assessment of the short-term, mid-term and long-term generation plans;
c) Updating the transmission plan to reflect the update in plans for connecting presently isolated regions and increased generation capacities; and
d) Economic and financial analysis

Tanzania has maintained a mixture of energy resources, but the plan now is to maintain a 40% to 60% ratio for hydro and thermal respectively. Under the thermal component, the plan is to have 30% of energy from gas and the rest from coal and other sources. Drought, low rains and availability of abundant gas, coal and geothermal potentials have resulted in the tilt towards more thermal power.

Key issues highlighted in the PSMP 2012 which form the main thrust of the Plan include generation including development costs, consideration on renewable energy; interconnector; transmission expansion and distribution plans, economic and financial analysis and key recommendations.

1.7 Projected energy demand as proposed in the revised PSMP, 2012

Tanzania is planning to attain middle-income levels by 2025. In order to achieve this goal, generation, transmission and distribution of affordable and sustainable energy is crucial. Despite the endowment of enormous resources for power generation (e.g., gas, coal, wind, hydro, solar, biomass, uranium as well as importation), some challenges exists including mobilization of adequate financial resources to implement the proposed power projects and inadequate requisite human resources skills and knowledge for developing the existing power resources.

For example, most generation resources are located in the southwestern part of the country while huge loads are located in the northwest of the country, implying the need for long distance transmission lines and huge costs.

The 2012 PSMP has considered development of alternative expansion generation plans covering five scenarios based on consideration of various options including cases of load forecast in which the scheduling of projects in each plan (high, base and low cases) takes into account a reserve margin on firm capacity in the order of 15percent - 20 percent, hydro – thermal mix of 40:60 percent and export/import of not more than 25 percent of total available capacity (URT, 2012). The purpose of these reserve margins is to allow sufficient generation capability to meet local demand and the possibility for power trading with the neighboring countries during average hydro supply.

The Base Case Plan" was considered as the preferred plan for 2012 PSMP update study as it does not commit over-investment and meets national development goals and policy targets such as

FYDP-I requires power generation of 2780 MW by 2015/16 and LTPP requires more than 6700 MW by 2025 (URT, 2012).

The Preferred Base Case Plan has a deficit of about 508 MW in the Short-term, which is less than 50% of the deficit in the High Case Plan. The Base Case Plan has a total of installed capacity of 8960MW by 2035 consisting of 3304 MW hydro, 995MW gas-fired generation, 3800MW-Coal, 100MW-Solar, 120MW-Wind, 40MW- Biomass/Cogen, and some export limited to 250MW of total available generation throughout the planning horizon (URT, 2012).

In view of the above, Tanzania will need a total of 3,400MW in the medium term (2013-2017) and 8,990MW by 2035. Meeting these demands will require financing of about USD 11.4 billion during the medium term period. Another UDS 27.7 billion will be needed to cover the period to 2035. When inflation and interest during construction are added, total investment required rises to US$ 40.9 billion dollars in the long run. Of this amount, about two third of it is for generation (URT, 2012).

Several energy development projects such as the Mtwara gas pipeline, Kinyerezi 1- IV with a combined total of 990 MW, Mtwara 600 MW, Rusumo 80 MW; thermal power at Kiwira (200 MW; Mchuchuma 600 MW and Ngaka 400 MW; Arusha – Singida, 400 KV and Iringa – Dodoma- Singida –Shinyanga (400KV) and several others are earmarked and some are implemented. The critical challenge however is availability of financial resources to implement all the planned projects that were included in the 2012 PSMP. Details of the proposed scenarios are presented on Chapter Six of this report.

1.8 Environmental Issues in the PSMP 2012.

Environmental and social issues in the current 2012 PSMP are considered on the basis of two components namely

i. Project environmental and social analysis: The system planning function that provided the mechanism to include environmental and social mitigation costs in the cost estimates for candidate new power option, as these are a real project costs. Additionally, this task provided an assessment of the acceptability of new generation options on a project-by project basis.

ii. Cumulative environmental and social analysis: This provided for an assessment of

Potential impacts on a cumulative basis, referenced to a generation plan, and thus combination of projects. Several environmental and social criteria were used to inform the selection of the options. These criteria included in Table 2.

Table 2: Environmental and Socio-Economic Criteria Considered in PSMP-2012

Criteria	**Indicator**
Socio-economic impacts	
Impacts Due to Population Displacement	Number of persons affected by project infrastructure and ancillary facilities (People/GWh)
Promotion of Rural Electrification	Number of rural persons living in a 10 km radius of the power station and in a 10 km wide corridor along the transmission line between the option and the main transmission grid (People/GWh)
Socio-economic Impacts on the Downstream Reaches	Number of persons living in a 1 km corridor along the river stretch with altered flow downstream of the dam (People/GWh)
Land Issues	Area required for project infrastructure, including reservoir and transmission facilities (ha/GWh)
Environmental impacts	
Impact on Resource Depletion	Energy payback ratio: ratio of energy produced during the normal life span of the option divided by the energy required to build, maintain and fuel the generation equipment. This indicator is a measure of

Criteria	**Indicator**
	the global pressure of an option on the Environment
Impacts of Greenhouse Gas Emissions	Net CO2 equivalent emissions over the life cycle of the project (t/GWh)
Impacts of Air Pollutant Emissions on Biophysical Environment	SO2 equivalent emissions over the life cycle of the project (t/GWh)
Land requirements	Area required for project infrastructure, including reservoir and transmission facilities (ha/GWh)
Waste management	Land area required for ash disposal (ha/GWh)
Environmental Impacts on the Downstream Reaches	Length of river with altered flow downstream of the dam (km/GWh)

Source: Adapted from PSMP-2012

Although these are robust criteria, it is not known how they were used to inform the selection of the options. More critically, the PSMP-2012 lacked an environmental and social monitoring plan; therefore, it is difficult to know the implication of the selected options on the environment and social criteria due to the absence of plan based monitoring system

2. SEA for updating the PSMP-2012

2.1 Objectives of an SEA

Strategic Environmental Assessment (SEA) is designed to assist strategic decision-making, with the purpose to improving the quality of policies, plans and programmes and to contribute towards sustainable development. In the case of the Power System master Plan (PSMP) the SEA plays a pivotal role in ensuring that energy sector planning becomes effective in integrating economic, social and environmental aspects. In fact, linking energy sector planning with SEA is an attempt to introduce sustainability considerations into decision-making.

Overall, development depends on the environment. The relationship and linkages that exist between people, natural resources and the economy are all part of the environment. It is also important to note that the goals of economic and social development must be defined in terms of sustainability issue. The latter occurs through integration of biophysical, economic and social objectives.

The strategic nature of SEA is a function of how it is applied (i.e. the process of SEA), its timing, outcomes and its interaction with the decision-making process. The characteristics of SEA that define its strategic nature include the following:

- The strategic component is the set of principles and objectives that shape the vision and development interaction incorporated in the plan or program. SEA is a process or means which leads to a strategy for action;
- SEA defines a vision of the desirable future. Once a vision is articulated, goals and objectives are defined and alternative means of achieving objectives are evaluated. The goals, objectives and alternatives are the desired future;
- The preferred option is the strategic choice or strategic decision; EIAs are applied once strategic decisions have already been made.

2.2 Objectives of this SEA

This SEA and as in many others elsewhere as noted by Partidário (2012), has three very concrete objectives:

a) Encourage environmental and sustainability integration (including biophysical, social, institutional and economic aspects), setting enabling conditions to nest future development proposals;

b) Add-value to decision-making, discussing opportunities and risks of development options and turning problems into opportunities;

c) Change minds and create a strategic culture in decision-making, promoting institutional cooperation and dialogues, avoiding conflicts.

Therefore, the key objective of this SEA is to mainstream sustainability issues in the Power System Mater Plan of Tanzania. The sustainability criteria for this SEA includes the following:

- Optimize the use of non-renewable resources
- Use renewable resources within limits of capacity for regeneration
- Environmentally sound use and management of hazardous/polluting materials and waste.
- Conserve and enhance the status of wildlife, habitats (including reduced deforestation) and landscape changes
- 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 3: SEA Objectives and 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 a result of the updated PSMP implementation	- Estimated emission levels from power stations and mining areas for gases and particulate matter (Carbon Dioxide, Sulphur Dioxide, various oxides of Nitrogen)
Climatic factor (emission)	- Minimize contribution to climate change by emission of greenhouse gases with appropriate energy mix compare	- 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
Natural resource uses	- Minimize use of non-renewable resources - Use renewable resources within limits for capacity for regeneration	- Status of water catchment areas and environmental flows - Rate of deforestation by 2040 based on the 2015 levels
Solid and liquid waste generation	- Environmentally-sound use and management of hazardous/polluting materials and wastes	- Amount of recycling and reuse of waste e.g. from coal as proportion of coal used

2.3 Defining the level /tier at which the SEA will take place

Timing is an important characteristic of SEA, which makes it strategic. SEA is applied at the higher level of planning i.e. policy, strategy, programme and plan level. It provides sufficient, reliable and usable information for development planning and decision-making. Also, SEA concentrates on key issues of sustainable development and is cost-and time-effective. The preferred option is the strategic choice or strategic decision; EIAs are applied once strategic decisions have already been made.

This SEA for the PSMP takes place at the level of the sector planning that will influence changes in the power systems for Tanzania. It a decision taken at the level of the Ministry but will have several tiers involved, including water, natural resources, land, finance, infrastructure, and several other sectors and almost every citizen of this country that will be touched by the decisions on power systems. Energy is the engine of the economy and therefore any decision in terms of type of energy, sources of energy and technologies will have implications on other sectors and the people within and beyond the border of Tanzania.

2.4 The SEA boundaries

Scope of Development items

The SEA will concentrate on major energy sources (gas, coal and hydro power), with less emphasis on sources such as solar and wind. Currently, the gas sources in Mtwara will receive highest preference. Hydo-power sources are concentrating in the southern, western part of Tanzania as described above main coal sources are Mchuchuma, Ngaka and Kiwira also in the southern part of the country.

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 scope for the PSMP as indicated on Table 4 below however, field visit were conducted in Morogoro, Mtwara and Ruvuma for hydropower, gas and coal respectively.

Table 4: 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
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

Temporal scope

The temporal scope refers to the duration of the PSMP as well as to the existence of impacts of issues associated with the various power generation procedures. The revised PSMP, which has triggered this SEA, is expected to last for the next 25 years from 2015 to 2040. Therefore some of the impacts may last that long others only a shorter period whiles others may last for much longer period beyond the plan period.

3. Legal, Institutional and Administrative Framework for this SEA

The Environmental Management Act of 2004 and its regulation of 2008 govern the Strategic Environmental Assessment (SEA) in Tanzania. However the proposed Power System Master Plan (PSMP) will have implications to several national policies, laws and international policies that relates to energy and development. The updating PSMP falls under several administrative regimes that include TANESCO and the Ministry of Energy and Minerals as the focal point for energy development in Tanzania. However, several other ministries and institutions have direct and indirect links with the plan. These include the Ministry of Lands, Housing and Human Settlement Development, Ministry of Agriculture and Food Security, Ministry of Water and Irrigation, and the Prime Minister's Office Regional Administration and Local Government. Some of the policies, laws and administrative regimes that are relevant to this plan are discussed below.

3.1 Policy framework

(i) The National Health Policy, 2007

The National Health Policy defines health as a state of wellness physically, mentally, socially and he absence of diseases. Further, it notes "good health contributes to personal development, the development of the family and the country; especially in ensuring improved livelihoods and poverty reduction" (URT, 2007). In view of this, the Policy aims to achieve sustainable welfare for the society.

The first National Health Policy was passed in 1990. Although a lot has been implemented based on that policy, tremendous political and social changes overtook the relevancy of that policy necessitating a review and promulgation of the new National Health Policy in 2007.

The main goal of the National Health Policy of 2007 is to provide geographically balanced and in acceptable standards, affordable and sustainable health services in general. The general objective of the 2007 Health Policy is to uplift the health status of the citizens, especially the vulnerable groups by putting in place health infrastructure that meets community expectations and increase life expectancy of Tanzanians. To achieve this general objective and to realize the policy goal, the National Health Policy has identified nine specific objectives including these two that are directly related to the proposed PSMP.

(a) To reduce the occurrence and spread of diseases and deaths among the citizens so as to raise life expectancy
(b) To prevent and control infectious and non-infectious diseases especially HIV/AIDS, malaria, tuberculosis, malnutrition and work place diseases.

Also, the Policy is promoting environmental cleanness in residential areas, work places, improved worker's health and safety and promotion of nutritional programmes and to prevent accidents. The Policy is also addressing crosscutting issues such as disaster management, HIV/AIDS, gender focus, poverty reduction, human rights and environmental protection. Thus the provisions of this Policy are critical for the success of the PSMP in as far as the health of communities and workers in many areas where the PSMP will trigger change that will have direct and indirect implications on the health condition of the people or the environment.

(ii) The National Environmental Policy, 1997

The main objective of the Policy is to provide the framework for making fundamental changes that are needed to bring environmental considerations into the mainstream of decision-making in Tanzania. It also seeks to provide policy guidelines, plans and gives guidance to the determination of priority actions and provides for monitoring and regular review of policies, plans and programmes. It further provides for sectoral and cross-sectoral policy analysis in order to achieve compatibility among sectors and interest groups and exploit synergies among them.

The overall objectives of the Policy are to:-

(a) Ensure sustainability, security and equitable use of resources for meeting the basic needs of the present and future generations without degrading the environment or risking health or safety;
(b) Prevent and control degradation of land, water, vegetation and air which constitute our life support systems;
(c) Conserve and enhance our natural and man-made heritage including the biological diversity of the unique ecosystems of Tanzania;

(d) Improve the condition and productivity of degraded areas including rural and urban settlements in order that all Tanzanians may live in safe, healthful, productive and aesthetically pleasing surroundings;

(e) Raise public awareness and understanding of the essential linkages between environment and development and to promote individual and community participation in environmental action; and

(f) Promote international co-operation on the environment agenda and expand the country participation and contribution to relevant bilateral, sub-regional, regional, and global organizations and programs including implementation of Treaties.

Therefore by carrying out this SEA, the proposed plan comply with the national environmental Policy as the main objectives of the proposed PSMP is to ensure improved energy generation and supply while bringing environmental consideration in the decision making.

(iii) National Land Policy, 1997

The overall aim of the National Land Policy (URT, 1997) is to address the various ever-changing land use needs and to promote or ensure a secure land tenure system; to encourage the optimal use of land resources and; to facilitate broad-based social and economic development without endangering the ecological balance of the environment (Ibid: 5). Several specific objectives are outlined in the Policy; however, the following are directly related to the proposed PSMP:

- Ensure that existing rights in land especially customary rights of small holders (i.e. peasants and herdsmen who are the majority of the population in the country) are recognized, clarified, and secured in law
- Ensure that land is put to its most productive use to promote rapid social and economic development of the country
- Protect land resources from degradation for sustainable development

The PSMP will identify several initiatives in order to improve power generation distribution and supply, which may require land, and therefore this policy will be relevant to the proposed to the PSMP.

(iv) The National Energy Policy, 2015

The main objective of the National Energy Policy of 2015 is to provide directives for sustainable development and utilization of energy resources to ensure optimal benefits to Tanzanians and contribute towards transformation of the national economy. Tanzania is poised to becoming an industrial – middle income country by 2015 and therefore, provision of affordable, sustainable and reliable energy is key to the success of the development goal of becoming industrialized.

The main scope for the Energy Policy of 2015 includes the following:

(a) To promote petroleum and gas upstream, midstream and downstream activities
(b) To promote renewable energy and energy conservation (non -hydro renewables include solar, wind, biomass and geothermal)
(c) To address cross cutting issues such as matters of subsidies, institutional, legal, regulatory as well as monitoring and evaluation.

Matters related to the environment are discussed under the cross cutting theme of the policy, which focuses on (i) Transparency and accountability (b) Regional and International Cooperation (c) Safety, Occupational Health and Environment, and (d) Gender issues and HIV/AIDS in the Energy Sector – with attention to mainstreaming gender and addressing HIV/AIDS in the Energy Sector. In this context, the Policy is advocating the application of tools such as Environmental and Social Impact Assessment (ESIA) for energy projects and Strategic Environmental Assessment (SEA) for higher-level decision-making points. Also, the Policy is promoting establishment of disaster prevention and response plans and the use of practices such as Polluter- Pays- Principle. Therefore, in order to meet the Policy objectives, the Government shall undertake the following measure:

a) Enforce environmental, health and safety standards and laws governing the Energy Sector
b) Ensure that contractors in the energy sector establish a decommissioning fund for environmental restoration where appropriate,
c) Strengthen institutional capacity in monitoring and enforcement of laws and regulations on safety, occupational health and environmental management.

The proposed updating of Power System Master Plan must take into account the provisions of this Policy in ensuring that the final Plan promotes the supply of energy in the most environmentally and socially acceptable ways.

(v) Sustainable Industrial Development Policy (SIDP), 1996

Sustainable Industrial Development Policy-SIDP (1996- 2020) (URT, 1996) is a framework for Tanzania's industrialization process within the short, medium and long-term perspective. The main objectives of the SIDP include human development and creation of employment opportunities; economic transformation for achieving sustainable economic growth; external balance of payments and; environmental sustainability and equitable development (URT, 1996: 3).

The Policy outlines several strategies for achieving the mission and objectives of industrialization and a range of activities that are to be implemented within short, medium and long-term priority activities. During the long-term period (2010-2022), this policy will focus on basic goods industries. The proposed updating PSMP will support the objectives of this policy especially covering long-term goals that also tie well with the planned attainment of a middle income level.

(vi) Water Policy, 2002

The main objective of the National Water Policy of 2002 is to develop a comprehensive framework for sustainable development and management of the Nation's water resources and putting in place an effective legal and institutional framework for its implementation (URT, 2002). The Policy recognizes the fundamental but intricate linkages between water and socio-economic development, including environmental requirements. The proposed updating of national Power System Master Plan with its focus on hydropower and coal and gas will put additional demand on water scarce resource and further compound the water availability issues. The proposed PSMP will examine the current water demand in relation to available resources, other users and address the implications of water demand arising from the establishment of power systems that will require more water.

(vii) The Tanzania Development Vision 2025

Composite Development Goal for the Tanzania Development Vision 2025 (URT, 2000) foresees the alleviation of poverty through improved socio-economic opportunities, good governance, transparency and improved public sector performance. These objectives, not only deal with economic issues, but also include social challenges such as education, health, the environment and increasing involvement of the people in working for their own development.

The Vision 2025 seeks to mobilize the people; the private sector and public resources towards achieving shared goals and achieve sustainable semi-industrialized middle market economy by year 2025. The proposed updating of Power System Master Plan is aimed at increasing supply of electricity that enable more development to take place and increase employment opportunities and contribute to improving the wellbeing of the Tanzanians.

(viii) The National Strategy for Growth and Reduction of Poverty (NSGRP II), 2010

The Cabinet and Parliament adopted the first National Strategy for Growth and Reduction of Poverty (NSGRP), in early February 2005. In 2010 it was reviewed and the current second version, is to be implemented between 2010/11 and 2014/15. The NSGRP II makes linkages with Vision 2025 and is committed to the Millennium Development Goals (MDGs) as internationally agreed targets for reducing poverty. The NSGRP II aims to reduce poverty through three broad outcomes: growth and reduction of income poverty; improved quality of life and social well being; and good governance and accountability.

The proposed plan is responding to the NSGRP II by investing in power generation and supply, which will contribute to fuelling the local and national economy. The availability of reliable and affordable power not just to the industrial areas but also to local people as well as other sector will be explored in the PSMP as part of the compliance to the NSGRP II.

3.2 Legal framework

(i) The Environmental Management Act, 2004

The Environmental Management Act (EMA) was passed in 2004 as the main legislative reference for environmental management in Tanzania, which establishes the environmental standards and provides for the requirement of Strategic Environment Assessment of Bills, regulations, policies, strategies, programs or plans

EMA (2004) seeks to provide for legal and institutional framework for sustainable management of environment; to outline principles for management, prevention and control of pollution, waste management, environmental quality standards, public participation, compliance and enforcement, to provide for implementation of the National Environment Policy, to provide for establishment of the National Environment Trust Fund and to provide for other related matters.

Section 15(a) in Part III of EMA (2004) states that in matters pertaining to the environment, the Director of Environment shall coordinate various environment management activities being undertaken by other agencies to promote the integration of environment considerations into development policies, plans, programs, strategies, projects and undertake strategic environmental risk assessments with a view to ensuring the proper management and rational utilization of environmental resources on a sustainable basis for the improvement of the quality of human life in Tanzania.

Section 104, subsection 2 Part VII states that Without prejudice to subsection (1), when promulgating regulations, Public Policies, programs and development plans shall include a Strategic Environmental Assessment statement on the likely effects of such regulations, public policies, programs or development plans may have on the environment.

Section 105 sub-section (1) emphasizes on undertaking SEA for the identified mineral or petroleum resource 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 shall carry out a Strategic Environmental Assessment (SEA). This SEA is in response to these provisions.

(ii) The Strategic Environmental Assessment Regulation, 2008

Part II Section 4 of the Strategic Environmental Assessment Regulation, 2008, made under Section 230 (2) (r) underlines key objectives of undertaking SEA under the Act which are to:

(a) Ensure that environmental concerns are thoroughly taken in draft Bills, regulations, plans, strategies or programs.
(b) Enable the public to contribute to the consideration of environmental concerns in the preparation of Bills, regulations, plans, strategies or programs.
(c) Establish clear, transparent and effective procedures for formulation of Bills, regulations, plans, strategies or programs and

(d) Integrate environmental concerns into measures and instruments designed to further sustainable development.

Thus Public and stakeholders involvement are a legal requirement in Tanzania’s SEA regulations as stipulated in part II Section 4(b) of the regulation. 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.

The SEA Regulations of 2008, especially Regulation 9 (1-4) further states with regard to consultations as follows:

(1) In these Regulations, the consultation bodies shall be-

(a) Sector Ministries;
(b) Government agencies and departments; and
(c) Local government authorities.

(2) During the process of conducting a strategic environmental assessment, the sector ministry may in consultation with the Director of Environment, seek views of any person or the general public.

(3) The Director of Environment shall be responsible for coordination of consultation in relation to the strategic environmental assessment.

(4) Sector Environmental Coordinator shall ensure that strategic environment assessment of Bills, regulations, policies, strategies, programs or plans as provided for under these regulations and the Act is carried out in the respective sector Ministry and all parastatal organizations under its respective jurisdiction. Emphasis is placed on early and adequate stakeholder involvement.

(iii) The Electricity Act, 2008

The Electricity Act (URT, 2008) provides for the facilitation and regulation of generation, transmission, transformation, distribution, supply and use of electric energy to provide for cross-border trade in electricity and the planning and regulation of rural electrification and related matters (URT, 2008:5).

The Act provides for requirements to obtain licenses for (a) generation (b) transmission (c) distribution (d) supply, (e) physical and financial trade in electricity and electrical installations (URT, 2008:11). Any person intending to conduct any of the activities stipulated in subsection 1 of Section 8 of this Act must apply for a license to Energy and Water Utilization Regulatory Authority.

In Section 6 sub-section (1) among other things, the Act gave power to the relevant ministry and authorities;

- Promote access to, and affordability of, electricity services particularly in rural areas
- Promote lease cost investment and the security of supply for the benefit of the customers
- Promote improvements in the operational and economic efficiency of the electricity supply industry and efficiency in the use of electricity
- Promote appropriate standards of quality, reliable and affordability of electricity supply
- Take into account the effect of the activities of the electricity supply industry on the environment

The proposed PSMP is relevant to the electricity Act as it promote improved power generation and supply.

(iv) The Land Act, 1999

The Land Act provides for the basic law in relation to land other than the village land, the management of land, settlement of disputes and related matters. The Land Act relates to land-use planning processes and land-use management and guidance to land ownership in Tanzania.

The Land Act vest all land in the President as a trustee and vest him with powers to grant rights of occupancy to individuals, legal persons and communities. The President is empowered to revoke the “Right of Occupancy” of any landholder for the “public or national interest” should the need arises. The President holds land in trust for all citizens and can acquire land for public use and benefit, for instance, to resettle people from densely populated areas to sparsely populated areas, settle refugees and so forth. The President can also acquire land for other national interests, like energy infrastructure.

However, the Land Act declares the value attached to any piece of land and as such any land rights transfer is subject to compensation. Under the *Government Standing Order on Expropriation for Public Utility*, the holder of a right of occupancy is guaranteed a free enjoyment of the land and is entitled to compensation if dispossessed by the Government for public use. In many cases, whilst the holders agree to leave their land, they are not happy with the amount and delay of the compensation. Often, for example, improvements that they have made to the land are omitted or underrated. The expropriation should match the price that improvements can fetch if sold in the open market.

Replacement value (defined as the cost of putting up a structure equivalent to the evaluated one) makes allowance for age, state of repair and economic obsolescence.

The Land Act is relevant to the updating PSMP and development of Dar es Salaam Power System Master Plan will involve identification of different type of energy sources where among of these may require land and therefore the provisions of this Act will be taken into account.

(v) The Village Land Act, 1999

The Village Land Act was enacted specifically for the administration and management of land in villages. Under the provisions of this Act, the village council is responsible for the management of the village land and is empowered to do so in accordance with the principles of a trustee managing property on behalf of a beneficiary. In addition, the Village Council is required to manage land by upholding the principles of sustainable development, relationship between land uses, other natural resources and the environment.

The Village Land Act is relevant since the expected project development resulted from updated PSMP shall be established within village lands, which will have to be acquired.

(vi) The National Land Use Planning Commission Act, 2007

The National Land Use Planning Commission Act, No. 8 2007; creates the National Land Use Planning Commission (NLUPC) whose most significant functions are to prepare regional physical land use plans, to specify standards, norms and criteria for protection of beneficial uses and maintenance of the quality of land. As an advisory organ, the NLUPC is also to recommend measures to ensure that government policies, including those for the development and conservation of land, take adequate account of their effects on land use (Section 4 (d)), stimulate public and private participation in programs and activities related to land use planning for the national beneficial use of land (Section 4 (e)) and seek advancement of scientific knowledge of changes in land use and encourage the development of technology to prevent or minimize adverse effects that endanger man's health or welfare. Section 2 of the Act defines a "beneficial use" as "a use of land that is conducive to public benefit, welfare, safety or health."

The proposed updating of PSMP is likely to trigger appropriation of land; therefore it will be important to carry out land use plans to determine how the remaining lands can be effectively and sustainability utilized.

(vii) The Water Resources Management Act, 2009

The Water Resources Management Act, 2009 (URT, 2009) provides a framework for the management and utilization of water, taking into account domestic, social, industrial and environmental needs. The Act provides principles and objectives of Water Resources Management, which includes among others (a) meeting the basic human needs of present and future generation (b) promoting equitable access to water (c) promoting the efficient, sustainable and beneficial use of water in the public interest (e) protecting biodiversity, especially the aquatic ecosystem (f) providing a system for the management of the resources and implementation of international obligations.

The Act directs the need to apply and pay all required fees for water utilization permits. It also directs the adoption of integrated water resource management approaches and the application of principles such as (a) precautionary principle (b) polluter pays principle (c) the principle of ecosystem integrity, to mention some. The proposed PSMP will identify different strategies for improvement of power system in the country including use of water and therefore, the provisions of this Act will be taken into account in order to safeguard this scarce resource.

(viii) Energy and Water Utilities Regulatory Authority Act, (2001)

The Energy and Water Utilities Regulatory Authority (EWURA) (Act No 11 of 2001) establishes a Regulatory Authority in relation to energy and water utilities and outlines its functions. EWURA is an autonomous multi-sectoral regulatory authority and is responsible for technical and economic regulation of the electricity, petroleum, natural gas and water sectors in Tanzania pursuant to Cap 414 and sector legislation.

The functions of EWURA include among others, licensing, tariff review, monitoring performance and standards with regards to quality, safety, health and environment. EWURA is also responsible for promoting effective competition and economic efficiency, protecting the interests of consumers and promoting the availability of regulated services to all consumers including low income, rural and disadvantaged consumers in the regulated sectors.

In carrying out its functions, EWURA strive to enhance the welfare of Tanzania society by:

- Promoting effective competition and economic efficiency;
- Protecting the interests of consumers;
- Protecting the financial viability of efficient suppliers;
- Promoting the availability of regulated services to all consumers including low income, rural and disadvantaged consumers;
- Taking into account the need to protect and preserve the environment;
- Enhancing public knowledge, awareness and understanding of the regulated sectors

The proposed PSMP is relevant to this Act as it promote improved and affordable power generation distribution and supply while taking into account the need to protect and preserve the environment.

(ix) The Petroleum (Exploration and Production) Act No. 27 of 1980

The Petroleum Exploration and Production Act regulate petroleum exploration and production activity. Section 48 of the Act provides that a registered holder of a license cannot exercise any of his rights in respect to among others, the following areas without the written consent of the Minister:

- Any land dedicated or set for any public purpose (other than mining)
- Any burial place
- Any land which is the site of or is within 100 meters of any building, reservoir, or dam owned by the Government
- Any land on which there is a defense installation, or on land, which is within 100 meters of the boundaries thereof
- Any reserved area; or any protected monument.

This Act also requires the holder to obtain the written consent of the lawful occupier before exercising his rights on the land and to pay al the necessary fees as well as approved compensations to affected persons.

(x) The Standards Act, 2009

This is the Act that provide for the promotion of the standardization of specifications of commodities and services, to re-establish the Tanzania Bureau of Standards and to provide better provisions for the function, management and control of the Bureau, to repeal the Standard Act, Cap 130 and to provide for other related matters.

The Bureau is re-established to be the custodian and an overseer of observance of standards in Tanzania. Among its many functions the Bureau is to (a) undertake measures fir quality control of commodities, services and environment of all descriptions and to promote standardization in industry and trade (b) to assist industries in setting up and enforcing quality assurance and environmental management systems procedures, (c) to prepare, frame or amend National Standards.

Also, in Part 2 Section 4 (3) the Act note, “notwithstanding the existence of any standard, the standards declared by the Minister shall prevail over other existing standards.” This means, industry and services in Tanzania are obliged to use national standards. These include:

(a) TZS 825:2012 (Air quality-Specification),
(b) TZS 860:2006 (Municipal and industrial wastewaters – General tolerance limits for municipal and industrial wastewaters),
(c) TZS 932:2007 (Acoustics – General tolerance limits for environmental noise),
(d) TZS 972:2007 (Soil quality – Limits for soil contaminants in habitat and agriculture).

There are also other standards and regulations that are relevant to this PSMP and which should be taken into account when selected projects are implemented. These are prepared as part of the Regulations for the Environmental Management Act, 2004, which include the following:

(a) Air Quality Standards Regulations (2007)
(b) Noise and Vibrations Standards Regulations (2009)
(c) Water Quality Standards Regulations (2007)
(d) The Soil Quality Standards Regulations (2007
(xi) National Environmental Standards Compendium (NESC), 2009

The National Environmental Standards Compendium (NESC) (URT, 2009) is a collection of various standards prepared at different times. The NESC consists of three parts. Part One comprises standards that require compulsory compliance, which includes standards for industries with peculiar effect on the environment. Part Two consists of standards that may be implemented on a voluntary basis. These include guidelines, codes of practice that can be enforced voluntarily by way of self-regulation.

Part Three provides the requisite test methods that should be followed when testing for compliance. Although these are national standards, the NESC states that the standards “are to be reviewed independently to reflect sector specific needs as regulated by the National Environment Management Council”. Most of the compulsory standards in the NESC are relevant to the proposed revision of the PSMP. These include:

(a) EMDC 2 (1778). Air Quality – Vehicular Exhaust Emissions Limits;
(b) EMDC (1777). Protection against ionizing radiation – Limits for Occupational Exposure; and
(c) EMDC 6 (1733) P2. Acoustics- General Tolerance Limits for Environmental Noise.

The PSMP will have to comply with these standards as well as several others as part of the broader compliance with EMA (2004).

3.2.1 International Conventions and Standards

Tanzania has signed and ratified a number of international conventions and treaties that commit the country to conservation and protection of biological and environmental resources. The revised PSMP will need to take into account relevant aspects of those conventions into the specific project designs and management. Some of the conventions that are relevant to the PSMP process include the following:

- ***United Nations Framework Convention on Climate Change – UNFCCC, 1992*** is an international environmental treaty negotiated at the Earth Summit in Rio de Janeiro in 1992, then entered into force on 21 March 1994. So far it has 196 signatories. The UNFCCC is regarded as the first step to a safer future because its ultimate objective is “stabilization of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference within the climate systems” The Convention states that such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that the food production is not threatened, and to enable economic development to proceed in a sustainable manner[1]. Although UNFCCC puts the onus on developing countries to lead on the way of cutting down in GHG emissions it also directs new funding to climate change activities in developing countries especially in adaptation measures. UNFCCC recognizes that economic development is vital to the world’s less developed countries and notes that as these countries struggle to develop, their share of GHG emission will grow. UNFCCC thus is works with these countries through a variety of arrangements to put in place policies and programmes that will limit emissions in ways that will not hinder their economic progress including adoption of Clean Development Mechanisms as part of the Kyoto Protocol (UNO, 1992).

  Parties to the Convention have been meeting regularly since 1992 to discuss various issues related to measures to take to reduce GHG emissions from 30 November to 132 December 2015, about 196 countries met in Paris and adopted the Paris Agreement

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[1] UNFCCC, www.unfcc.int/essential_background/convention/items/6036.php

that is aimed at limiting global warming to less than two degrees Celsius and pursue efforts to limit the raise to 1.5 degrees Celsius.

Tanzania has been attending all these meetings is a signatory to the Kyoto Protocol and was in Rio de Janeiro as well. Tanzania has signed up to many of the UNFCCC directives and is implementing a National Climate Change Strategy. Tanzania has also submitted Intended Nationally Determined Contributions (INDC) on GHG emissions. In view of this as well as the Paris Agreements that Tanzania has also ratified, the planned power development options in the revised PSMP will have to take into account those commitments and GHG emission might be future constrain in implementing PSMP in a long term perspective, especially with regard to combinations that push for more coal as source of energy.

- The ***UNESCO Convention for the Protection of the World Cultural and Natural Heritage, (World Heritage Convention) 1972*** aims at encouraging the identification, protection, and preservation of earth's cultural and natural heritage. It recognizes that the nature and culture are complementary and that cultural identity is strongly related to the natural environment in which it develops.

  The Convention provides for the protection of those cultural and natural 'properties' deemed to be of the greatest value to humanity. In the course of implementing this Project, cultural and heritage objects may be discovered. Recommendations will be made according to the Tanzanian legislation and policies and international best practices on how to handle these objects at the project level.

- The ***Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1979*** seeks to control the trade in species of wild animals and plants that are, or may be, threatened with extinction as a result of international trade. The PSMP will trigger the implementation of various projects; therefore project sponsors must ensure that such trade is not happening in the project site.

- The ***African Convention on the Conservation of Nature and Natural Resources, 1968*** requires contracting states to adopt measures necessary to ensure conservation, utilization and development of soil, water, flora and fauna resources in accordance with scientific principles and with due regard to the best interests of the people.

Protected species should be accorded special protection, including the maintenance of habitats necessary for their survival. The PSMP implementation will result in affecting several areas on generation site as transmission lines. Such sites may be the habitat for some important species. Detailed assessment of the status and characteristics of flora and fauna in each site should be be part of the ESIA process for each project.

- ***International Convention on Biological Diversity***. Tanzania is a signatory to the Convention on Biological Diversity (CBD) since June 1992 and has taken steps to ensure conservation and use of these resources in judicious ways. Biological resources in Tanzania are facing a significant threat from unsustainable utilization, including increased poaching of wildlife. It is important to ensure the basic tenets if this Convention are adhered to in all stages of the specific project development.

- ***International standards on emissions:*** While Tanzania has established various standards to safeguard the environment, in areas such standards are not available or are considered less stringent enough to meet international quality standards, other sources of standards such as from World Bank, International Finance Corporation and JICA will have to be used to protect the environment. This is likely to be the case in areas such as emissions and discharges from coal and gas processes.

3.3 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 Minerals (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 which fully functional, however, there is need to develop its capacity in terms of human resources, finances and equipment so that it can discharge its functions properly.

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.

4. Selection of Regions and Sites for this SEA

Priority sources or energy under this PSMP concentrate in the Southern and south western part of Tanzania specifically in Morogoro, Ruvuma, Mbeya, Njombe and Mtwara regions. Therefore, the selection of Regions and sites to be visited were based on major sources of energy as priorities in the PSMP revisions.

The main objective for the field visit was to observe environmental and social issues associated with the energy type in the regions and consultation with stakeholders such as government officials at local level, operating institutions on site and other relevant stakeholders. Three sites were visited. These include the Kidatu Hydro Power Station in Morogoro Region, Mnazi Bay Gas Project in Mtwara Region and Ngaka Coal Project (thermal energy) in Ruvuma Region.

4.1 Brief Background of the Regions

4.1.1 Morogoro Region

Morogoro Region is located in mid south-eastern part of Tanzania between latitude $5^0$58" and $10^0$0" south of the Equator and longitudes $35^0$25" and $35^0$30" east of Greenwich. The region has a total area of 72 939 sq. kms. (http://www.tzonline.org/pdf/Morogoro.pdf)

Morogoro Region is bordered to the north by the Tanga Region, to the east by the Pwani and Lindi Regions, to the south by the Ruvuma Region and to the west by the Iringa and Dodoma Regions. Administratively the region has seven districts - Morogoro Urban, Morogoro Rural, Kilosa, Kilombero, Mvomero, Ulanga and Gairo.

Morogoro Region is characterized by extensive flat agricultural productive land of Ifakara-Kilombero; followed by mountainous area of Uluguru and about 50% of the region’s land is in the protect areas of Mikumi and Udzungwa National Parks as well as the Selous Game Resourves. Morogoro is also home to two major hydrodams – Kidatu and Kihansi.

4.1.2 Mtwara Region

Mtwara Region is located in southern Tanzania bordered by Ruvuma Region to the west, Lindi Region to the North and the Ruvuma River to the South making a natural boarder with Mozambique. The Region has a total area of 16,720 km^2. Administratively the region has six districts of Mtwara Urban, Mtwara Rural, Masasi, Nanyumbu, Newala and Tandahimba. Most of the gas development is likely to happen in this region as well as Lindi.

4.1.3 Ruvuma Region

Ruvuma Region lies between latitudes 9^0 35' to 11^0 45' South of the Equator and between longitudes 34^0 35' and 38^0 10' East of Greenwich. It borders with the Republic of Mozambique to the South and shares Lake Nyasa with the Malawi Republic to the West. Mtwara Region is to the East. To the northeast is Lindi region and in the north the region borders with Morogoro and Njombe regions.

The Region has a total surface area of 67,372 sq. kms. Of this area the water area comprises of 3,582 sq. kms. The water area is dominated by some 2,979 sq. kms of Lake Nyasa. Hence, the 603 sq kms of water are scattered throughout the rest of the region. This leaves a land area of some 63,790 sq. kms

4.1.4 The Kidatu Hydro Power Plant

Kidatu Hydropower Plant was built in two phases under the Great Ruaha Power Project that was carried out in the 1970’s for phase one and 1980’s for phase two. Phase I was completed in 1975 and comprised of construction of an earth-rock fill dam, an initial capacity of 2 x 50MW, and 220kv transmission line to Dar es Salaam via Morogoro. Phase II was completed in 1980 and involved additional of 2 x 50MW, and the construction of a bigger storage dam at Mtera with a capacity of 3,200 Mill m^3.

The plant has undergone two major rehabilitation works involving various aspects such as computerizing the control and protection system, repair on turbines, replacement of runners on units 1and 2, generators and waterways.

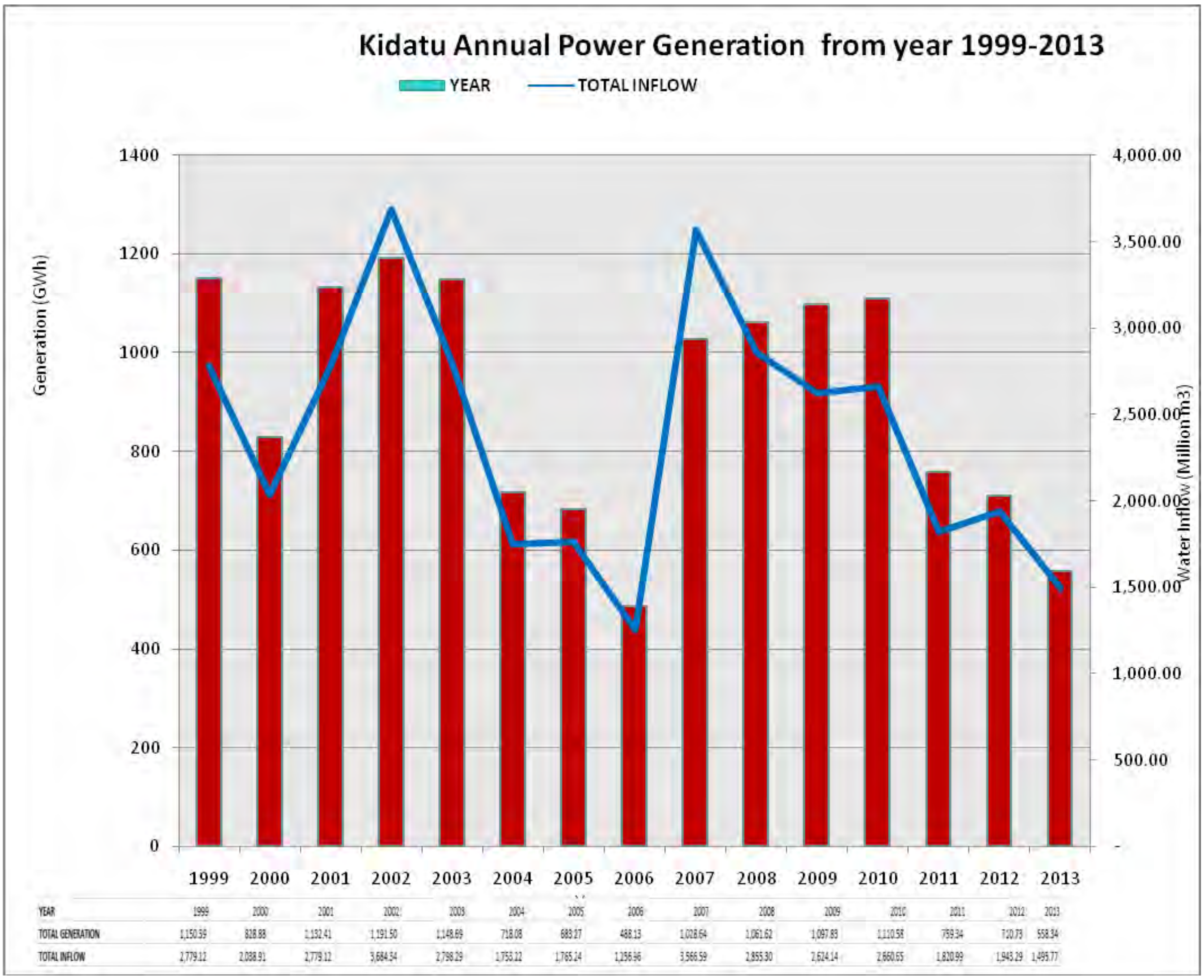
Kidatu Hydro Power Plant has a capacity to generate 204MW (4x51MW). Currently it is the biggest hydro power plant in Tanzania with average power generation of 700GWh during dry years and 1,000GWh during wet years. The power plant contributes about 36% of the total hydro installed capacity. The main water sources to Kidatu Dam are Mtera Reservoir, Lukosi River and Iyovi River

Future plans

Phase II rehabilitation project could not cover all necessary repairs of plant and equipment therefore it is planned to have Phase III rehabilitation project to cover the following:

- Modification of the 220kV system because the substation is the major link of interconnections e.g. Kihansi, Mtera and new power stations to be built in a near future.
- Repair and refurbishment of auxiliary equipment.
- Generator No.2 realignment of up-bracket.

Figure 4: Power Generation at Kidatu Power Plant



YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOTAL GENERATION	1,150.39	828.88	1,132.41	1,191.50	1,148.69	718.08	683.27	488.13	1,028.64	1,061.62	1,097.83	1,110.58	759.34	710.73	558.34
TOTAL INFLOW	2,779.12	2,038.91	2,779.12	3,684.34	2,798.29	1,753.12	1,765.24	1,256.96	3,566.59	2,855.30	2,624.14	2,660.65	1,820.99	1,943.29	1,495.77

Figure 4 show trends in generation from 1999 to 2013 with years when generation went down due to among others, technical as well water availability issues

Figure 5: 2013 Power Generation Trends

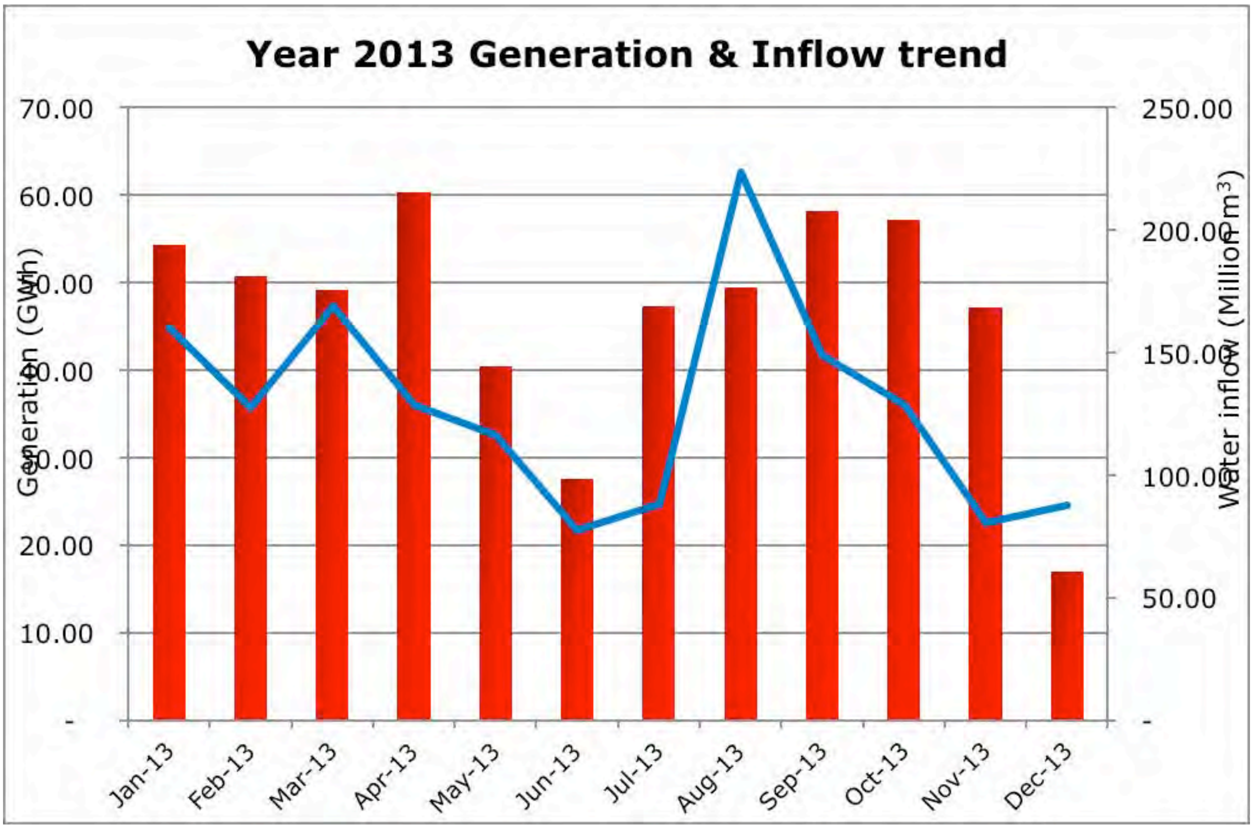


Figure 5 show annual flows into Kidatu Hydropower dam and generation levels. It is noted that generation was declining slowly from January to lowest levels in June and picked up gradually to highest peak in October when it started to go down again. This is an indication of the fluctuations in availability of water for power generation and major issue to consider for future plans.

Issues of concern for Kidatu

Despite being the biggest hydro plant in Tanzania Kidatu hydro power plant is facing the following challenges

- Inadequate water for power generation
- Climate change effect pertaining to shortage of rain
- Increased catchment degradation upstream of the reservoirs Environment degradation
- Increased water usage in basins
- Technical problems including recurrent breakdown of machines

4.1.5 Mtwara – Mnazi Bay Gas

In 2003 Artumas Group Inc (AGI), entered into an Agreement of Intent with the Ministry of Energy and Minerals of the United Republic of Tanzania ("MEM") and the Tanzania Petroleum Development Corporation ("TPDC") on (i) Hydrocarbon Exploration and Development in Mnazi Bay and (ii) Power Development (Generation, Distribution and Transmission) in the Mtwara-Lindi region (collectively the "Project") (AGI 2006). The gas exploration and development was carried out in phases

Phase 1 of the gas development program, involving the re-entry, testing and completion of an existing natural gas well in the Mnazi Bay natural gas concession and the acquisition of seismic data were conducted in 2005. Phase 2 of the Mnazi Bay gas program was completed in 2006 by drilling 2 new development wells.

In 2006 the company completed the installation of gas production facilities at Msimbati Peninsula, the construction of a 28 kilometre pipeline linking Msimbati Peninsula to Mtwara town, gas receiving facilities, and a 12 megawatt power generation facility[2].

First electricity was generated at the Mtwara power plant on December 23, 2006 and full commissioning of the integrated gas-to-power project – the Mtwara Energy Project was achieved on March 5, 2007. As a result, the Mtwara town and soon the centres of Lindi and Masasi and neighbouring villages had to secure, reliable, affordable power supply.

Description of the Current Facilities at Mnazi Bay

Current production facilities at Mnazi Bay consist of four producing wells (MB-1, MB-2, MB-3& MS-1X), gas processing plant and a 28 km pipeline, which conveys the gas from Mnazi Bay Gas Processing Plant to Mtwara Power Plant, which demands around 2MMSCF/day of gas. Development of these facilities was done in phases, whereby MB-1 well was drilled by AGIP in 1982, which was re-entered by Artumas, the previous operator in 2005 after signing the Production Sharing Agreement (PSA) with the Government in 2004. MB-2 was drilled in 2006, MB-3 and MS-1X drilled in 2007: This power plant supplies electricity to the southern coastal regions of Tanzania including the regional headquarters of Mtwara, Lindi and Masasi towns In 2009, M&P and Cove Energy was farmed and become

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[2] Artumas Group Inc Annual Report 2006, http://www.wentworthresources.com/pdf/reports/2006_Annual_Report.pdf

the operator of the facility on December 2009. In 2012, M&P started new exploration works, Ziwani-1 well drilled and acquisition of 250 km² offshore seismic. Later in 2012 M&P started Mnazi Bay redevelopment, work covering MB-2, MB-3 and MS-1X wells.

Each of the producing well has the following characteristics;

- MB-1 is located 800 meters off shore to the gas processing facility on the Msimbati peninsula. The MB-1 well is capable of producing 20 MMSCFD. This well is currently closed.
- MB-2 appraisal well extends the Mnazi Bay field structure up dip from MB-1. The two wells (MB1 & MB2) are capable of a combined production of 50 MMSCFD with the present tubing configuration.
- MB-3 exploration and appraisal well is located approximately 1.5 km east of MB-2 and drilled to further extend the up dip structure of the Lower Miocene and Oligocene sandstone formations of the Mnazi Bay field and to test a Lower Oligocene structure.
- MB-3 is the only well currently serving the power plant in Mtwara town. Exploration well Msimbati-1X (MS-1X) is located approximately 5 km east of MB-1. There is an existing gas processing plant designed to produce 10 MMSCFD, however it is currently processing 1 MMSCFD of gas, which is used for power plant at Mtwara.

Currently there is a major gas infrastructure upgrade, which comprises; construction of gas pipeline from Mnazi Bay Gas Production Facility to Madimba Central Processing Facility, gas gathering network and Mnazi Bay Gas Production Facility. The pipeline will be a 16” steel pipeline of a length of 11.8km, starting at Mnazi Bay Gas Production Facility to Madimba Central Processing Facility. This second pipeline will run parallel to the existing pipeline, which conveys the gas to Mtwara Power Plant. The central gas processing plant at Madimba intended to supply gas to the major pipeline linking to Dar es Salaam.

Challenges of the Mnazi Bay Project

- Instability of the seashore; increased trends of wave erosion toward the plant
- Increased generation of hydrocarbons (impurities of the gas) to the surrounding areas

- Degradation of marine environment including loss of mangroves

4.1.6 Ruvuma – Ngaka Coal Project

Ngaka coalfield is located in Ruhuhu Basin, Mbinga District in Ruvuma Region, Southwest of Tanzania. It is 40km from Lake Nyasa.

The Ngaka coal project involves opening up a surface open cast mine of 2.0 mil tons per annum and setting up a 400 MW Thermal Power Station to be connected to the National Grid at Mufindi (300km). The Ngaka coalfield comprise of Mbalawala sub-basin, Ngaka central basin and Mbuyura basin. Studies done at Mbalawala have established coal reserve of about 251 million tons. Drilling explorations in other coalfields in Ngaka are in process to establish quantity and quality of the coal.

Tancoal Energy Limited ("Tancoal") which is a Joint Venture between the National Development Corporation (NDC -30%) and Pacific Corporation East Africa (PCEA) – 70%, a subsidiary company of Atomic Resources of Australia is implementing the project. Tancoal intends to establish a coalmine with different capacity in phases starting with 150,000 tons per annum (t/a) in 2011 up to 5 million tons per annum in phase III. Further, it is intended to establish power station to generate 400MW but starting with 100MW in 2014.

The status of Ngaka Coal Project

Coal mining commenced at Ngaka in August 2011, with initial mining conducted by a simple, low cost "truck and shovel" operation, and selling up to 250,000 tonnes per annum (Mtpa) of unwashed coal to Tanzania's domestic customers. As the mining rate increases, Tancoal aimed at ramping up coal production to meet the requirements for the Power Station by 2014. In addition to supplying coal for domestic customers and the Power Station, the Ngaka Coal Project will produce between 2-3Mtpa of coal for export. At an estimated maximum production rate of 4-5Mtpa, the Ngaka Coal Project has sufficient proven coal resources for over 50 years of profitable, low-cost production.

At the moment no power is being generated from Ngaka, but mining of small quantities of coal is taking place and transported to a site about 40 km form the mine area for further on loading into trucks and to markets in Mbeya, Tanga and Kenya. Trucks ferrying coal to those destinations are on the road every day.

Figure 6: Coal Mining at Ngaka

Challenges

- Very High level of GHG emissions (Carbon Dioxide and Methane)
- Management of fly ash and coal slurry at the loading bay, that is now seen on water bodies causing pollution of the water
- Management of aquatic and biodiversity resources due to significant heated waste water discharge into natural drainage systems
- Potential trans boundary impacts on water quality/quantity and biodiversity on Lake Nyasa (polluted and heated waste water released)
- Cumulative effect of coal plants (Ngaka and Mchuchuma) and other related mining and production industries (Liganga steelworks) on Lake Nyasa resource

5. Approaches and Methodology for this SEA

5.1 Overview of methodology and approaches

This SEA was based on extensive stakeholder consultations, literature review as well as field visits to selected sites.

Stakeholder consultation is an inclusive and culturally appropriate process for sharing information and knowledge that seeks to understand the concerns of stakeholders, and to provide them with an opportunity to express their views. These views are then considered, responded to and incorporated into the decision making process.

5.2 Requirements for Stakeholder’s Consultation

5.2.1 JICA Requirements

JICA’s definition of SEA is simple and thus the actual implementation is flexible depending on the country and the plan concerned. The following procedure is indicated as the standard procedure under the New JICA Guidelines

a. Survey of basic conditions policies, regulations, geography, etc.
b. Formulate development scenario/alternative
c. Scoping and setting indicators for evaluation
d. Stakeholder meetings
e. Survey, prediction, analysis, evaluation of impacts
f. Mitigation measures
g. Selection of programs/ projects
h. Reporting (including stakeholder meetings if appropriate)

SEA under JICA also specifies the importance of stakeholder’s engagement and ensuring that stakeholders meetings are disclosed through meetings and any other possible mechanisms. In most scenarios, JICA adopts World Bank procedures as far as various environmental studies are concerned. Therefore this report will also adopt WB requirements as far as Stakeholders engagement is concerned.

5.2.2 World Bank Requirements

The World Bank has published several operational policies that include the following:

- O.P 4.01 Environmental Assessments
- O.P 4.10 Indigenous People
- O.P 4.12 Involuntary Resettlement

These operational policies require public consultation and participation to ensure that projects in which it invests are implemented in an environmental and socially responsible manner. As per these policies, the affected persons, host communities and NGOs, need to be meaningfully consulted on issues relating to land acquisition and displacement of persons as well as environmental issues. For Instance The World Bank Group's Environmental Assessment Policy (OP 4.01, January 2013) provides that stakeholders should be consulted about the project's potential environmental and social impacts during the Environmental Assessment (EA) process. The World Bank Group also specifies requirements for disclosure of documentation resulting from the process.

5.2.3 Tanzania Requirements

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.

The Strategic Environmental Regulations, 2008 PART IV section 12 (b) states the Sector Ministry preparing the SEA shall invite the Director of Environment, relevant Ministries and other key stakeholders to express opinion on the relevant documents within such period as the Sector Ministry may specify.

5.3 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. By classifying stakeholders it has been possible to develop a plan that is tailored to the needs of different stakeholder groups. Recognizing the strategic importance of the energy sector, a diverse range of stakeholders were identified that could be involved in the consultation process. Different issues are likely to concern different stakeholders and so different types of stakeholder were grouped based on their connections to the initiative (Table 5). 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 favourable environment for investment as well as to ensure that there is a harmonized relationship between investors and the Government as well as TANESCO.

5.4 List of Stakeholders

This listing of stakeholders should not be seen as definitive rather it should serve as checklists to enable include the main sectors who will be interested in the outcome of the SEA. Table 5 shows the list of identified stakeholders.

Table 5: List of Stakeholders

STAKEHOLDERS	ROLE/RESPONSIBILITY (IES)	ISSUES TO ADDRESS
Client Stakeholder's Group		
Ministry of Energy and Minerals	Policy and decision maker; Beneficiary (Revenue); Key	▪ Policy guidance
Vice President's Office – 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
JICA	Investment partners (donor); Key	▪ Systems design and combinations
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; Not Key	▪ Land losses; Energy Consumers
EWURA	Regulator; Beneficiary (revenue); Not 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

STAKEHOLDERS	ROLE/RESPONSIBILITY (IES)	ISSUES TO ADDRESS
		▪ 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; Beneficiary (revenue); Key.	▪ Availability of water ▪ 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

5.5 Stakeholder’s Engagement

One aspect to be addressed in the preparation of the SEA is the means of engaging stakeholders to improve the efficiency and effectiveness of their involvement. The specific techniques for achieving stakeholder participation included workshops, consultative meetings focused group discussions.

5.6 Methodologies for stakeholder’s participation

Appropriate stakeholders engagement methods were used for various groups of stakeholders and they are as follows:

- **Meetings-** this included 1) Individual meetings with key informants and stakeholders representatives. 2) Small Group meetings-Focus Group Discussions
- **Posts on Media**- This shall be done on local daily newspapers prior to the stakeholders workshop
- **Large Group meetings/Workshop** where all categories of stakeholders identified were invited to attend the meetings

5.7 Key Stakeholders Consulted during SEA process

Consultations that started during scoping continued during the extended phase of the SEA process leading to the preparation of the draft report. This included consultation with private companies that are investing in the energy sector, government parastatals such as TANESCO, local government authorities and companies that are producing/supplying energy to the National grid.

During the second phase from January-February 2015, further consultation was done with stakeholders that were not consulted mainly those at the sites and regions with energy producing clusters. Focused group meetings and interviews were held with stakeholders in these areas

Further consultation with central government authorities mainly government ministries and its agents were undertaken during stakeholders workshop; the purpose of the meetings were to update stakeholders on various major issues of concern that either required their immediate attention or need to be taken into consideration in the implementation of the Master Plan. Local level public meeting were held with in Mtwara and Ruvuma Regional Authorities in to mainly discuss issues related to

- Land acquisition
- Environmental Management and Water

In order to engage with the wider public at key intervals, the Ministry of Energy in collaboration with JICA will continue to use other various engagement mechanisms to keep stakeholders informed; such methods include Ministry Website and setting up a dedicated email address for the SEA process to enable stakeholders to mail their views

5.8 Consultation outcomes and issues noted

Stakeholders consulted had various opinion and concerned with regard to the PSMP; such opinions are determined either with stakeholders experience in implementing the PSMP, conflict of interest in implementation or and are beneficiaries of the Master Plan. Stakeholders raised several issues including the following:

a) Ministry of Energy and Minerals

The Ministry of Energy and Minerals is the main stakeholder of the PSMP with the mandate to oversee among others energy development in the country. The Ministry informed that different projects for power generation expansion indicated in the PSMP are at different stages of implementation. E.g. Kinyerezi 1, 150MW is expected to be commissioned by March 2015. The Iringa – Shinyanga (Backbone) and Makambako – Songea transmission lines contractors are at sites.

Some changes, which have occurred in the current PSMP, include the introduction of PPP framework in power generation, review of the National Energy Policy, 2003; implementation of Electricity Supply Industry (ESI), Reform Strategy and Roadmap; Natural Gas Policy, 2013.

With relation to power generation and technologies; the main target is to have different sources of power by promoting efficiency of utilization of natural resources and reduce dependency on hydropower. Renewable energy resources such as geothermal, solar and wind are highly encouraged. For short-term measures, the plan is to generate power from natural gas and renewable energy. For medium and long term plans, the focus will be on coal-to electricity as base load.

MEM opinion on institutional arrangement for generation, transmission and distribution through the implementation of ESI Reform Strategy and Roadmap, it is envisaged to have vertical separation of power generation from transmission and distribution in a gradual transformation. Similarly a MEM opinion on PPP in relation to energy development is that the framework is welcome in the interest of easing Government’s financial burden on key electricity generation projects. Greater focus should be on involvement of Private sector so as to break up project financing on shared interests.

b) Stakeholders at Ministry level

Various ministries were consulted as stakeholders as far as the energy sector are concerned; ministries emphasis was mainly on the importance of engagement and harmonization during preparation of master plans. For instance various ministries require water for their various programmes and most of this water is from similar sources as those that would be required to enhance the energy sector particularly hydropower projects. This will reduce conflicts among water users, inefficiency of various projects due to lack of sufficient water or even degradation of the water resources.

With increase in climate change, water is becoming scarce while demand is increasing; increase in hydro project will result in more water scarcity and cause conflicts with farmers and other users of water. Therefore, considering the scarcity of water in the country, other ministries suggest that the energy sector should prioritize other energy sources such as gas and coal and minimize dependency of hydro. In case of coal power generation, high technology should be used to reduce the impact of emissions to the environment.

Energy availability is also important in the development of other sectors such as agriculture and industries in general therefore it is important for the government to ensure availability of electricity and at an affordable price to boost the growth of other sectors as power fluctuation is dangerous for manufacturing industries. The government should subsidize power generalization activities, in order to reduce the price to consumers; consumers had a thought that with energy source being gas prices are likely to be more affordable.

Stakeholders have also noted that the current PSMP has underestimated power demand for manufacturing sector; there is a need to establish power demand considering this kind of aspect.

Consultation with the Ministry of Land insisted that it should be clear that foreign investors are not allowed to own land but they access land through local institutions such as TPDC, NDC, and TIC. For any project that involves land take, the MLHHSD will insist on full, fair and prompt compensation to affected persons to avoid conflicts.

For harmonization purpose, PSMP for the energy sector should be submitted to the Ministry of Lands for purpose of harmonization with other master plans from different sectors. Also there is a need for sector coordination such as TANESCO under MEM, TANROADS and Ministries should be upheld and by-laws should be established for the purpose of harmonization.

Stakeholders also pointed that currently, power demand for industrial development is high than TANESCO can supply considering that TANESCO has the monopoly of power supply and distribution, which has proved to be not effective in ensuring efficiency and quality services. To ensure sustainability in the energy sector, the government should encourage PPP; however, the government should take a leading role to ensure quality and manageable cost of power.

Consultation with the Ministry of Water indicated that MEM is one of key stakeholders for the water sector especially in abstraction, it ranks number two after the Ministry Agriculture and the current major problem is to balance water for human use and other users considering the growing demand of water from various sectors particularly agriculture and energy.

Other challenges is lack of coordination in conservation of water sources even from sectors with high water use as well as coordination prior to preparing master plans of various sectors that also includes lack of harmonization among various national policies. Most water users including the MEM are reluctant in paying royalty for water services despite the requirement. Currently the Ministry has adopted Integrated Water Resource Management and all stakeholders should be involved in conservation of water sources considering the high rate of degradation of water source in the country.

c) Stakeholders at Local Government Level

Stakeholders indicate that there is an increase in economic activities in the areas that include mining, gas, agriculture etc and therefore it is important for the Government to ensure sustainability of these opportunities. Currently Regions such as Ruvuma are not connected to the National Grid and therefore, development of Ngaka electricity project will benefit the region. To ensure these benefits at National and local level, the government should invest in energy infrastructures such as construction of transmission lines.

Other issues raised are related to environment, for instance, mining of coal is likely to be a major source of pollution to the rivers and the Lake Nyasa- such pollution is likely to affect other sectors such as agriculture and fisheries considering the cumulative impact of pollution on lake Nyasa from the various coal mining activities in the cluster and therefore recommend that environmental protection and social issues should be well handled considering the scale of the projects.

With regard to gas production; Regions consider gas as a reliable source as currently hydro power is not a reliable source due to pressure on water resources as well as fluctuation and availability of rain due to various reasons including climate change.

Considering that the government has opened up investments in the gas sector, there has been a massive increase in population and demand for other services in the receiving regions; this therefore requires the respective ministry to consider assisting such areas in ensuring sustainability economically, socially and from the environment. For instance the current location of treatment plant with its incinerators for wastes from Gas exploration is not proper because it is located close to settlement.

Companies investing in gas should continue ensuring that local communities benefit directly from the investments, have a significant contribution to the regions through cooperate social responsibility, fair and prompt compensation when land acquisition is involved and protect the environment.

d) TANESCO

TANESCO is the National power utility responsible for generation, transmission and supply and therefore one of the major stakeholders of the PSMP and therefore officials at TANESCO headquarters and regional offices were consulted. TANESCO indicated that currently hydropower electric power is more preferable as it is a renewable source and no air pollution or radioactive waste problems associated with it compared to fuel generated power.

Hydropower stations have an inherent ability for instantaneous starting, stopping, load variations etc and help in improving the reliability of power systems. The projects have a long useful life extending over 50 years and average cost of generation, operation and maintenance over lifetime is lower than any other sources of energy. Hydropower has a higher efficiency (over 90%) compared to thermal energy (up to 45%) and gas (up to 60%).

The practice in various parts of the world is that Power Master Plans are updated after every two years while Comprehensive Master Plan is after five years; therefore for Tanzania the current revision of the PSMP is inevitable due to increasing demand for power. Challenges for implementing the current PSMP include lack funds, delay in implementation of projects and associated components within the project such as paying compensation; price of electricity especially from independent power suppliers is too high for customers;

TANESCO therefore recommend the following:

- The government should invest on power system to reduce dependence on private suppliers;
- Funding for power projects should be provided on time to ensure timely implementation of programs;
- Ministry of Finance should provide government guarantee for TANESCO to access loans to implement power projects;
- The Government should encourage and strengthen Public and Private Partnership in Power generation;
- TANESCO and MEM to work on harmonization of PPP policies;
- Frequent review of PSMP in order to ensure smooth implementation of programs.
- Encourage Investment on renewable energy sources such as wind, solar and oceanic currents as hydropower is more preferable only if there will be sustainable conservation measures in water catchments.
- This should be followed by coal and gas that should remain as reserve until when is absolutely critical;

TANESCO also revealed that there is an increase in number of large investors showing interest in investing in large-scale industries due to assurance in power generation particularly with the current trend in gas investments.

Environmental and social challenges encountered by TANESCO in implementation of the PSMP include:

- Land acquisition for way leaves. Way leaves are associated with land use conflicts due to the fact that community agreed to contribute land for way leaves but at the end they changed.

- Inadequate water for power generation
- Lack of sector coordination
- Climate change effect pertaining to shortage of rain
- Increase in human activities upstream of our reservoirs
- Environment degradation
- Increase demand of water from other sectors

e) Government and Private Parastatals

Various Parastatals both government and private are stakeholders of the energy sector either as investors or implementers of PSMP. NDC as a leading Industrial development and promotion organization dealing with projects that have huge impact to the country as well as developing infrastructures to enable industrial growth such as electricity clarified that the current projection for energy in the country needs to be revised as there is suppressed demand for electricity in the country. The current figures cannot service heavy industries and the mining sector therefore most investors turn down their investment in the country due to inadequate power. It was therefore recommended that all relevant stakeholders should be involved in preparing the PSMP, for example, the National planning Office, Heavy Industries, Mining, Agriculture and manufacturers; and MEM should coordinate.

Stakeholders acknowledge that the PSMP is well documented but problem is funds for implementation; therefore donors, financial institutions should be involved during the planning phase. The Electricity Act provides for private investors in the sector BUT during negotiations it is a challenge; the revised PSMP should consider this process.

For sustainability it was recommended that there is a Need to consider coal as the base load for reliable power and gas and hydro can be intermediate and/or peak source, however technologies used for any generation associated with coal should be stipulated in the guidelines to ensure environmental friendly generation.

Southern Agricultural Growth Corridor of Tanzania (SAGCOT) has several investment and planned investment in different clusters from the coastal zone to southern highland on commercial agriculture with agro processing and energy generation projects. Several planned investment on commercial agriculture is being planned in areas where MEM/TANESCO are planning to put several hydro power plant. There is a need to look for alternative sources of power and move away from total dependence of hydropower as a source of power given the fact that water is becoming scarce due to increased population, climate change and other demand.

f) Private Investors-Energy Sector

Currently there are various investors in the country generating electricity and sales to TANESCO; the companies are aware of the PSMP and recommend power mix generation as crucial because of various risks associated with only depending heavily on hydropower generation. Investors in Mtwara revealed that consumption is still low compared to generation though this is expected to change with the current increase in large-scale investments in the region. Utilisation of gas as a source of energy has reduced pollution from fuel as well as running cost of fuel generators as currently large industries such as those manufacturing cement are utilizing gas as the major source of energy; investments in gas have also increased employment opportunities in the region-directly and indirectly, this is expected to increase.

Considering that most investments obtain financial resources from international financial institutions such as the World Bank; there is high consideration of the environment and safety issues with most plants following ISO standard for safety and health. Other environmental consideration include servicing of Machines re-fuelling carried out beyond 100 m from the water source in order to control pollution of water bodies from spills. Noise generators are well maintained or fitted with noise silencers such as mufflers to reduce noise.

g) Energy Consumers

Micronix system is the private company involved in collection and processing of cereals crops in Africa with branches in Tanzania. Currently the company depends on diesel generator supplied by TANESCO as the only source of power for the Newala and Tunduru plants which is relatively expensive compared to power from gas or any other source, therefore, running cost in Tunduru and Newala factories is very expensive compared to Mtwara. Other energy consumers particularly those in Mtwara acknowledge that power availability was worse before gas production; however, with the gas exploration and investments there has been an increase in availability as well as increase in business opportunities that has increased energy use and generation of government revenues.

Stakeholders from the mining sector revealed that the demand for power in the sector is high and more power is needed to meet this demand; the projected demand of power in the mining sector is estimated at 200-300MW per year. Not only the amount of power needed, but the issue is the quality of power needed to run the kind of machines and equipment that need constant un-interrupted flow of electricity to meet the required need throughout the production circle. The quality of power is poor forcing the Mining investors to look for alternative reliable standby sources of power. This decreases the bargaining power of the government to mining sector. Self-generation of power by investors which is being practiced by all investor in Tanzania is increasing the cost of production- in most cases mining companies enter into agreement with reliable companies to generator sufficient power to meet the demand.

Challenges are that TANESCO fail to extend the power grid to where mining are located- thus mining companies enter into agreement with TANESCO to develop the infrastructures and utilize power for years until they recover the investment cost.

5.9 Summary of stakeholders issues are:

- **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 harmonized.
- **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

scrutinized 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 as well as procedures.
- **Dismantle TANESCO to increase efficiency**-Currently TANESCO is responsible for generation, transmission and distribution
- **Inefficient energy supply particularly in mining sites**- Most areas with mining potentials are not connected to the National grid and therefore no investment
- **Cooperate social responsibility by sector investments**- This aims at ensuring direct benefits to the communities (District/ Region)
- Priority should be given to renewable sources

6. Consideration of Proposed Energy Scenarios

This SEA looked at a number of proposed energy generation scenarios to meet the projected and foreseen demand for power in short term, midterm and long term. The approach in generation is focusing on energy mix options where combination of various sources at various scale and time has been developed to form energy generation scenarios. These scenarios are examined in terms of power generated, environmental implications in terms of waste generated, pollution particularly greenhouse gases and transmission issues where the viable projects /scenario options are implemented. On these bases, five scenarios that have been considered are analysed in detailed in the following section.

6.1 Consideration for Renewable energy for PSMP

Several renewable energy options have been considered during the course of updating the PSMP-2012. While hydro was a natural choice, the inclusion of geothermal and wind power in the energy mix adds a new dimension in terms of renewable sources considering reliability of power supply and current progress of renewable energy development in Tanzania. However, it does not mean to prohibit adding other renewable energy as power supply source, but the PSMP is currently focusing on these three sources and especially geothermal and wind, as new entries in the mix pattern.

Geothermal power operates 24 hours a day, 7 days a week regardless of changing weather, providing a uniquely reliable and continuous source of clean energy. Geothermal is also capable of achieving high capacity factors, a measure of actual output over a period of time, usually at or above 90%, which is on par with, or higher than, other base-load power sources such as coal-fired or nuclear power plants, and much greater than intermittent sources. Geothermal power comprises mature renewable technology options that can provide stable base-load power from energy stored in trapped vapour and liquids

Other renewable energy sources such as wind and solar power could be complementary power supply sources since these power sources are unstable. Depending on unstable wind and weather conditions and adverse effects on the electric power system, they are causing much concern, if connected to the grid.

According to JICA PSMP team study, current progress and potential of renewable resources in Tanzania are as follow.

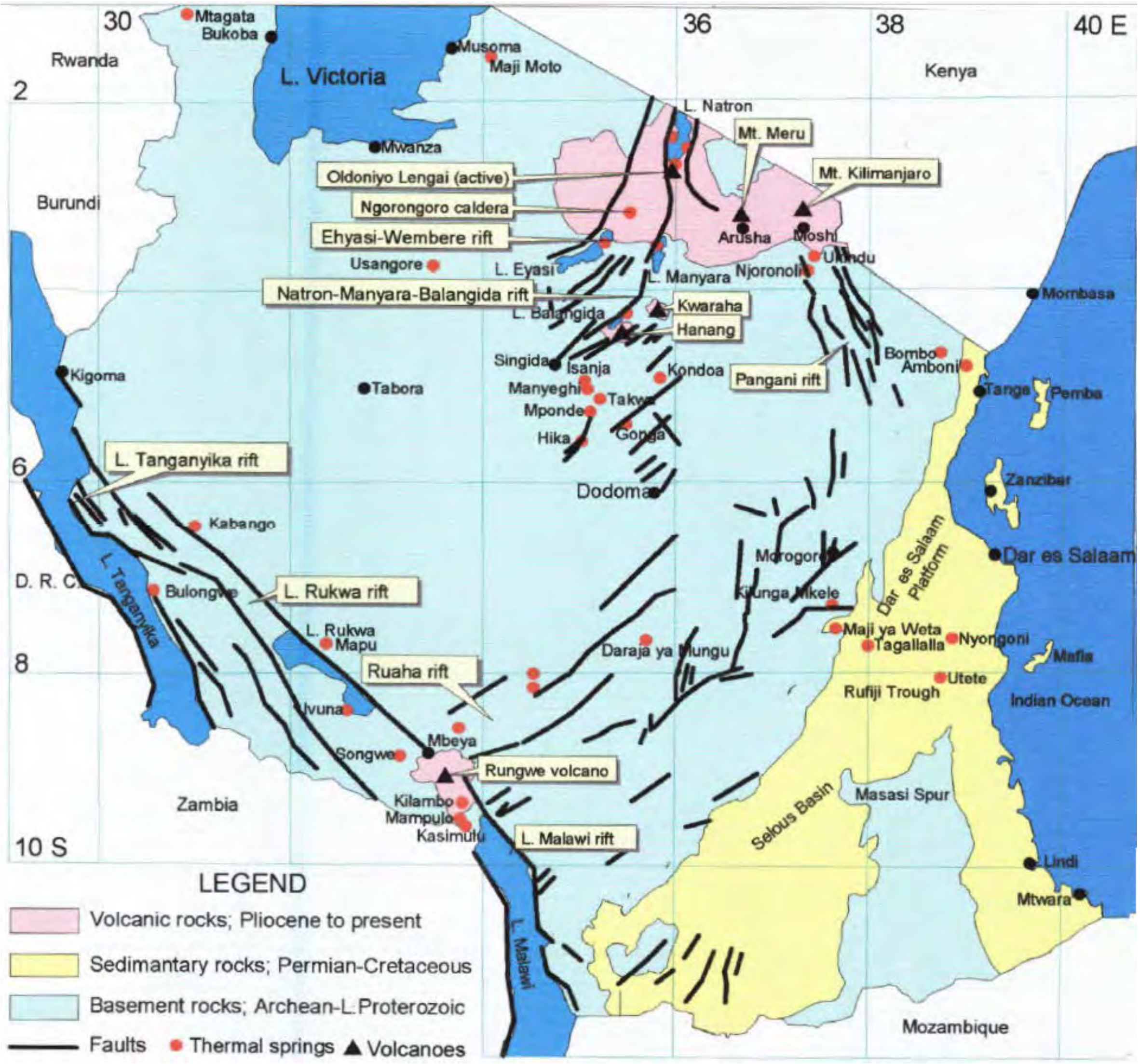
6.1.1. Small Hydropower

Tanzania is one of the pilot countries for the Scaling-Up Renewable Energy Programme (SREP) under the Strategic Climate Investment Funds (CIF). According to the SREP, the total 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 power grid.

6.1.2. Geothermal Power

The 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 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· 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 678MW although current estimates stand at 5,000MW.

There are about 50 geothermal prospects in Tanzania grouped into three main prospect zones; 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).



Map 15: Geothermal Fields in Tanzania

Source: Geothermal exploration in Tanzania, Presented at Short Course VII on Exploration for Geothermal Resources, organized by UNU-GTP, GDC and KenGen, at Lake Bogoria and Lake Naivasha, Kenya, Oct. 27 – Nov. 18, 2012.

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, 2010), the government cancelled all the other licenses except two at Lake Ngozi and one at Mbaka licensed to GPT. This PSMP is considering Lake Ngozi as the source of geothermal that is projected to start operation in 2025.

6.1.3 Wind power

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 (Njombe) have been identified as having adequate wind speed for grid-scale electricity generation. At Kititimo, wind speed averages 9.4 meter per second and 8.7 meter per second at Makambako, at a height of 30 m from the ground.

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

Table 6: 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^{o}46'34.8"	039^{o} 50' 37.2"E	on progress	on progress
9	Mwanza	Ukere	9^{o}79.4'178"	5^{o}10.324"E	4	5.6

Source: TANESCO

6.2 Considered Scenarios

Five power source mix scenarios have been considered by the PSMP Task Force Team based on all possible sources of power in Tanzania, by putting varying ratios of power source types contributing to final power source mix for the country. For all five scenarios renewable energy sources have been given the same contribution of 5% while varying other possible sources as detailed in each of the scenario analysis below.

6.2.1 Scenario 1

This power system expansion plan is considering natural Gas, Coal, Hydro, and renewable sources. Initially the contribution of Gas is 50% while Coal contributes 25%, hydro 20% and renewable sources 5%. In this power expansion scenario the contribution of coal is kept constant at 25% until year 2040 while maintaining substantial contribution from Gas powered sources at 50%. The contribution of 5% from renewable sources is expected to come from wind, geothermal and solar. Environmentally, scenario 1 is the best with a reduction of coal by 10 % compared to scenario 2, and this will reduce GHG emission and water consumption levels significantly.

Analysis by using WASP (Wien Automatic System Planning Package) software, ranked scenario 1 as second best, and ranked it third in terms of cost and power balance. However environmentally, this scenario is ranked as number one.

6.2.2 Scenario 2

Scenario 2 of power system expansion plan continues to utilize same sources with proportional contribution of Gas and Coal dropping and increasing by 10% respectively. The scenario is developed based on 40% contribution by Gas, 35% Coal, and hydro and renewable sources being maintained at 20 % and 5% respectively. This power source mix is expected to operate from 2015 to 2040 projection period. However the introduction of full swing Gas and Coal will begin to be realized by the year 2024 while significant contribution by renewable sources will be clearer by 2025. By the year 2025 the planned geothermal source will reach 100MW, while the contribution by wind sources will be 50 MW and 75 MW by 2017 and 2018 respectively. The projection of power expansion by scenario 2 from 2015 to 2040 will meet a projected demand at a minimum cost considering potential power sources mix. In terms of cost and power balance this scenario is ranked number one, while it ranks number two environmentally, probably due to heavy contribution of coal to power source mix. Overall scenario 2 is ranked number one, and according to the PSMP Task Force Team, this scenario is selected for power source mix for the project 2015 to 2040 power master plan for Tanzania.

Power source mix scenario 2 has been developed into two variations: variation A is project that works under normal circumstances and variation B is an accelerated scenario variant. Under normal circumstances realization of scenario 2 - variation A, begins with Gas source as major contributor to the power mix, supported by hydro source at least for the year 2015 and 2016, while contribution of renewable source starts 2017. By 2020 significant contribution from Gas source will be backed by contribution from hydro and renewable source with coal contributing little since most of the coal fired plant from Mchuchuma and Ngaka will be at their construction phases. By the year 2026 the contribution of coal and renewable source will increase and will continue to grow (especially coal) significantly to reach the projected contribution by 2040.

Accelerated variation B implies that there will be deliberate accelerated investment from the Government and private sector in energy projects to make sure that realization of the installed power capacity is achieved much earlier than projected by normal scenario. Under accelerated scenario the contribution by renewable sources and coal begins much earlier by 2017 as compared to 2020 under variation A. even the graph curve for accelerated scenario has an upward kink between 2017 and 2018 as well as 2019 and 2020 before it continues to grow gradually and similar to variation A scenario.

This accelerated scenario however seems to require considerable efforts given the situation of the country like Tanzania. For the accelerated variation B to be realized there are issues that will have to be in place such as land required to host the power projects, availability of experts to smoothly construct and run the projects, continued economic activities that require power to create the assumed power demand and presence of private investors ready to gamble in investing in power projects in Tanzania. Assessing all these factors, none of them have been addressed to-date, making realization of accelerated variation B requires considerable efforts. Analysis by using WASP software, finds power source mix scenario 2 the best option in terms of cost and power balance, but environmentally it is the second best.

6.2.3 Scenario 3

Power source mix Scenario 3 allocates large share of contribution to coal and minimizes significantly the contribution from gas sources. Initially, projects in this scenario reduces contribution from gas by 15% to have only 35% contribution while raising contribution from Coal to 40% with hydro and renewable sources remaining constant at 20% and 5% respectively. In the first two years (2015/2016) the scenario is predominantly gas fired, hydro and little contribution from diesel fired plants. The contribution from diesel will diminish gradually, being replaced by renewable sources, which begin to feature in the scenario by 2017, while coal contribution begins by 2020. The introduction of coal-fired thermal will start contributing 5%, increasing dramatically to 40% by 2040. This increase in coal fired thermal contribution will reduce the contribution by gas-fired thermal to 35%, and hydropower to only 20% share contribution, while renewables will contribute only 5% by the year 2040.

Analysis by using WASP software, found this scenario the best in terms of energy source balance. However the scenario is the most expensive in terms of costs, it ranks third in term of environmental performance thus coming up third in overall ranking. The increase in the contribution of coal and subsequent reduction of contribution from gas implies increasing levels of GHG emissions, water use and cost for mitigating environmental issues.

6.2.4 Scenario 4

This power source mix plan Scenario 4 allocates large contribution of power source to coal fired thermal sources while significantly minimizing the share contribution from gas source. The initial project for scenario 4 is reducing share contribution from gas to only 25% while raising the contribution from coal source to 50%. Meanwhile the share contribution by hydro sources and renewable sources is kept at 20% and 5 % respectively. The projection from this scenario is that in the first two years the power source mix will come from gas by 65 -70%, diesel fired plant 4%, and hydro over 35%. The first contribution from renewable sources will begin by 2017 and continue to grow gradually to reach the projected 5%. The share contribution from Coal will begin at 2020 with 10% increasing to 30% by 2022 and eventually stabilizing at 50% contribution by 2040. By the year 2033 most of the diesel powered engines will be phased out thus their contribution will drop to 0% while the contribution of coal, gas, hydro, and renewable operating at projected scenario 4.

Analysis by using WASP software, found that overall, scenario-ranking 4 came second in terms of cost, it ranks third in terms of energy balance and the worst in terms of environmental performance. Increased share contribution of coal to 50% and reducing gas to only 25% will have huge implication in terms of environmental consequences as significant amount of emission from coal will be generated, requiring significant amount of water as well. Compounding these environmental consequences the issues of climate change and acid rain might as well emerge thus impacting even other sources like hydro sources that are predominantly rainfall dependant and thus subject to risk of drought. In addition to these constrains environmental cost of using large share of coal and gas will significantly raise the cost of implementing this scenario.

6.2.5 Scenario 5

This scenario plan analyses different combination of sources at much reduced proportion of coal and hydro while increasing the share contribution from gas sources. The scenario anticipates raising contribution by gas source to 50%, coal reduced to 35%, hydro reduced to 10% while renewable sources remaining at 5% share contribution to total power demand. Initially the power mix starts by gas 65%, diesel 3% and hydro 32%. Contribution by renewable sources begins by the year 2017 with coal contributing 15% by 2020 raising to 25% by 2021 (assuming the Mchumhuma and Mbeya coal projects are operational). Introducing coal and renewable sources reduces the share contribution from diesel powered plants to near zero and by the year 2032 all diesel powered plants will be phased out and the power mix will constitute coal 35%, gas 50% hydro 10% and renewable sources 5% which will operate up to 2040 projection period.

Analysis by WASP software rank this scenario at number 4 in terms of cost, number 4 in terms of environmental performance, number 5 in terms of energy balance and rank number 5 overall. Thus the scenario will have significant environmental implications in terms of GHG emission levels from coal and gas, significant water use from coal and gas and it will be expensive to mitigate environmental impacts due to significant use of gas and coal.

6.2.6 The proposed scenario 2

The PSMP Task Force Team has proposed Scenario 2 as basis for revising the Power Systems Master Plan, which considers a number of energy mix including importation of power from Ethiopia based on the performance of the scenario in terms of cost, energy balance and perhaps environment (as it ranked 2 in terms of environment) earning an overall score of number 1. The scenario is likely to be implemented without acceleration as stipulated in scenario 2 variation A since there are a number of constraining factors such as land availability, presence of available private investor ready to invest, experts and guaranteed economic growth to push the power demand higher, making variation B challenging. The value of choosing this scenario is analysed in detail in the following section.

Although scenario 2 looks better in many aspects of the environment, scenario 1 looked more promising as it ranked lower in terms of GHG emission level and thus emerging number 1 environmentally. Similarly, in terms of cost the difference between the two scenarios is not significant and in fact, the high cost in scenario 1 will be incurred once (i.e. short-term) during installation, which can easily be compensated via mitigation. In scenario 2 on the other hand, the environmental effects tend to be long term with multiply effects in terms of health of the people. If all these costs are included, scenario 1 is likely to emerge the best from the environmental perspective. However, it is important to note that all scenarios will have environmental effects in the initial years but the amount of GHG emission for example will decrease as new technologies are introduced in the system.

6.3. Transmission Issues

Despite the challenges in generation and measures adopted in the PSMP in the form of energy mix in order to guarantee long term reliable power supply, there are significant issues in terms of transmission of the generated power to reach energy users. Tanzania is a large country with a low population density, and the principal demand centres are located very far away from main gas, hydro and coal areas. This means that the cost and losses in transmission are expected to be high. Similarly, the country has experienced the consequences of over-dependence on a single source for years (e.g., the power cuts of the early 2000). Thus, there is significant value in both high diversity of power sources, and a wide geographical spread. The diversity and spread of energy sources together with isolation and remoteness of bigger energy users call for diversified power transmission.

Issues associated with transmission line include significant land take to allow establishment of way leave for transmission line. Since there are diversity of sources with varying generation capacity there will be varying magnitude of impacts for specific project but cumulatively it signifies high land take issue to cater for transmission lines. This master plan indicates several 400 kV transmission lines, 220 kV and 300 kV lines, which demand way, leave between 60 m to 90 m size. Considering the distance from the source to the users several thousands of hectors will be taken to accommodate the proposed transmission lines.

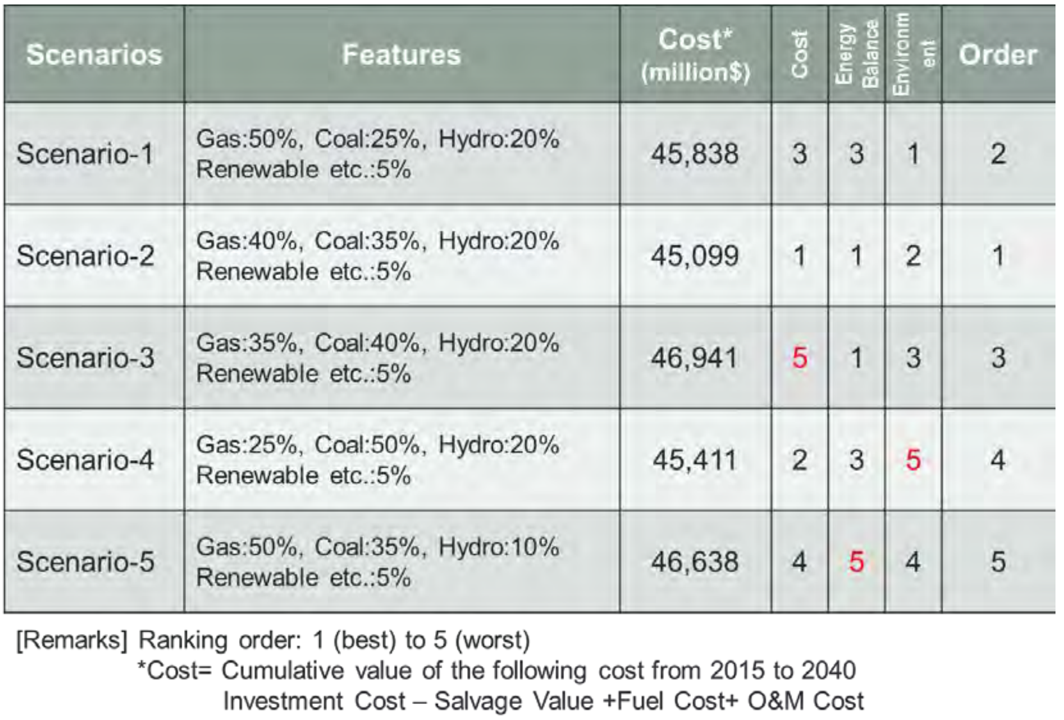
Other issues of concern with regards to transmission line are potential bird collisions. Presence of multiple transmission lines closer to important bird areas like Kilombero valley, south coast corridor from Mtwara to Dar es Salaam and southern highland areas interfere free flying zone particularly for migratory birds. In addition to loss of biodiversity due to clearing of vegetation there will be land scape issues where multiple transmission lines will distort the scenic quality of the areas traversed by crossing transmission lines.

7. Analysis of Environmental and Social Implications of Scenario 2

7.1 Comparison of five power development scenarios:

Table 7 is an evaluation of the five proposed power development scenarios. Generally, all the five proposed scenarios put emphasis on the higher contribution of gas and coal (>75%) while hydro and renewables contributes relatively less (<25%). The contribution of hydro and renewables is largely the same in all five scenarios. Gas tops the contribution (50%) in Scenarios 1 and 5, and contributes the lowest (25%) in Scenario 4. Coal on the other hand tops contribution (50%) in Scenario 4 and contributes the lowest (25%) in Scenario1. With coal being the worst poluting source followed by gas, scenarios 5, 4 and 3 are probably the worst environmentally because they have the highest contributions of coal or gas. This leaves scenarios 1 and 2 as the best options. The PSMP Task Force Team has recommended scenario 2 as the best. However, as stated above, gas being environmentally better than coal, and in order to adequately protect the environment and ensure sustainability of the PSMP, scenario 1 is preferable to 2 from the environmental perspective. If scenario 2 is to be chosen, necessary environmental cost and mitigation measures are to be considered in implementing the scenario.

Table 7: Evaluation of the Power development Scenario



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

7.2 Environmental and Social Implications

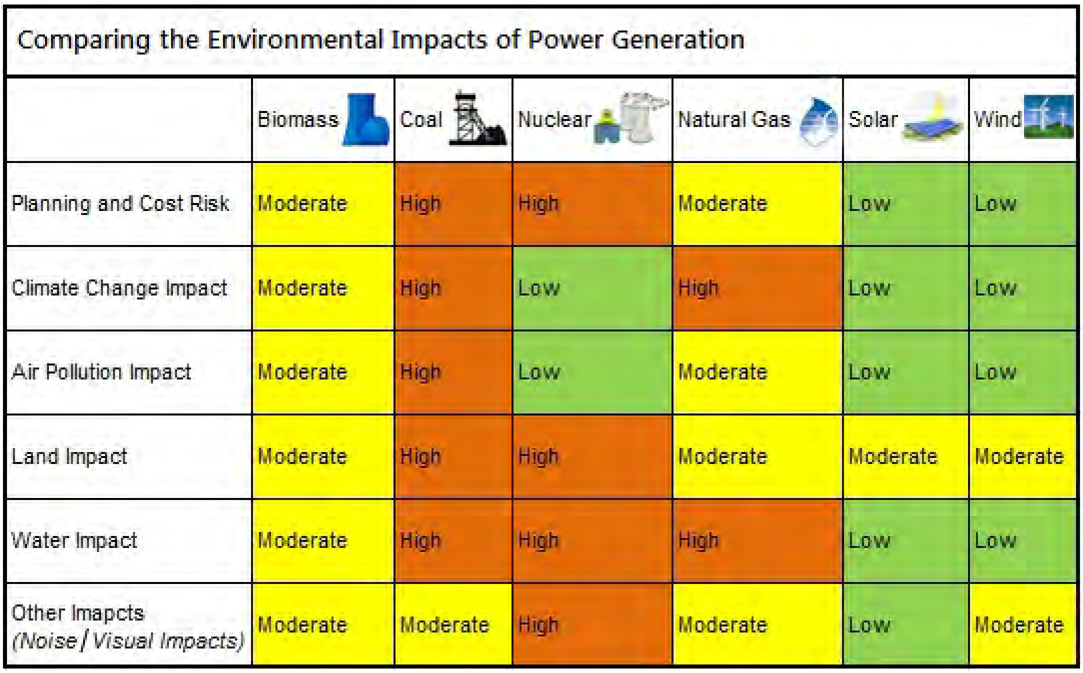
The scenarios 1 and 2 still put more emphasis on the comparatively higher contribution of coal fired power generation (35%) and gas (40%). The environmental and social implications of adopting the two scenarios are discussed in the following sections.

7.2.1 Environmental and Natural Resources Issues

Air emission and pollution

Under the power generation scenarios 1 and 2, gas and coal will play an essential role in the national energy mix with gas contributing only 10% more in scenario 1 than in scenario 2. Of the two power sources, coal is relatively more polluting than gas (See Table 8).

Table 8: Comparing Environmental Impacts of power Generation



Comparing the Environmental Impacts of Power Generation

	Biomass	Coal	Nuclear	Natural Gas	Solar	Wind
Planning and Cost Risk	Moderate	High	High	Moderate	Low	Low
Climate Change Impact	Moderate	High	Low	High	Low	Low
Air Pollution Impact	Moderate	High	Low	Moderate	Low	Low
Land Impact	Moderate	High	High	Moderate	Moderate	Moderate
Water Impact	Moderate	High	High	High	Low	Low
Other Imapcts *(Noise / Visual Impacts)*	Moderate	Moderate	High	Moderate	Low	Moderate

Source: “The Hidden Costs of Electricity: Comparing the Hidden Costs of Power Generation Fuels” by Synapse Energy Economics, Inc. 19 Sept. 2012

Thus, when coal is burnt, carbon dioxide, sulfur dioxide, nitrogen oxides, and mercury compounds are released. More so, coal mining, cleaning, and transportation to the power plants generate additional emissions. For example, methane, a potent greenhouse gas that is trapped in the coal, need to be often vented during these processes to increase safety . The most damaging air emmission impacts of coal that occur through its mining, preparation, combustion, waste storage, and transport include among others the following:

- Air pollution via carbon dioxide, sulfur dioxide, nitrogen oxide, particulate matter (PM), and heavy metals, leading to smog, acid rain, toxins in the environment, and directly affecting humans via numerous respiratory, cardiovascular, and cerebrovascular effects. In terms of human health, a 2011 Harvard report estimated $74.6 billion a year in public health burdens in Appalachian communities, with a majority of the impact resulting from increased health care costs, injury and death.

- Additional air pollution due to emissions of other gases including methane (CH4), as well as carbon monoxide (CO).

- Climate impacts due to carbon dioxide (CO2) emissions, making coal a huge contributor to global warming. Black carbon resulting from incomplete combustion is an additional contributor to climate change.

- Coal dust stirred up during the mining process, as well as released during coal transport, can cause severe and potentially deadly respiratory problems to humans and other organisms.
- Coal sludge, also known as slurry, is the liquid coal waste generated by washing coal. Since huge amounts of coal sludge are associated with coal-fired energy generation, a sign of use of inefficient technologies, there will be need for adoption of costly technologies to use coal efficiently and concomitantly reduce its environmental footprint.

The inefficient use of coal is highly undesirable and must be avoided because it wastes a non-renewable natural resource and leads to unnecessary pollutants and greenhouse-gas emissions. To maximise the utility of coal in power generation, plant efficiency is a crucial performance parameter. Improving efficiency has several benefits including:

- Prolonging the life of coal reserves and resources by reducing consumption;
- Reducing emissions of carbon dioxide (CO2) and conventional pollutants;
- Increasing the power output from a given size of unit; and

- Potentially reducing operating costs

The amount of both annual total and unit GHG emissions with Scenario 2 are significantly higher than those of scenario1 in the year 2040 (by > 2,500,000 tons CO $_2$ eq/annum and >0.050 kg CO2 eq/kwh, respectively). Furthermore, the annual total GHG emission breakdown by fuel type shows that coal in scenario 2 emits relatively more GHGs (about 10,000,000 tons CO_2 eq) per annum than in scenario 1 in the year 2040. The relatively lower cost shown in scenario 2 (i.e. $45,099 Million) compared to scenario 1 ($45,838 Million) would definitely be due to compromised environmental quality by foregoing expensive mitigation costs. In fact, what is proposed as acceleration of scenario 2 is very challenging in Tanzania given the experience with the rate of development processes including compensation for land take which takes long and often times amidst disgruntlement from project affected people (PAPs).

It is known that at any power plant, the burning of natural gas produces nitrogen oxide and carbon dioxide, but in relatively lower quantities than burning coal. Thus, methane, a primary component of natural gas and a greenhouse gas, can also be emitted into the air when natural gas is not burned completely. Similarly, methane can be emitted as the result of leaks and losses during transportation (Table 9). Generally, these gases and suspended particulate matter (SPM) and respirable suspended particulate matter (RSPM) emissions disperse over 25km radius from the thermal power station (Pokale, 2012).

Table 9: Comparison of Power Plant Emissions (g/kWh)

Plant Type	**CO**	**NO_X**	**SO_2**	**CO_2**
Coal	0.11	3.54	9.26	1,090
Oil	0.19	2.02	5.08	781
Gas	0.20	2.32	0.004	490

Source: Virginia Tech's Consortium on Energy Restructuring, 2007, *http://www.dg.history.vt.edu/ch2/impact.html*

It is well established that the southern and south-western regions of Tanzania have a prolonged unimodal rainfall regime based on the north-westerly winds from the Indian Ocean. The cumulative generation of gases like CO_2, NOx and SO_2 from both gas (in Mtwara region) and coal (in the south-western highland regions) is likely to cause precipitation of acid rain particularly in the south-western highlands, the major timber and food crop producing areas of Tanzania. On the long-term, acid rains could result in disastrous food insecurity problems in these regions in particular and the whole country in general if air emission is not properly managed.

Water use and demand

In comparing the water-related impacts of natural gas- and coal-fired electricity generation, there is also need to consider water withdrawals (water that is taken from a source, used, and returned) and water quality impacts. It is pretty hard to quantify and compare water quality impacts associated with resource extraction, but coal mining seems to be more harmful to water quality than natural gas drilling. Also, coal mining is often associated with dewatering, or pumping out all the groundwater near a mine to keep the operation dry. It can take years to restore the groundwater table near coalmines, as this disrupts the local hydrology. In India for example, the water requirement for coal-based power plants has been estimated to be about 0.005 – 0.18 m^3/Kwh (Pokale, 2012). Therefore, the higher the demand for coal use for energy generation, the higher the quantity of water is required for extraction and dewatering mines.

Also, electricity generation especially via gas and coal involves the consumption of water resources (e.g. for steam production and cooling, equipment cleaning, and other purposes). The water consumption and the environmental impacts of water use vary from technology to technology (Table 10).

Table 10: Water Consumption in Thermoelectric Power Plants per unit of Net Power Produced Closed-loop Cooling

Type of Thermal Power	Litres per MWh	Gallons per MWh
Nuclear	2,700	720
Subcritical Pulverized Coal	2,000	520
Supercritical Pulverized Coal	1,700	450
Integrated Gasification Combined-cycle, slurry fed	1,200	310
Natural Gas Combined-cycle	700	190

Source: Water Requirements for Existing and Emerging Thermoelectric Plant Technologies. US Department of Energy, National Energy Technology Laboratory, August 2008.

The amount of cooling water required by any steam-cycle power plant (of a given size) is determined by its thermal efficiency. It has essentially nothing to do with whether it is fuelled by coal or gas. However, the bigger the temperature difference between the internal heat source and the external environment where the surplus heat is dumped, the more efficient is the process in achieving mechanical work – in this case, turning a turbine and generating electricity. Thus, it is desirable to have relatively high temperature internally and low temperature in the external environment. This consideration gives rise to the need for citing power plants alongside very cold waters. However, the burning of natural gas in combustion turbines requires very little water. But, natural gas-fired boiler and combined cycle systems do require some water for cooling purposes. In the case of coal usage on the other hand, relatively larger quantities of water are frequently needed to remove impurities from coal at the mine.

Natural gas-fired power plants generally use less water for cooling for two major reasons. First, natural gas-fired power plants are often more efficient than coal-fired power plants, so less heat needs to be dissipated. Second, natural gas can be burned directly in a turbine (unlike coal, which is solid), and gas turbines are air-cooled. So power plants running gas turbines (including combined cycle plants, which run natural gas through a gas turbine, then use the waste heat to boil water and run a steam turbine) use less water for cooling than plants with steam turbines.

Thus, when power plants abstract water from a lake or river, fish and other aquatic life can be exterminated, affecting animals and riparian communities who depend on these aquatic resources especially downstream the abstraction point. More important, sustainability of water supply for the power plant very much depends on catchment condition of the water source. Both the southern region of Mtwara which is rich in gas, and the southern highlands regions (Ruvuma, Njombe, Mbeya and Songwe) which are rich in coal, have shortages or have inaccessible surface water (e.g. from rift valley lakes). Thus there is a potential problem related to water supply and use with regard to the proposed power generation mix particularly in scenario 2 where substantial coal is to be burnt. The solution to this will be either to adopt efficient technologies that will use less water (which implies some cost), use available water sparingly to avoid draining the sources or ignore the environment and abstract all the water from the source which would be unacceptable by Tanzanian law (EMA, 2008) .

Solid and liquid waste generation

Both coal and gas electricity generation technologies result in the generation of solid waste. In some cases, solid wastes can be disposed of in landfills. In most cases, these wastes contain toxic and hazardous elements and materials that require special handling, treatment, and disposal. Technologies that produce no solid wastes or relatively low amounts exist and should be used to minimize the effect of using such sources, but they are expensive.

The use of natural gas to create electricity is a typical case that does not produce substantial amounts of solid waste. The burning of coal on the other hand creates solid waste, called fly ash, which is composed primarily of metal oxides and alkali. On average, the ash content of coal is 10 percent. Fly ash has to be captured and removed from the flue gas by electrostatic precipitators or fabric bag filters (or sometimes both) located at the outlet of the furnace. The fly ash has to be periodically removed from: the collection hoppers below the precipitators or bag filters; the hopper at the bottom of the furnace, and the crushed clinkers to a storage site. In India for example, coal based thermal power plants are releasing about 105MT of CCRs per annum (Coal Combustion Residuals; a collective term referring to the residues produced during the combustion of coal regardless of ultimate utilization or disposal) and possess major environmental problems (Pokale, 2012; Averneni and Bandlamudi, 2013) (www.isca.in). Solid waste is also created at coal mines when coal is cleaned and at power plants when gaseous pollutants are removed from the stack gas.

Both gas and coal electricity generation also produces liquid wastes that need to be dealt with in order to minimize their impacts on the environment. However, relatively more significant impacts are associated with coal electricity generation. For example, acid mine drainage (AMD), referring to the outflow of acidic water from coal mines or metal mines, often abandoned mines where ore- or coal mining activities have exposed rocks containing the sulfur-bearing mineral pyrite. Pyrite tends to react with air and water to form sulfuric acid and dissolved iron, and as water washes through the mines, this compound forms a dilute acid, which can wash into nearby rivers and streams, thereby negatively affecting aquatic life..

More so, thermal pollution degrades water quality when water used as a coolant is returned to the natural environment (lakes and rivers) at a higher temperature. Change in temperature impacts organisms by decreasing oxygen supply, and affecting ecosystem composition and biodiversity. Thus, long-term discharge of such liquid wastes into Lake Nyasa from most coal-fired generating plants located in the south-western Highlands of Tanzania could affect the chemistry of the lake and hence its biodiversity including fish and fisheries. This could lead to diplomatic wrangling with neighboring countries, as Lake Nyasa is a trans-boundary lake

Also, coal tends to contain many heavy metals, thus too much of these may cause acute or chronic toxicity (poisoning) due to environmentally and biologically toxic elements, such as lead, mercury, nickel, tin, cadmium, antimony, and arsenic, as well as radio isotopes of thorium and strontium.

Impact on flora and fauna

The effect on biological environment can best be divided into two parts, viz: the effect on the flora and the fauna. The main environmental impacts with regard to water at the site, and elsewhere in the water cycle, are the resulting effects from the process water discharge. Changes are observed in the temperatures between recipient and cooling waters for both the surface water hydrology and quality. This has a subsequent impact on the local water chemistry due to the temperature changes and contaminants in discharges. The result of site drainage is also a very influential factor causing many activities and impacts. These include an increase in surface runoff from soil compaction, rapid transfer of rainwater to water courses via drains, changes to flow and deposition regimes in the downstream water course, possible pollution from contaminated run-off and increased flood risks (Pokale, 2012))

Any form of polluting emissions into the atmosphere is considered a negative environmental impact, however the presence of pollutants such as sulfur dioxide, nitrogen oxides, carbon dioxide, and particulate matter particularly in association with coal, is particularly critical. It contributes both to the greenhouse effect and the formation of acid rain, and should thus be critically controlled at all times e.g. by significantly minimizing the burning of coal to minimize impact on flora and fauna. The impact upon the flora and fauna should be considered in respect of the toxicity of wastes from a thermal power plant and harm to vulnerable ecosystems such as natural and plantation forests and coral reefs because of rising temperatures and less rainfall. A major risk to coral reefs is bleaching, which takes place when coral is stressed by temperature increases, high or low levels of salinity, lower water quality, and an increase in suspended sediments. These conditions cause the *zooxanthallae* (the single-celled algae which forms the colors within the coral) to leave the coral. Without the algae, the coral appears white, or "bleached" - and rapidly dies[3].

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[3] Environmental Impacts of Tourism, UNEP

http://www.unep.org/resourceefficiency/Business/SectoralActivities/Tourism/FactsandFiguresaboutTourism/ImpactsofTourism/EnvironmentalImpacts/tabid/78775/Default.aspx

Water abstraction and discharge may cause potential entrapment, or alteration of habitats through changed temperature or water chemistry. Another cause for environmental concern is that the waste disposal activities may affect local habitats and species through disturbance due to noise pollution, and pollution as a result of toxic harmful waste.

Most of these impacts are unavoidable resulting from thermal power production especially with respect to use of coal. Therefore, they should be minimized and controlled to avoid unexpected environmental deterioration. More importantly, such large investment on a power plant should ensure that the water is managed as a valuable commodity and the stewardship of that investment means that water is used responsibly mandating that cooling technology be used in order to avoid negative ripple effect on the national economy as water availability could impact other sectors throughout the country.

Impaired landscape

Coal based power plants are particularly associated with landscape/aesthetic impacts. Because of continuous and long lasting emissions of sulfur dioxide and nitrogen oxide, which are the principal pollutants emitted from coal based power plants, structures and buildings get affected due to corrosive reactions. Such effects tend to change the visual quality of structures and infrastructure with aesthetic consequences, leading to costly rehabilitations and maintenance.

Tourism, especially nature tourism, is closely linked to biodiversity and the attractions created by a rich and varied environment. Loss of biodiversity can lead to loss of tourism potential. For example, bleaching of coral reefs happen when coral is stressed by temperature increases, high or low levels of salinity, lower water quality, and an increase in suspended sediments. These conditions cause the *zooxanthallae* (the single-celled algae which forms the colors within the coral) to leave the coral. Without such algae, the coral appears white, or "bleached" - and rapidly dies. The Great Barrier Reef, which supports a US$ 640 million tourism industry, has been experiencing coral bleaching events for the last 20 years[4].

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[4] Environmental Impacts of Tourism, UNEP http://www.unep.org/resourceefficiency/Business/SectoralActivities/Tourism/FactsandFiguresaboutTourism/ImpactsofTourism/EnvironmentalImpacts/tabid/78775/Default.aspx

Generally, environmental pollution by the coal based thermal power plants all over the world is cited to be one of the major sources of pollution affecting the general aesthetics of environment in terms of land use, health hazards and air, soil and water in particular and thus leads to environmental dangers (www.isca.in).

More significant for both gas and coal fired energy generation, relates to transmission. Since almost all power generation will be confined to the southern (gas) and south-western highland regions (coal and probably geothermal), the transmission of generated energy to the rest of the country will be associated with long-distance pyrons all over the country and significantlt affect the aesthetic quality of the country’s environment.

7.2.2. Social Issues

Although the basic SEA process is similar to that of EIA for projects, the former is generally more broad-brush, less detailed and quantitative and more focused on broad directions of change. In light of this, some of the impacts/issues revealed during stakeholder’s consultation have social significance although they have more meaning at project level. These are discussed here within the context of their cumulative effect.

Land acquisition, Land use change and resettlement

The amount and type of land used for energy production effects both economics and ecosystems. Before the electricity reaches the consumers, much land will be utilised directly and indirectly for power generation. This includes the land area required to house the power plant, the land used for gas supply and transmission lines. In addition, considering the social effects that can be caused by accidents, the area of impact may, in fact, extend way beyond the immediate boundaries of the power generation facility.

Land acquisition and land use change will vary depending on the kind of electricity generation. Processing plants, coalmines, fuel refineries, transportation, and power transmission all require land. For hydropower, however, determining the total land use is challenging. Water reservoir areas must be considered in addition to the power plant site (Husebye, 2000). Further, if the dam utilises water supplied from a catchment area, the total land use impact could be considered enormous. Yet, the land is not only being used for electricity generation. The water resources in the reservoirs, rivers and catchments are most likely also utilised for agriculture, industrial and domestic water resources, forestry, wildlife, and other uses. Thus, setting boundary conditions is an important step for the implementation of PSMP.

The implementation of the PSMP will also involve a change of land use. This triggers off requirements for approval in terms of land use planning ordinance, environmental acts and heritage acts. Changes in land use and tenure will result in rural communities losing access to and control over land that they previously depended on for their livelihoods. It will also probably cause encroachment into protected areas and sensitive habitats if their needs cannot be met locally. The implications need to be clearly 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. This is especially true for pastoralists and other marginalised groups, vulnerable households and women as they solely depend on their natural resources for their livelihoods and frequently do not have a voice during negotiation processes at the local level.

The issue of resettlement and compensation is very much related to the land right issue for those communities and households who are to be resettled. When people have to resettle, they lose access to both owned and common property land, with the latter being one of the most important livelihoods assets of these communities. Involuntary resettlements may result from the need for lands for powerhouse, steam wells and transmission lines. The proposed transmission lines for the PSMP for example, will require significant amount of land for the high-tension cables. Measures must be put in place to minimize land take through technological designs of the towers and way leave adjustments.

It must be noted that the southern and southwestern Highland regions of Tanzania will be the main target for both coal and gas fired power generation. The south-western Highland regions are also the principal sources of hydro and to some degree geothermal power generation. Furthermore the latter regions are also main “bread basket” for Tanzania. Therefore, the expected cumulative demand for land for locating power stations and energy transmission, as well as for local community and commercial timber and food production would lead to major land use conflicts, which could subsequently backfire and affect power generation itself.

Employment and Socio-economic development issues

Employment creation is an important objective of any national policy, program or plans. Most people especially the young people who form a huge percentage of the population are not engaged in any means of income generating activities for their livelihoods. This is partly due to the fact that private sector investments, which create employment opportunities, are very minimal. Therefore, it is anticipated the implementation of the PSMP will have both direct and indirect impacts on job creation and economic development of the country. The implementation of the PSMP will provide direct employment opportunities at different stages of its implementation. Indirectly, the power to be generated as result of implementation of PSMP will enable effective participation of private investment in different economic activities. Private investments will create employment opportunities, which will ultimately create income opportunities and alleviate poverty and consequently improve standard of living of the people.

However, it must be emphasized that there are a number of risks associated with mining especially of coal. Historically, coal mining has been a very dangerous activity and the list of historical coal mining disasters is a long one. Underground mining hazards include suffocation, gas poisoning, roof collapse and gas explosions. Open cut hazards are principally mine wall failures and vehicle collisions. In the United States, an average of 26 coal miners per year died in the decade 2005-2014[5].

7.2.3 Health issues

There are three categories of health impacts that are of importance: those associated with hydro plants, which are largely associated with waterborne diseases, those associated with thermal plants, which are largely related to exposure to increased ambient levels of airborne pollutants (such as SOx NOx and particulate matters) and those associated with influx of people such as HIV/AIDS.

a) **Hydropower:**

Some infectious diseases can spread around hydropower reservoirs, particularly in warm climates and densely populated areas. Some diseases (such as malaria and

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[5] Coal Fatalities for 1900 Through 2015, US Department of Labor, http://arlweb.msha.gov/stats/centurystats/coalstats.asp

schistosomiasis) are borne by water-dependent disease vectors (mosquitoes and aquatic snails); others (such as dysentery, cholera, and hepatitis A) are spread by contaminated water, which frequently becomes worse in stagnant reservoirs than in fast-flowing rivers (Girmay, 2006). Corresponding public health measures should include preventive measures (such as awareness campaigns and window screens), monitoring of vectors and disease outbreaks, vector control, and clinical treatment of disease cases, as needed. Control of floating aquatic weeds (see below) near populated areas can reduce mosquito-borne disease risks.

b) Thermal power:

Air pollution contributes to the incidence of respiratory diseases. Pollutants like, Sulphur Oxide (SOx), Nitrogen Oxide (NOx) and particulate matters contribute to the incidence of acid rain which is a form of precipitation that contains high levels of sulphuric or nitric acids, can contaminate drinking water and vegetation, damage aquatic life, and erode infrastructure. Generally, dust or fumes emissions from operating machines, equipment and vehicles can cause air pollution. Dust pollution may result from various activities associated with power generation including production of fumes as exhaust from stationary and mobile machinery and equipment and from rehabilitation works. Dust deposition onto vegetation may affect photosynthesis, respiration, and transpiration and allow the penetration of phototoxic gaseous pollutants. The health impact of dust pollution on humans will depend on the distance from the sources, size of the particulate matter, and the constituents of the pollutants. Generally, the communities in the southern and south-western highland regions, would be impacted the most.

Excessive noise in power plants, coal mining and oil and gas exploration can potentially lead to hearing impairment, hypertension, ischemic heart disease, annoyance and sleep disturbance. Changes in the immune system and birth defects have also been attributed to noise exposure, (Kryter, et al, (1994). Elevated noise levels can create stress, increase workplace accident rates and stimulate aggression and other anti-social behaviour.

c) Influx of people:

Furthermore, influx of people searching for job opportunities will have significant contribution to the spread of diseases including HIV/AIDS and tuberculosis. As population increases, there will be greater pressure on existing social services including health services unless they are expanded. An increase in population has the potential to impact on biodiversity, water quality, air quality and landscape. Individual and cumulative changes in the quality of the environment at local, regional and national level has the potential to impact to varying degrees on human health and wellbeing. With population increase, the quality and access to health care will deteriorate resulting in greater incidence of otherwise preventable health problems.

7.2.4 Archaeological and cultural issues

Tanzania is well endowed with abundant significant archaeological and cultural heritage resources, which range from the Pliocene period about four million years ago to present time. Cultural heritage represents the identity of a community and its environment. Cultural heritage can include monuments or other buildings that represent important events or eras in local or national history, traditional lifestyles, such as the performing arts and handicrafts, and even the everyday activities of local people as they farm, fish or prepare food. Cultural heritage are categorized into seven groups as follows:-

i. Archaeological or Paleontological sites
ii. Historical sites
iii. Historical towns
iv. Traditional Settlements
v. Historic Buildings like Colonial Administrative Buildings (BOMAs) in many Districts in Tanzania;
vi. Sites with special memories like Colonialists Cemetery, Cemeteries of World War I and II and Defensive Walls;
vii. Natural Features and Structures

The legal protection of Tanzania Archaeological remains of special interest and cultural heritage resources is effected through the Antiquities Act of 1964 (Act No. 10 0f 1964 Cap 550) which is the principal legislation and the Antiquities (Amendment) Act of 1979 (Act No. 20 of 1979) as well as Rules and Regulations of 1981, 1991, 1995 and 2002. The 1964 Act repealed the Monument Preservation Ordinance of 1937 and 1949 and enlarged the scope of heritages that need to be conserved (URT, 2014). The legislation offers general protection to objects or structures, which are of archaeological, paleontological, historic, architectural, artistic, ethnological or scientific interest.

Archaeological and cultural heritage such as monuments, archaeological sites, cultural landmarks, traditional ways of using the land and its resources, culturally important plants and animals, waters sources and landscape, may be disturbed at different levels of PSMP implementation. These impacts may be disproportionately experienced in view of the geographical scope of the plan. Based on anecdotal evidence, areas known for their significant archaeological will be mapped out and care taken to preserve those important archaeological resources.

One of the main issues to be addressed in the implementation of the PSMP will be on how to protect archaeological, architectural and cultural heritage while recognising the need for continued development. Sympathetic re-use and/or development of structures, including appropriate contemporary design additions near a protected structure, will allow architectural and archaeological heritage to continue to offer aesthetic, environmental and economic benefits for future generations.

7.3 Recommended Scenario based on SEA Analysis from the environmental perspective

Based on the foregoing analysis this SEA, with focus on mainstreaming environmental parameters into the Power System Master Plan, it is recommended to consider that SCENARIO 1 is the better option from the environmental perspective, compared to SCENARIO 2. Most of the environmental parameters discussed above perform relatively better and more “friendly” to the environment than those of SCENARIO 2. The advantage of SCENARIO 2 is the relatively inexpensive cost of the establishing compared to scenario one. However, this difference in cost is assumed to the difference in environmental costs that is not reflected in scenario 2. It is argued here that should the true environmental cost be reflected in scenario 2, it would not be seen as relatively inexpensive as it is now. This SEA thus further argues that there is need for the government to internalise true environmental cost into the further design and implementation of the master plan. Therefore, if scenario 2 is chosen for the PSMP 2016 Update, these are to be taken as part of the cost instead of externalising them to the communities that will have to bear those costs over a long period of time.

8. Cross Cutting Issues

Several cross cutting issues are associated with the Power System Master Plan and intended changes. These are discussed below in view of their implications to eventual success of the planned PSMP.

8.1 Institutional Issues

The key to the success of the implementation of the PSMP is clear institutional arrangement and defined responsibilities as well as mandates. Discussions with MEM and TANESCO on their experience in the implementation of the existing PSMP revealed lack of clarity in terms of their roles with regard to the implementation of the PSMP.

Yet a critical matter of concern regarding institutional arrangement relates to the functions and roles of TANESCO as the main player in energy generation, transmission and distribution. Various stakeholders are of the opinion that TANESCO may not be best placed to manage all the three functions, and instead, there is need to split this organization into independent sections that deal with generation, transmission and distribution. These suggestions are considered positive in increasing the efficiency of TANESCO on managing power sector in Tanzania. Indeed, although private sector is involved, it is still TANESCO that basically deals with transmission and distribution. The effective implementation of the revised PSMP calls for re-assessment of the roles and functions of TANESCO.

Another institutional issue relates to management of water resources that are crucial for ensuring sustainable hydropower generation as envisaged in the PSMP. While the PSMP earmarks the use of water for hydropower for various rivers and projects growth of such source to fuel the planned power generation, the Ministry of Energy and Minerals in not responsible for management of water bodies or catchment areas that supply water for hydropower. These are under the Ministry of Water and Irrigation.

However, the main catchments areas are not even under the Ministry of Water and Irrigation, these are under the Ministry of Natural Resources and Tourism, through the Catchment Forest. The latter however is not allocating water to various users. It is the Basin Water Offices under the Ministry of Water and Irrigation. Therefore, this institutional arrangement does not provide sufficient safety and guarantee in terms of ensuring sustainable supply of water to meet the desired power generation. The need to address this issue is apparent otherwise planned targets under the PSMP may not be fully realized.

The other institutional issue that may affect the implementation of the planned PSMP changes relates to the roles and position of the Environmental Units in MEM and TANESCO. The implementation of the PSMP will result in several environmental and social issue; the environmental units in these two offices need to be fully equipped and supported to be able to do their work properly. Currently, there seems to be less support to these two units and that may undermine mainstreaming environmental issues into day-to-day operations of the PSMP.

8.2 Economic and Financial Issues

The implementation of the PSMP 2016 Update will require huge investments in terms of money, personnel and equipment. Discussing with MEM and TANESCO revealed the dare need to finances as it has affected the planned operations of the existing PSMP. Therefore, as the PSMP 2016 Update is being developed, there is need to align the plans with the resource mobilization otherwise, the plans will face difficulty in implementation. The net effect will be the failure to achieve desired goals. The PSMP should also include element of financing mobilization and strategies.

8.3 Technology and Sustainability Issues

Renewable energy potentials in Tanzania

Sustainable energy is the form of energy obtained from non-exhaustible resources, such that the provision of this form of energy serves the needs of the present without compromising the ability of future generations to meet their needs.

Technologies that promote sustainable energy in Tanzania include renewable energy sources, such as hydro-electricity, solar energy, wind energy, geothermal energy, bioenergy, and also technologies designed to improve energy efficiency. Renewable energy is derived from natural processes including derivation from the sun, or from heat generated deep within the earth. Also, there are electricity and heat energy generated from the renewable energy resources.

Renewable energy technologies are essential contributors to sustainable energy as they generally contribute to world energy security, reducing dependence on fossil fuel resources, and providing opportunities for mitigating greenhouse gases (International Energy Agency (2007). First-generation technologies including hydropower, biomass combustion and geothermal power are most competitive in locations with abundant resources like Tanzania. Their future use depends on the exploration of the available resource potential and on overcoming challenges related to the environment and social acceptance (ibid).

- **Hydropower:** Among sources of renewable energy, hydroelectric plants have the advantages of being long-lived. Also, they are clean and have few emissions. Criticisms directed at large-scale hydroelectric plants include; dislocation of people living where the reservoirs are planned, and release of significant amounts of carbon dioxide during construction and flooding of the reservoir (New Scientist, 2005). However, it has been found that high emissions are associated only with shallow reservoirs in warm (tropical) localities, and recent innovations in hydropower turbine technology are enabling efficient development of low-impact run-of-river hydroelectricity projects[6].

  Generally, hydroelectric plants produce much lower life-cycle emissions than other types of generation. Currently, hydroelectric growth is fastest in the booming economies of Asia where it is driven by much increased energy costs—especially for imported energy—and widespread desires for more domestically produced, clean, renewable, and economical generation.

- **Geothermal power:** Geothermal power plants have the advantage of operating for 24 hours per day, providing base-load capacity. Although geothermal power is accessible only in limited areas of the world, it is accessible in East Africa, including Tanzania. The costs of geothermal energy have dropped substantially from the systems built in the 1970s (International Energy Agency, 2007). Furthermore, geothermal heat generation can be competitive due to introduction of enhanced geothermal system (EGS) technology, so it can be used in areas that were previously unsuitable for geothermal power, if the resource is very large.

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[6] Ferris, David (3 November 2011). "The Power of the Dammed: How Small Hydro Could Rescue America's Dumb Dams". Retrieved 4 January 2012.

- **Solar power:** Second-generation technologies in Tanzania would include solar heating and cooling, wind power, modern forms of bioenergy and solar photovoltaics. These technologies are now entering markets as a result of research, development and demonstration (RD&D) investments since the 1980s. Solar heating systems for example, may be used to heat domestic hot water, swimming pool water, or for space heating. The heat can also be used for industrial applications or as an energy input for other uses such as cooling equipment. Solar power is complicated due to changes in seasons and from day to night, cloud cover, and the fact that not all radiation from the sun reaches the earth because it is absorbed and dispersed due to clouds and gases within the earth's atmospheres.

- **Wind power:** Other second-generation renewable technology, such as wind power, has high potential and have already realised relatively low production costs. At the end of 2008, worldwide wind power produced some 1.3% of global electricity consumption (World Wind Energy Association, 2008). However, it may be difficult to site wind turbines in some areas for aesthetic or environmental reasons, and it may be difficult to integrate wind power into electricity grids in some cases (International Energy Agency, 2007).

Renewable energy and energy efficiency

Renewable energy and energy efficiency, often said to be the “twin pillars” of sustainable energy policy, must be developed in order to stabilize and reduce carbon dioxide emissions. Efficiency slows down energy demand growth so that rising clean energy supplies can make deep cuts in fossil fuel use. If energy use grows too fast, renewable energy development will chase a receding target. A recent historical analysis has demonstrated that the rate of energy efficiency improvements has generally been outpaced by the rate of growth in energy demand, which is due to continuing economic and population growth[7].

Thus, despite energy efficiency gains, total energy use and related carbon emissions have generally continued to increase. Therefore, given the thermodynamic and practical limits of energy efficiency improvements, slowing the growth in energy demand is unavoidable (Huesemann, *et al* 2011). However, unless clean energy supplies come online rapidly,

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[7] “The Twin Pillars of Sustainable Energy: Synergies between Energy Efficiency and Renewable Energy Technology and Policy”, ACEEE Report Number E074, 2007.

slowing demand growth will only begin to reduce total emissions. This implies that reducing the carbon content of energy sources in the planned power mix is essential, and any serious vision of a sustainable energy economy thus requires commitments to both renewables and efficiency (American Council for an Energy-Efficient Economy, 2007).

It must be pointed out that renewable energy (and energy efficiency) are no longer niche sectors that are promoted only by governments and environmentalists. The increased levels of investment and the fact that much of the capital is coming from more conventional financial actors, suggest that sustainable energy options are now becoming mainstream (*op.cit.*). According to a trend analysis from the United Nations Environment Program (UNEP), climate change concerns coupled with oil prices and increasing government support are driving increasing rates of investment in the sustainable energy industries. Investment flows in 2007 broadened and diversified, making the overall picture one of greater breadth and depth of sustainable energy use. Thus, the mainstream capital markets are now fully receptive to sustainable energy companies, supported by a surge in funds destined for clean energy investment.

8.4 Follow-up: Monitoring and Evaluation

The PSMP-2012 did not have an element of monitoring and evaluation; therefore, even the task of revising it now is based on uncoordinated and irregular data. Monitoring and evaluation is a matter of inter-connectedness between the SEA and policy and planning processes in order to harmonize recommendations, monitor measures and indicators, ensure synergism, and avoid conflicts and overlaps. The basis for a follow-up programme includes planning, management and preparation of monitoring guidelines.

8.4.1 How to follow-up

Follow-up in SEA should be based mainly on monitoring and evaluation and supported by a web of instruments to assist SEA systematically. A follow-up programme is part of the continuous SEA directed by the planning, management and monitoring guidelines, and evaluation studies and stakeholders engagement. An effective follow-up programme includes: monitoring indicators, a system of rapid evaluation, a set of evaluation instruments, and a responsible team, as well as resources.

It is important that a parallel environmental monitoring registry system and database are set in place to up-date to provide or provide data for future control and environmental studies. This monitoring registry system and database needs to be under the responsibility of a public authority to allow for public availability of data for future needs, and should be financially sustainable. Communication and participation is also fundamental. On-going liaison for engaging relevant stakeholders should be established and operationalized.

8.4.2. Monitoring and evaluation

Monitoring and evaluation of the strategic decisions is essential in SEA processes in order to enable uncertainty management. Legal requirements refer only to monitoring and reporting. But ideally follow-up activities should be integrated into existing planning and policy-making, monitoring and evaluation mechanisms. For this to happen, systematic control over performance and conformance outcomes as well as inputs to address emerging unexpected issues that require change of pathways are the key purpose of follow-up. Performance and strategic indicators should be selected, based on standard available indicators.

State of the environment reports, local, regional, and sectoral sustainability reports should be fundamental contributors to setting up a monitoring database that may, whenever necessary, inform any future changes of strategic direction in a rapid and simple way. A limited number of follow-up indicators need to be selected to ensure a viable follow-up programme and effective control. In general, selection of indicators is usually done based on the following criteria:

a) The indicator must provide timely information (to allow for response);
b) The indicator must be sensitive to be able to detect small changes in the system;
c) The indicator must be based on good quality data that are available at a reasonable cost (i.e. cost- effective or affordable;
d) The indicator must be based on data of correct spatial and temporal extent;
e) The data must be attainable and its collection process should have minimal environmental and social impact.

Particular attention must be paid to strategic changes and especially to emerging strategies or ruptures in the system that may suddenly change previously expected trends. Instruments such as environmental impact assessment (EIA), environmental management systems, public policies analysis and evaluation, spatial planning and conservation programmes, amongst others are instruments that may assist SEA in following up policy, planning and programme implementation. The following tasks maybe considered in a follow-up programme:

a) Develop, or review, follow-up guidelines (planning, management and monitoring).
b) Verify the efficiency of the governance framework and any institutional changes.
c) Verify changes to Environmental and Social Management Plan (ESMP) and additional conditions or orientations.
d) Verify uncertainties and unexpected events.
e) Verify adequacy of monitoring indicators.
f) Analyze selected follow-up indicators (preferably around 20).
g) Verify SEA efficiency.

8.4.3. How to communicate and undertake engagement

Public participation is considered a major activity in stakeholders engagement in SEA, for which communication is one of the main components. The principles of learning and knowledge sharing underline communication and engagement. Only a well-informed community is capable of effective participation. Multi-stakeholders platforms are in a better position to convey the majority of existing perceptions and values. Various communication tools and methods need to be used to engage stakeholders, depending on the occasion, type of stakeholders, context, time and resources available.

Thus, the publication of newsletters from early moments and throughout the process is a very informative tool. Where internet is easily accessible by the majority of relevant stakeholders it may be a preferred means of communication for information and reciprocal exchange. In any case internet should not replace direct contact and opportunities for dialogue and constructive exchange of ideas and perspectives namely in workshops, social networks and other direct forum. Finally, reporting should also be seen as a mean of communication to both reviewing authorities as well as key stakeholders.

The important moments for communication are many, but there are at least three indispensable ones i.e. when discussing the main problems and the strategic focus, when assessing possible strategic options, and when sharing final results.

8.5. Institutional arrangement

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. 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.

Thus, the principal institution relevant for the implementation of the SEA and its recommendations is the Ministry of Energy and Minerals (MEM). The ministry is particularly responsible for policy issues, legal processes, and overall implementation of the policies in this SEA. Therefore, it is also be responsible for overseeing the implementation of the PSMP 2016 Update. As directed by the Environmental Management Act (Cap. 191), the Sector Environmental Coordination Unit within the Ministry of Energy and Minerals shall be responsible for monitoring and evaluation.

However, the Ministry of Energy and Minerals shall ensure that the Environmental Unit is fully functional and has well-developed capacity in terms of human resources, finances and equipment so that it can discharge its functions properly.

It is notable that at the level of implementation of PSMP, the Ministry of Energy and Mineral has created the EWURA, Tanzania Electricity Supply Company (TANESCO), TPDC, TGDP, and Rural Energy Agency to deal with specific issues related to Energy. Therefore, overall the proposed updating of PSMP falls under the MEM and will be implemented by TANESCO. EWURA directs and regulates energy utilization, and issues licenses for generation and operation. Besides the MEM, several sectors may be directly involved in implementation of PSMP.

9. Conclusion and Recommendations

9.1. Conclusions

The PSMP-2012 required upadating in view of the fast pase of development Tanzania has been experiencing since then and the desired goal of becoming an industrialized country by 2025. Demand to meet the ever increasing development needs and targets lead to the revision of the Power System Master Plan so that the country could not only achieve reliable energy but also afforable and possibly environmentally friendly energy supply.

Five energy development balance and mix were considred taking into account energy balance, cost and environmental implications. Based on a WASP software of analysis for such large scale development scenarios, the PSMP Task Force Team has proposed the adoptuon of Scenario 2 for development of the PSMP. This scenario is projeted to consist of 40% gas;35% coal; 20% hydro and 5 % renewables and would cost an estimated US 45,099 million to establish.

The detailed environmental analaysis however, shows that scenario 1 is more environmentaly frienndly than scenario 2. This scenario will consist of 50% gas; 25% coal; 20% hydro and 5% renewables and would cost an estimated US$ 45,838 million. The higher cost in this scenario is attributed to adoption of more environmentally friendly solutions that internalizes and minmizes effecct of emissions as opposed to scenario 2 that has externalized those environmental costs.

Also, it has been noted that the PSMP-2012 did not have a coherent and comprehensive monitoring and evaluation program, which makes it diffocult to measure the effect of the program. Other impacts that have also been highlighted in this SEA include health risks associated with gas emissions that may lead to human diseases. Others are climate change, acid rain, excessive pressure on water resource, change in vegetation cover due to clearing for transmission lines, loss of land due to establishment of various power generation stations and transmission lines, impact on bird movements and impact on marine resources arising from release of hot water from gas powered plants that are located along the coast of Tanzania.

9.2. Recommendations:

I. Gas being environmentally relatively better than coal, and in order to adequately protect the environment, the people and ensure sustainability of the PSMP, scenario 1 is considered and recommended from the environment point of view as a more environmentally friendly development scenario compared to scenario 2.

II. Each power generation and transmission project must be subjected to detailed and participatory Environmental and Social Impact Assessment.

III. National and international standard on emission levels sould be applied to protect the people and the environment,

IV. The best affordable and environmentally friendly technologies for power generation and transmission should be adopted as means to safeguard the environment and the people,

V. Where land will be acquired for establishment of power generation plants, transmission lines of substations, fair and timely compensation to the affected persons should be provided.

VI. Capacity development measures to the Environmental Unit of the Ministry of Energy and Minerals and TANESCO for the implementation of the SEA recommendations should be designed, financed and implemented.

VII. A robust Monitoring and Evaluation system for the implementation of the PSMP and this SEA should be established, funded and implemented.

VIII. As a matter of policy, there should be a deliberate programme to show when and how the country will gradually switch to more use of cleaner renewable energy sources.

IX. Coal based power plants must be cited close to reliable and sustainable sources of water for cooling.

X. The citing of thermal electricity plants should avoid prime biodiversity areas including wetlands and natural forests.

XI. All waste water from thermal power plants should be collected,and thoroughly treated before discharging into receiving water bodies.

XII. Fly ash and other wastes should be disposed in surveyed landfills or abandoned mines, while some amounts are recycled into useful products, such as cement and building materials.

XIII. With regard to management of water for hydropower generation, there is need for policy changes that will allow MEM to manage strategic cachtment areas that feed into the power supply. This sort of decision will require detailed assessment of the challenges the current arrangement imposes on power generation.

XIV. Design measures that will reduce land acquisition for transmission and other utilities muts also be built in the PSMP.

XV. Deliberate policieis need to be put in place to ensure large population is accessing electrictiy. This will not only improve livelihood but also reduce the use of biomass as sourec of energy and miminize deforestation

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11. ANNEXES

The annexes constitute:

1. Stakeholders consultation Results/Issues
2. Signatures of stakeholders consulted
3. Power transmission maps
4. Photo of consultation and visit at different sources of energy and energy users

Annex 1: Stakeholders Consultation Results/Issues

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
1	**Introduction and Kick – off meeting to MEM** Meeting with Mr. Silinge and Mr. Kasege - Environmental Unit of MEM.	08.10.2014	MEM HQ	• MEM staff is aware of the work and are ready to give the SEA team the support needed. • Agreed to set up a meeting of all parties in this SEA process - namely representatives from Environmental Units of MEM, TANESCO; Engineers from MEM, TANESCO and JICA and our Team from IRA. • The purpose of the meeting is to establish contacts among the team and to agree on the mechanisms of ensuring we work together and inform each other on the progress and decisions. • MEM will arrange the meeting and call all participants to attend. • We need to engage stakeholders in consultation and in particular meeting with the Permanent Secretary or even the Minister to get their policy views on the revision of the PSMP and development in the country for now and in future. MEM will arrange the meeting. • We will need to share stakeholder list and analysis with MEM and others and agree on consultation plan. • MEM would like to have one staff attached to the SEA team to serve as secretariat but also as part of capacity development on SEA for MEM. • MEM will provide IRA team with reports, policies, laws, and guidelines related to energy development in Tanzania. •
2	**Introduction and Kick – off meeting to VPO - DOE**	25.08, 2014	VPO- DOE Office	• DOE is aware of the proposed SEA and has already issued a letter to MEM to allow them to proceed with the process. • DOE had stressed the importance of producing a quality report. • DOE outlined areas that they will be involved, to include: a) Take part in a site visit – after the submission of the Draft SEA report. b) Call a stakeholders' workshop to discuss the draft SEA report. c) Call Technical Review Committee of the DOE to review the draft report after incorporating comments from the stakeholders' workshop. d) Prepare a summary report to advise the Minister responsible for the environment on the decision about the SEA and intended use of the SEA report.

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				• The client, in this case MEM, will have to cover DOE’s cost for site visit, stakeholders’ workshop and TRC meeting. The cost will be provided later but it is important that MEM is aware of this requirement well in advance. • VPO –DOE will share with the IRA SEA team various laws, standards and policies relevant to the proposed development.

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
3	Introduction and Consultation with TANESCO officials. The following officials were involved Ally K. Kondo – Environmental Officer Pastory N. Mwijage – Statician James J. Kivugo – Commercial Engineer Focas Daniel – Planning Engineer AbdallahChikoyo - Planning Engineer Enid Bukambu – Investment Officer	15/10/2014	TANESCO Training Centre	***i. SEA - Training*** • Discussed about offering SEA training to TANESCO and MEM officials involved in the implementation and revision of the Master Plan; ***Why review the current PSMP?*** • Worldwide, Power Master Plan is updated after every two years while Comprehensive Master Plan is after five years; • Current revision is inevitable due to increasing demand for power. ***iii. Challenges for implementing the current PSMP*** • Lack funds; • Compensation issues delaying projects – e.g. 150 MW Kinyerezi planned from 2014 now 2015; Kinyerezi – Arusha now 2017 instead of 2016; Kinyerezi 240 now 2017 instead of 2016; • Price of electricity especially from independent power suppliers is too high for customers; • TANESCO as utility organization should be allowed to generate. ***iv. What should be done?*** • The government should invest on power system to reduce dependence on private suppliers; • Funding for power projects should be provided on time to ensure timely implementation of programs; • Ministry of Finance to provide government guarantee for TANESCO to access loans to implement power projects; • Encourage and strengthen Public and Private Partnership in Power generation; • TANESCO and MEM to work on harmonization of PPP policies; • Involvement of academicians in Power plant generation is crucial for effective implementation of programs; • There is a need for frequent review in order to ensure smooth implementation of programs. ***v. Sustainability of energy programs/projects*** • Invest on renewable energy such as wind, solar and oceanic currents; • This should be followed by coal and gas that should remain as reserve until when is absolutely critical; ***vi. What need to be included in the PSMP*** • Include element of Monitoring and Evaluation in the new PSMP • Monitoring should involve all components of the program

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
4.	**Consultation with Rural Energy Agency official (REA).** Boniface GissimaNyamo – Hanga- Technical Assistant Manager	26/09/2014	REA Head Office, Mawasiliano Tower	The role of REA in the implementation of PSMP • Promote, facilitate and improve modern energy access for productive uses in rural areas in order to stimulate rural economic and social development. • Promote rational and efficient production and use of energy, and facilitate identification and development of improved energy projects and activities in rural areas. • Finance eligible rural energy projects through Rural Electrification Fund. • Build capacity and provide technical assistance to project developers and rural communities. Challenges for implementation • Shortage of human resources • Little capacity to generate electricity compared to energy demand in rural areas • Donor dependence for the implementation of various projects How environmental issues have been /should be addressed in the implementation of PSMP. • Adhere to NEMC and EMA (2004) requirements • Guided by sector environmental action plan • All projects supported by World Bank are required to adhere to the WB requirements on environmental issues What should be done to ensure effective implementation of PSMP • There must be a strategic plan for PSMP implementation and mechanism for implementation.
5	**Consultation with Ministry of Industry and Trade officials** Eng. Deodatus T.	04.10. 2014	Ministry of Industry and Trade office Water Front	• Power demand for industrial development is high than TANESCO can supply. • Monopoly of power supply and distribution is not effective to ensure good and quality services. • Monopoly in Power generation, supply and distribution should be abolished. • Water should not be the only source of power. Gas, coal, wind and

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
	Ndunguru - Assistant Director, Industrial Development Mizuno			geothermal should be promoted • In case of coal power generation, high technology should be used to reduce the impact of emissions to the environment • The government should subsidize power generalization activities, in order to reduce the price to consumers • PPP is good, however, the government should take a leading role to ensure quality and manageable cost of power • Power fluctuation is dangerous for manufacturing industries • PSMP have under estimated power demand for manufacturing sector, there is a need to establish realistic power demand. • Power from gas is still expensive; TPDC should interfere to reduce the price.
6	**Consultation with Ministry of Water** Eng. Elizabeth Nkini	26.09.2014	Ministry of Water Head Quarters –Dar es Salaam	• MEM is one of key stakeholders especially in abstraction, it ranks number two after the Ministry Agriculture. • Water policy 2009 address issues of water uses to large number of consumers. • Water Sector Development Program is our program mostly used in villages. • The major problem is to balance water for human use and other users • There are challenges of irrigation, livestock and agriculture • We have enough water but we find there are so many projects in one area that require water • Partners such as MEM are not in conserving water sources • In our nation there is no coordination of plans for example MEM have not asked us if we have enough water and we have not budgeted for the proposed project in this strategic master plan • Management of water is decentralized at basin level TANESCO used to give royalty for basin office to enhance conservation of water sources. • Now days there is no loyalty, the only money TANESCO pays is fee for water obstruction which is not sufficient. • Because we have adopted Integrated Water Resource Management and all stakeholders should be involved in conservation of water sources. For

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				example MEM should participate in conservation of water catchment. • Conservation of water source should be the key issue to all stakeholders including MEM • Degradation of water source is very high in the country. This is a problem which need to solved as soon as possible • Mining process is also a problem since government provide license of mining process in sources of water • Integrated water resource management adopt plan to know demand for each basin. This will help to make our plan for sustainable water sources • In policy and laws there is no harmonization. Different laws and policies contradict each other • Relying on hydropower is a very big challenge because of climate variation. • The MEM should start thinking about using Uranium and Coal to generate power
7	**National Development Cooperation** Ramson Mwilangali-Director Heavy Industries Isack Mamboleo-Mining Engineer Sospeter Kerefu-Head of Steel and Electrical AbdallahMandwanga Metallurgical Engineer	23.09. 2014	NDC Head office	• NDC is a leading Industrial development and promotion organization dealing with projects that have huge impact to the country as well developing infrastructures to enable industrial growth such as electricity Challenges for implementation PSMP • The current projection for energy in the country needs to be revised as there is suppressed demand for electricity in the country-The current figures cannot service heavy industries so most investors turn down their investment in the country due to inadequate power • Most industries cannot develop because of power shortage. • The current target is 3,000 MW but with the sources we have, this cannot be reached • Currently in Tanzania, energy consumption is very low. • The power system in terms of infrastructure is poor and unreliable. • Mining sectors cannot develop in many parts due to unreliable power. Recommendations for PSMP

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				• All relevant stakeholders should be involved in preparing the plan example the National planning Office, Heavy Industries, Mining, Agriculture and manufacturers; the MEM should be the coordinator. • The PSMP is well documented but problem is funds for implementation; therefore donors, financial institutions should be involved during the planning phase. • The Electricity Act provides for private investors in the sector BUT during negotiations it is a challenge; the revised PSMP should consider this process. • It is important to dismantle TANESCO into several components. • Problem with private investors is that they also have to build infrastructure such as transmission lines- The Government should consider developing power infrastructure and handling issues of compensation of land for investments • Need to consider coal as the base load for reliable power and gas and hydro can be intermediate and/or peak source How environmental issues have been /should be addressed in the implementation of PSMP? • Technologies used for any generation should be stipulated in the guidelines to ensure environmental friendly. This includes use of both national and international standards of emissions.
8	**Ministry of Land Housing and Human Settlement Development-** Mr. Daniel Nguno Ag Assistant Director of	25/09/2014	Ministry of Lands Housing and Human Settlement Development	• Land ownership is stipulated in the Land Act of 1999, that foreign investors are not allowed to own land but they access land through local institutions such as TPDC, NDC, and TIC etc. • Certificate of occupancy normally can be revoked for public interest. • Various projects proved failure due to complications and contradictions of laws and regulations in using land by foreign investors as a mortgage. • Incorporation of master plans should be in place i.e. Ministry of Land should incorporate various Master Plans from different sectors. Therefore,

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
	Master Plan			PSMP should be submitted to the Ministry of Lands at the earlier stage for the purpose of harmonization. • Sector coordination such as TANESCO, TANROADS and Ministries should be upheld and by-laws should be established for the purpose of harmonization. • Master plans should not be rigid, design can be changed i.e., there is a need for flexibility. • For any project that involves land take, the MLHHSD will insist on full, fair and prompt compensation to affected persons to avoid conflicts • There are so many problems associated with land acquisition by development projects; these includes: ✓Delay and unfair compensation ✓Influx of people and development in the project areas before compensation. Prohibiting development is not stipulated in the regulations ✓International rate of compensation paid by foreign companies usually conflicts with government/local companies because foreign companies pay higher rates.
9	**Ministry of Agriculture and Food Security** Mary Majule Principal Agricultural Officer -EMU ZainabuSheuya-Agricultural Officer	02/10/2014	Ministry of Agriculture and Food Security	• In preparing a Master Plan it is very important to involve all stakeholders very closely including farmers. Currently we are promoting irrigation farming (Irrigated farming). • The Ministry of Agriculture and Food Security have Irrigation Master Plan it is important to look at it so that the proposed updated power system master plan does not conflict with it. • The effect of power project to agricultural sector depends on the location (where the power project will be located) because some locations as seen in the maps are corridors for irrigation • Currently agricultural sector is encouraging the use energy for irrigation and several farmers are using electricity for irrigation however they are complaining that the cost is too high and therefore they are not benefiting from it. • The improvement of power generation and supply should result into low cost in using electricity

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				• Apart from irrigation the Ministry of Agriculture and Food security is encouraging on mechanized agriculture; value addition agro-mechanics, thus electricity is important in agriculture in order to improve agricultural sector • The MAFS have several departments such as Irrigation; Land Use Planning; Policy and Planning, Crops Development; Food Security etc. Each sub-sector has to be involved because the PSMP may affected their operations or vice-versa. • There is a plan to have cold rooms to the area where vegetables and fruits are produced at high rate to allow preservation of the farm products. This will need power as well. • Awareness to the local people about the project should be provided in order to reduce conflicts. • With increase in climate change water is becoming scarce while demand is increasing; increase in hydro project will result in more water scarcity and cause conflicts with farmers and other users of water. •
10	**Consultation with MEM and TANESCO officials.** **Thirteen officials from MEM and Two from TANESCO attended the meeting**	08/10/2014	Ministry of Energy and Minerals	***Issue/question-*** Any update on the implementation of the current PSMP ***Response*** – Different projects for power generation expansion indicated in the PSMP are at different stages of implementation. E.g. Kinyerezi 1, 150MW is expected to be commissioned by March 2015. The Iringa – Shinyanga (*Backbone*) and Makambako – Songea transmission lines contractors are at sites. ***Issue/question***: What are changes on the implementation of the current PSMP – institutional, human resources, financial, environmental and policy issues ***Response***: Some changes which have occurred include the introduction of PPP framework in power generation, review of the National Energy Policy, 2003; implementation of Electricity Supply Industry (ESI), Reform Strategy and Roadmap; Natural Gas Policy, 2013 ***Issue/question***: What is the MEM opinions in relation to sources of power

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				generation and technologies ***Response:*** The main target is to have different sources of power by promoting efficiency utilization of natural resources and reduce dependency on hydropower. Renewable energy resources such as geothermal, solar and wind are highly encouraged. For short-term measures, the plan is to generate power from natural gas and renewable energy. For medium and long term plans, the focus will be on coal-to electricity as base load. ***Issue/question:*** What is the MEM opinion on institutional arrangement for generation, transmission and distribution ***Response:*** Through the implementation of ESI Reform Strategy and Roadmap, it is envisaged to have vertical separation of power generation from transmission and distribution in a gradual transformation ***Issue/question:*** MEM opinions on PPP in relation to energy development, what each should do? ***Response:*** PPP framework is welcome in the interest of easing Government's financial burden on key electricity generation projects. Greater focus should be on involvement of Private sector so as to break up project financing on shared interests ***Issue/question:***Sustainability of energy projects/programs ***Response:*** To abide on PSMP for resources diversification and optimum utilization of human capital and technologies ***Issue/question:*** What need to be included in the new PSMP

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				Response: - Maintain the ratio of 40:60 for hydro to thermal or hydro should be less. - Establish PSMP 2014 update implementation strategies ***Issue/question:*** Is there any monitoring and Evaluation system of the existing PSMP? ***Response:*** There is no specific system, however, Monitoring and evaluation of project implementation of projects is done under PSMP 2012 update as per financial year budget plans ***Issue/question:*** Reports/data in relation to power demand and supply in the country • ***Response:*** Apart from PSPM 2012 update, data is available at different levels i.e TANESCO Regional Offices but are scattered and spatial. Normally, load demand survey is conducted to establish forecasted demand for 25 years
11	**Tanzania Chambers of Minerals and Energy (TCME).** Mr. Emmanuel W. Jengo – Executive Secretary Mr.Nyanda J. Shuli – Communication and Advocacy Manager	06/10/2014	TCME office Dar Dar es Salaam	• The demand for power in mining sector is high, currently Geita need 25 MW, MwaduiWilliamson 6 MW, North Mara about 15-20 MW, Buzwagi 15 MW and Buryankuru 25 MW, Kambanga will need about 30MW while Uranium at Mkuju River will need 15MW. More power is needed to meet this demand. • Not only the amount of power needed, but the issue is the quality of power needed to run the kind of machines and equipment that need constant un interrupted flow of electricity to meet the required need throughout the production circle. • The quality of power is poor forcing the Mining investors to look for alternative reliable standby sources of power. This decreases the bargaining power of the government to mining sector. Self-generation of power by investors which is being practiced by all investor in Tanzania is increasing the cost of production- in most cases mining companies enter into agreement with reliable companies to generator sufficient power to meet the demand. • The projected demand of power in the mining sector is estimated at 200-

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				300MW per year. • TANESCO fail to extend the power grid to where mining are located- thus mining companies enter into agreement with TANESCO to develop the infrastructures and utilise power for years until they recover the investment cost. • TANESCO should be divided to have generation unit, which will focus on generating power and looking for alternative source of generation to meet the increasing demand. Distribution section should provide real cost and not unjustifiable high cost. • PPP can help to minimize the generation problems as private may look for alternative sources that are cheap and generate power that will be affordable to the users. • The government can come up with policy decision that every house in the country should have solar power and minimize the dependence of hydro power source. Similarly wind power can contribute to alternative sources of power.
12	**Southern Agricultural Growth Corridor of Tanzania (SAGCOT)** Mr. John B. Nakei – Environment and Social Specialist	10/10/2014	SAGCOT Office Dar es Salaam	• There are several investment and planned investment in different clusters from the coastal zone to southern highland. Most of the investment is on commercial agriculture with agro processing and energy generation projects. • Several planned investment on commercial agriculture is being planned in areas where MEM/TANESCO are planning to put several hydro power plant to increase generation capacity to meet increasing demand for power in the country. • In all area where the plans are underway, SAGCOT is assessing the water situation to come up with the demand and projected demand to cater for the planned investments • In addition to water assessment by SAGCOT there is other planned investment in infrastructure such irrigation road and storage facilities supported by BRN projects • Most of the SAGCOT planned investments are focusing on capital investment agriculture where investor are guided by established guideline to deal and mitigate the challenging issues in their cluster of investment. For example how to mitigate water shortage, power fluctuation and shortage, the developer

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				has to come with possible implementable means to solve the problem while investing in the area. • Environmental issues are well taken care of by planned investment under SAGCOT, there are several guidelines that guide the operation and how to achieve green print, similarly there is a SAGCOT green strategy and an Advisory Committee on Environment • In preparing SEA and updating the PSMP: MEM/TANESCO should look at the SAGCOT green strategy, the document that stipulates a number of strategies and how to deal with potential risks associated with implementation of several investments in the area. • MEM/TANESCO can adapt some of the measures proposed in the SAGCOT green strategy • There is a need to look for alternative sources of power and move away from total dependence of hydropower as a source of power given the fact that water is becoming scarce due to increased population, climate change and other demand. • Possible alternatives include wind farms, solar and natural gas. • There is need to communicate and coordinates activities, projects and programs that are carried by SAGCOT and MEM/TANESCO on same area utilizing same common resource.
13	**KIDATU HYDROPOWER PLANT** Eng. Justus B.C.Mtolera - Plant Manager Eng. Joseph Kuyugu - Civil Technician	02/02/2015	Kidatu Power Plant Office - Kidatu	• Currently Kidatu power plant is the biggest hydro plant in Tanzania. • Average power generation is: 700GWh during dry years and 1,000GWh during wet years • Water sources to Kidatu Dam are Mtera reservoir, Lukosi River and Iyovi River • Hydropower Electric power is more preferable due to the following: Hydropower is a renewable source of energy—and saves scarce fuel reserves. • It is a clean power source, because there is no air pollution or radioactive waste problems associated with it.

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				• Since water power produces no carbon dioxide, it does not contribute to global warming. • Hydropower stations have an inherent ability for instantaneous starting, stopping, load variations etc. and help in improving the reliability of power systems. • Hydroelectric projects have a long useful life extending over 50 years. (e.g. the plant installed in 1897 in Darjeeling, India still in operation). • Average cost of generation, operation and maintenance over lifetime is lower than any other sources of energy. • Hydropower has a higher efficiency (over 90%) compared to thermal energy (up to 45%) and gas (up to 60%). **Challenges** • Unavailability of adequate water for power generation • Lack of sector coordination • Climate change effect pertaining to shortage of rain • Increase in human activities upstream of our reservoirs (Mtera). In Nyumba ya Mungu for example Lower Moshi irrigation scheme sponserd by JICA was a big threat to hydropower generation. • Environment degradation • Increase in water usage in basins. This is due to so many provision of water rights, Illegal, handmade water diversions in the water catchment areas.
14	**Mtwara Tanesco Regional Office** Mr. Azizi Salum Tanesco Regional Manager Mr. Daniel Kayombo Tanesco Mtwara-Engineer	04/02/2015	Mtwara Tanesco Regional Office	• Previously diesel generators were used to generate power to cutter for Mtwara and Lindi. This was before gas. • Gas production has increased power reliability in Mtwara region. • The current capacity for Power Generation is higher compared to consumption. The plant has the capacity to generate18MW. Among these, only 14.6Mw is utilised. • Generally the demand is rapidly increasing in Mtwara and Lindi. In the year 2011, 11,179 customers were connected compared to 22,016 customers who were connected in 2014. The increasing trend is associated with government decision to subsidies connection fees for domestic used which reduced the

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				cost from 397,000/= to 99,000/= • 400MW has been proposed in 2015 to service Mtwara town and the entire region. It will also be connected to the National grid in Makambako and Songea. • In Mtwara there are only 3 larger consumers who have electricity demand exceed 500kVA. These are TPA, Dangote (SNOWMAN) and Water pump station in Newala. • Hydro power is more preferable only if there will be sustainable conservation measures in water catchments. • There are so many investors from different places showing interest to invest in processing industries in Mtwara therefore in five years there could be a tremendous power demand. Challenges • Way leaves are associated with land use conflicts due to the fact that community agreed to contribute land for way leaves but at the end they changed. • Land for power distribution lines are not planned in advance, hence difficult to get land for power distribution and sometimes it leads to land conflicts • There are so many encroachers in the way leaves
15	**Mtwara Power Plant** Mkulungwa Chinomba - Mtwara Power Plant Manager	04/02/2015	Mtwara power plant office	• Plant installed capacity is 18Mw • Maximum power demand is 14.6Mw • Daily maximum gas consumption is 2,600,000 scf/day • The plant has reduced pollution from fuel which was previously used • Ensured reliable power supply for Mtwara region • It has created employment opportunities – directly and indirectly • In terms of environmental management, the plant follows the ISO standard for safety and health • It also, adhere to manufacturer recommendations • Power mix generation is crucial because of various risks associated with power generation

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
16	**Micronix System** Sunil Mizar - Production Incharge	04/02/2015	Mtwara plant office	• Micronix system is the private company involved in collection and processing of cereals crops in Africa. There are various branches in Tanzania. • In Mtwara the company deals with collection and processing of cashew nuts. • Approximately only 50% of electricity is used in the operation, the rest 50% of energy is from other sources particularly steam/boiler using cashew nut husks. • The company owns the same factory in Newala and Tunduru. • Diesel generator supplied by TANESCO is the only source of power for the Newala and Tunduru plants. • Energy consumption depends on the production, though energy from diesel generator is relatively expensive compared to power from gas or any other source, therefore, running cost in Tunduru and Newala factories is very expensive compared to Mtwara.
17	**TPA- Mtwara Port** Mr. Alex M Ndibalema – Ag. Port Master Capt. H. Kasugulu – Harbour Master Mr. Nobert M. Kalembe – Senior Estate Officer Mr. Melessy Okachu – Port Fire and Security Officer Mr. Juma Mairo – Ag. Port Security Officer Eng. Peter Odock Ogulo – Port Engineer	04/02/2015	Mtwara TPA office	• Power availability was worse in 1990's before gas production. • Port operations are on increase as well as power consumption. In the year 2007, the port authority spent about 6million compared to 25million in 2014 per month for electricity • TPA is planning to expand Mtwara port, currently, Mtwara port is operating under the existing 70 acres while the total land owned by TPA is 2693hk of which 2623hk has been reserved for port expansion. • Fishermen have experienced decrease of fish catch in recent years compared to the 1990,s. Besides, some fish species has disappeared and there is perception that the water quality has changed, possibly due to pollution from gas exploration. • Gas Exploration companies have taken some measures in relation to waste management. They have a treatment plant with two incinerators.
18	**Mtwara Regional Office** Halima Dendegu- RC - Mtwara	05/02/2015	Mtwara Region Office	• Currently Mtwara and Lindi regions are benefiting more from gas production because this is the only reliable source of power in these regions. • Hydropower generation is not preferable because river Ruvuma is the only reliable river and switching to H.E.P may trigger pressure to water resources.

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
	Alfred Luanda –RAS-Mtwara			• Due to gas production in Mtwara and Lindi there is a massive development of small towns especially in Nanyumbu and Newala districts. • The gas is also potential to public entities in these regions such as health sectors, schools, army areas, and school laboratories • The location of treatment plant with its incinerators for wastes from Gas exploration is not proper because it located close to settlement. There is a need to relocate the plant
19	**Mnazi Bay Gas Production Facility** Mr. David – Operation Manager Mr. Musa Kongola – Assistant Operation Manager Ms. Remna Mnandoa – Health, Safety and Environmental Officer	05/02/2015	M&P Mnazi Bay office	• The Government of Tanzania (GOT) through its Tanzania Petroleum Development Corporation (TPDC) invited the international petroleum industry and other specialized investors to participate in the exploration of hydrocarbons in Tanzania under the Production Sharing Agreement (PSA). • In year 2009, M&P Exploration Production in Association with Wentworth Gas Limited started activities in the Mnazi Bay exploration and production concession block that covers an area of 756 sq. km located some 400 km south of Dar es Salaam closer to the border with Mozambique. • The block has gas production facilities at Mnazi Bay consisting of four producing wells (MB-1, MB-2, MB-3 & MS-1X), gas processing plant and a 28km pipeline which conveys the gas to Mtwara Power Plant, which demands around 2mmscf/day of gas. This power plant supplies electricity to the southern coastal regions of Mtwara and Lindi. • Machineries are properly serviced and checked to make sure that they do not leak fuel and lubricants. • Refuelling is carried out beyond 100 m from the water source in order to control pollution of water bodies from spills • Noise generators are well maintained or fitted with noise silencers such as mufflers to reduce noise
20	**SONGAS** Mr. Jonnes Masalla – Environmental Coordinator Mr. Moses Mgeni – Health and Safety Coordinator	27/02/2015	Songas Office, Ubungo	• SONGAS Limited commenced its operations in July 2004. The company generates electricity using gas from the SongoSongo Island gas fields, off the coast of southern Tanzania. • SONGAS conducts gas processing, transportation and power generation. The gas is processed on SongoSongo Island and is transported from there through a 225km pipeline to Dar es Salaam where it is used in the SONGAS Ubungo

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				Power Plant. • The 190 MW natural gas-fired plants at Ubungo consist of six open-cycle gas turbines. The plant supplies electricity to the national electricity grid • SONGAS supplies gas from the SongoSongo Island directly to 30 industrial consumers for electricity generation. One of them is the Twiga Cement Plant at Wazo Hill in Dar es Salaam • Environmental management is guided by IFC – World Bank Guidelines. • The Emissions at stack - compliance parameter for NOx has emission limit of 200mg/Nm (WB Guideline), CO has emission limit of 100mg/Nm (UK Guideline and PM has emission limit of 50mg/Nm (IFC & WB Guideline • Ambient Air Quality follows IFC and WB Guideline
21	**Kihansi Hydropower plant**	22/12/2015	Kihansi Hydropower plant	• Discussion with the Manager and other supporting staff During the field visit it was observed that various conservation and management initiatives in Kihansi catchment have been triggered by the following factors:- i. The discovery of Kihansi Spray Toads coupled with the significance attached to the Udzungwa Mountains which created a lot of discussion in the conservation World. ii. Tanzania as a signatory to the Convention on Biological Diversity (CBD), Convention on International Trade of Endangered Species (CITES), Ramsar Convention and other Environmental Agreements, was bound to abide by these Conventions. Due to these factors, it was therefore important the Kihansi Spray Toads which represent other endemic species must be conserved. In order to address conservation issues in Kihansi catchment, the following iniatives have been undertaken by the government in colloboration Non Governmental Organizations:- i. To establish a long term Ecological Monitoring of Kihansi Gorge

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				ii. Immediate Rescue and Emergency Measures and iii. Formulation of Lower Kihansi Management Project which was followed by Kihansi Catchment Conservation and Management Project. The field study revealed that the implementation of conservation activities involved several stakeholders. These stakeholders are:- i. The Vice President Office – under the National Environmental Management Council (NEMC) ii. The Ministry of Natural Resource and Tourism – through Tanzania Wildlife Research Institute (TAWIRI). iii. The Ministry of Water - through Rufiji Water Basin Office (RWBO) iv. The Ministry of Energy and Minerals – through TANESCO v. Local Government Authorities and NGO's According to the discussion with the Kihansi Plant manager, the Ministry of Energy and Minerals is responsible in maintaining the spray wetland habitat by making an artificial sprinkler as well as stairways, bridges, and the research station in the Kihansi Gorge which permits researchers and staff to access and work in the spray wetland to ensure reintroduction of the Kihansi Spray Toad back to its normal habitat. In summary the discussion with officials of Kihansi Hydro Power Plant covered the following key issues: • Kihansi hydropower catchment is well conserved and therefore, its

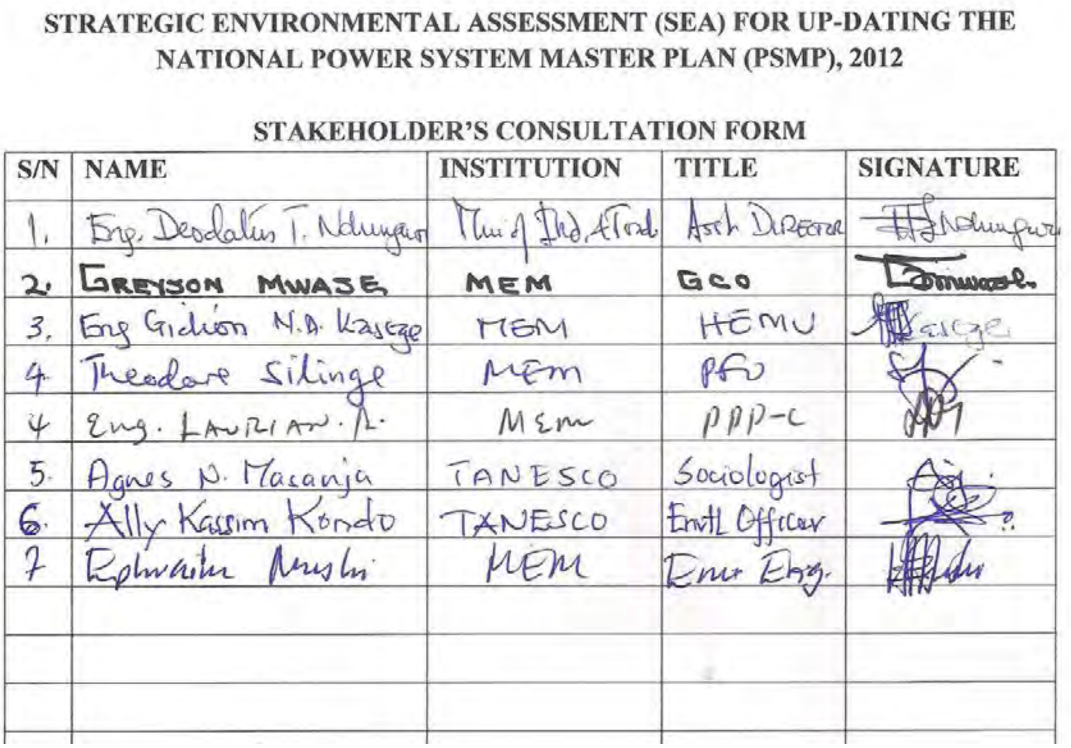
S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				power generation capacity is not much affected by shortage of water as compared to other hydropower plants such as Kidatu and Mtera • The discovery of Kihansi Spray Toads coupled with the significance attached to the Udzungwa Mountains triggered various conservation and management initiatives around Kihansi catchment areas. • Tanzania as a signatory to the Convention on Biological Diversity (CBD), Convention on International Trade of Endangered Species (CITES), Ramsar Convention and other Environmental Agreements, was bound to abide by these Conventions. Due to these factors, it was therefore important the Kihansi Spray Toads which represent other endemic species must be conserved. • In order to address conservation issues in Kihansi catchment, the following iniatives have been undertaken by the government in colloboration Non Governmental Organizations:-To establish a long term Ecological Monitoring of Kihansi Gorge, immediate Rescue and Emergency Measures and formulation of Lower Kihansi Management Project which was followed by Kihansi Catchment Conservation and Management Project

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				- There is an increase in human activities upstream the reservoirs - 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 - 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, however, these initiatives should be properly coordinated to ensure that those with an interest in water resource and energy play they are role in conservation and management of catchments.
22	**Rufiji Basin Water Office (RBWO)**	23/12/2015	Rufiji Basin Water Office (RBWO)	▪ Discussion with RBWO manager The main functions of the office include the following: ▪ Monitoring of water uses including the operations of the Mtera and Kidatu dams. ▪ Monitoring of the Water Resources (availability and quality). ▪ Issue of Water Rights and consents to discharge waste water. ▪ Conflict resolutions. ▪ Holding stakeholder meetings.

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				▪ Researches pertaining of Water Resources Utilization and Regulation. ▪ Administration of the water utilization law in the basin including collection of various water user fees. ▪ To educate and mobilize water users on matters concerning water resources management. ▪ In summary discussion with officials at the RBWO covered the following issues: ▪ There is environmental decline within Ruvu basin which is mainly caused increased human activities. The decline have economic, social, ecological, and cultural implications. ▪ Various initiatives are being undertaken by the basin authority in collaboration with Kilolo and Mufindi district to ensure that the environment is destructed by human activities ▪ Awareness and training program to farmers on environmental conservation are by using various Community Based Organization in the surrounding districts ▪ Population increase around the catchment areas is also threatening the sustaibility of the environment in the basin. The population growth have resulted to increased human settlements, smallholder agriculture, harvesting of fuelwood and building materials, salt-making, aquaculture, and fishing, all of which may have direct ecological impacts on terrestrial and aquatic environments ▪ There is lack of effective coordination among the various institutions

S/N	Activities Performed	Date	Venue	Outputs/Results/Issues
				involved in the environmental conservation.such as Division of Forestry, the Division of Lands, the Division of Fisheries, the Ministry of Water and the Ministry of Energy and Minerals simultaneously ▪ Harmonization of policies is crucial, but not sufficient, to redress the problem. Effective coordination among stakeholders also required. , ▪ The lack of capacity to enforce rules and regulations is a major issue for environmental conservation within the basin ▪ Participation of big water users in payment for environmental services. • Rainfall harvesting during rainy season and use the water during dry season ▪ There is a need to establish and implement good land use plan ▪ There is need to introduce payment for environmental services to all big water users within the basin

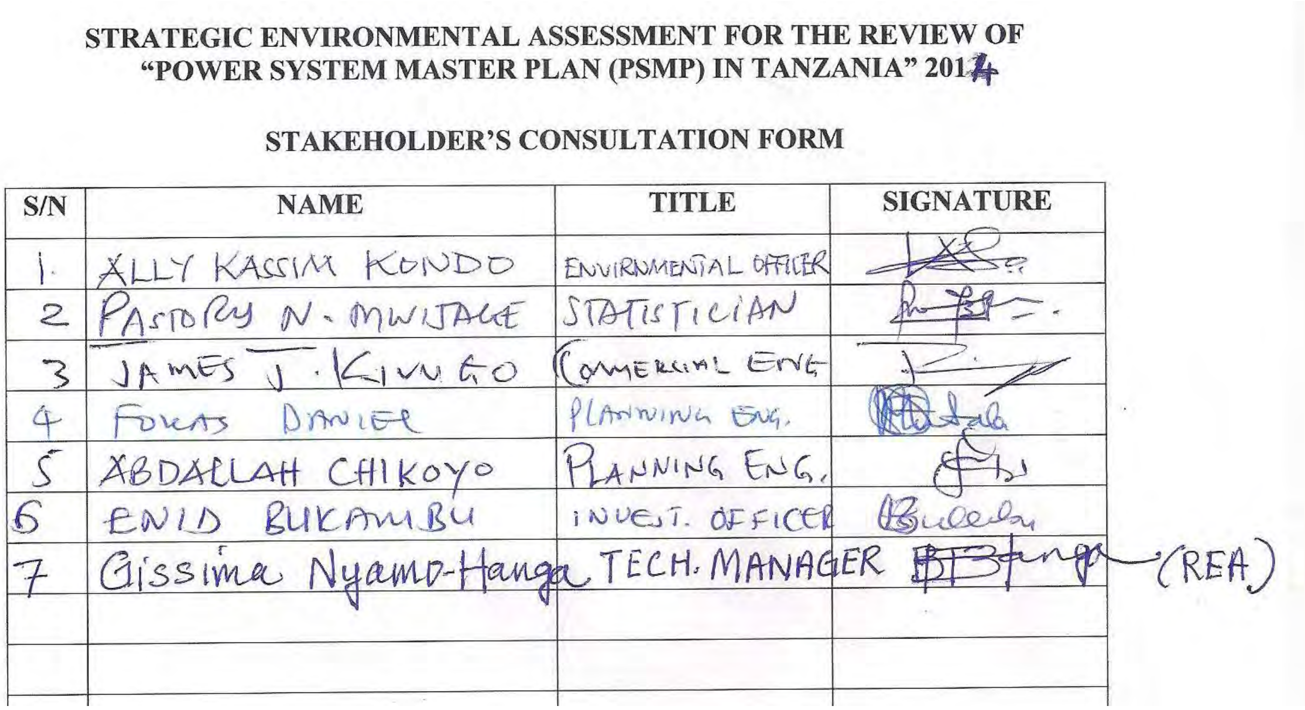
Annex 2: Signatures of stakeholders consulted



STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) FOR UP-DATING THE NATIONAL POWER SYSTEM MASTER PLAN (PSMP), 2012

STAKEHOLDER'S CONSULTATION FORM

S/N	NAME	INSTITUTION	TITLE	SIGNATURE
1.	Eng. Deodatus T. Ndunguru	Min. of Ind. & Trad.	Asst. Director	
2.	GREYSON MWASE	MEM	GCO	
3.	Eng Gidion N.A. Kasege	MEM	HEMU	
4.	Theodore Silinge	MEM	PFO	
4	Eng. LAURIAN . R.	MEM	PPP-C	
5.	Agnes N. Masanja	TANESCO	Sociologist	
6.	Ally Kassim Kondo	TANESCO	Envtl Officer	
7	Ephraim Mushi	MEM	Env. Eng.	

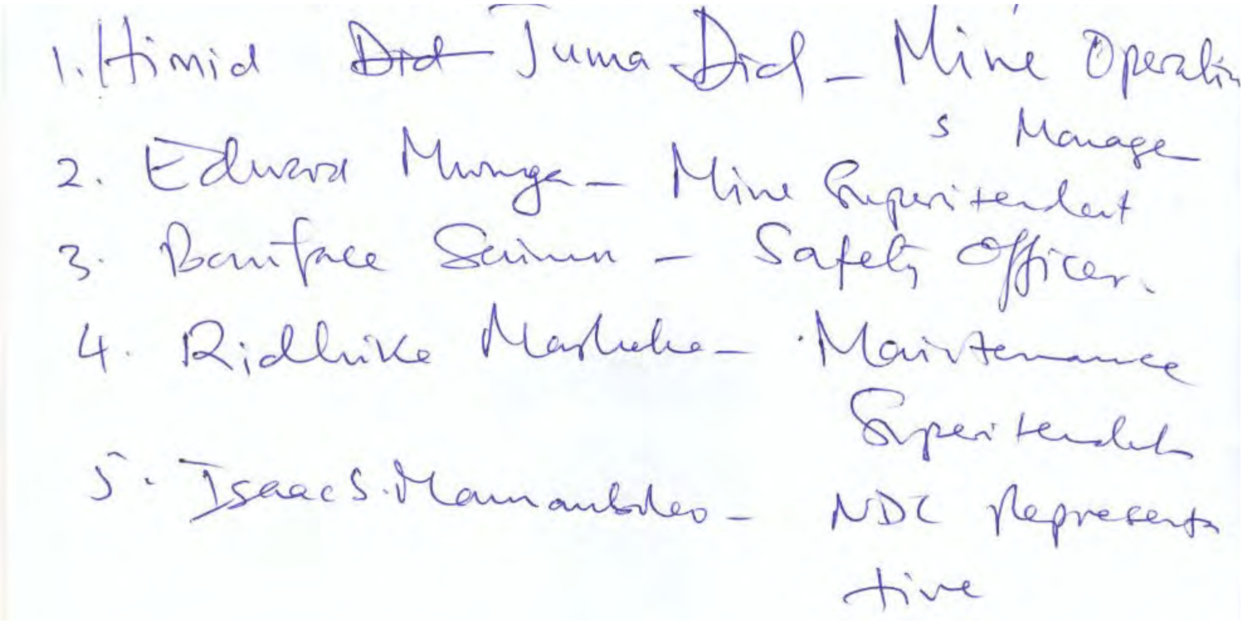


STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE REVIEW OF "POWER SYSTEM MASTER PLAN (PSMP) IN TANZANIA" 2014

STAKEHOLDER'S CONSULTATION FORM

S/N	NAME	TITLE	SIGNATURE
1.	ALLY KASSIM KONDO	ENVIRONMENTAL OFFICER	
2	PASTORY N. MWIJAGE	STATISTICIAN	
3	JAMES J. KIVUGO	COMMERCIAL ENG	
4	FOKAS DANIEL	PLANNING ENG.	
5	ABDALLAH CHIKOYO	PLANNING ENG.	
6	ENID BUKAMBU	INVEST. OFFICER	
7	Gissima Nyamo-Hanga	TECH. MANAGER	(REA)

Consultation with TANCOAL ENRGY Limited 21/01/2015

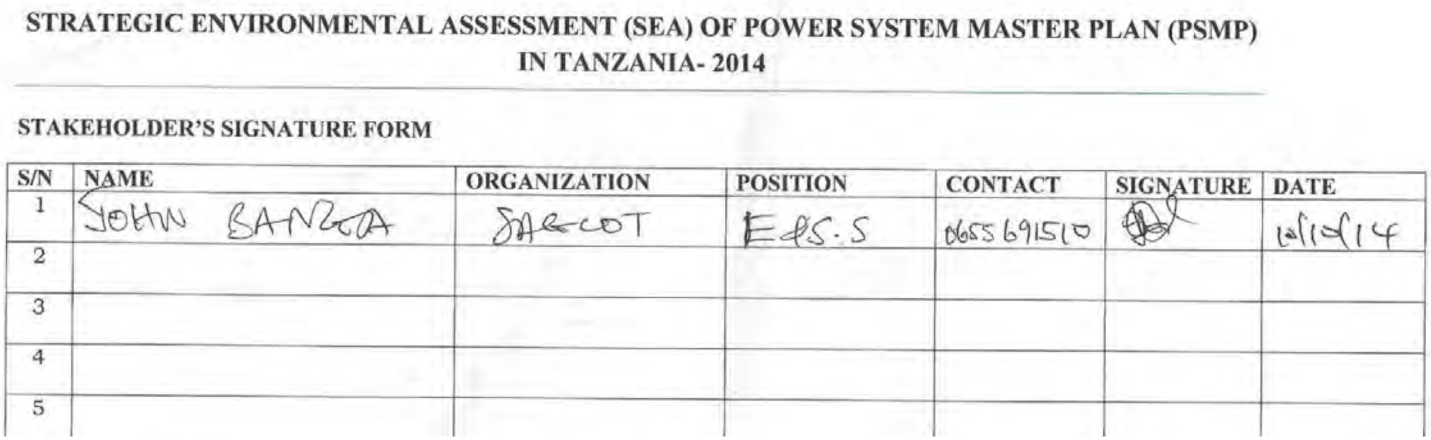


1. Himid ~~Did~~ Juma Did – Mine Operations Manager
2. Edward Mwinga – Mine Superintendent
3. Boniface Seimu – Safety Officer.
4. Ridhike Mashuke – Maintenance Superintendent
5. Isaac S. Mamambaleo – NDC Representative

STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) OF POWER SYSTEM MASTER PLAN (PSMP) IN TANZANIA- 2014

STAKEHOLDER'S SIGNATURE FORM

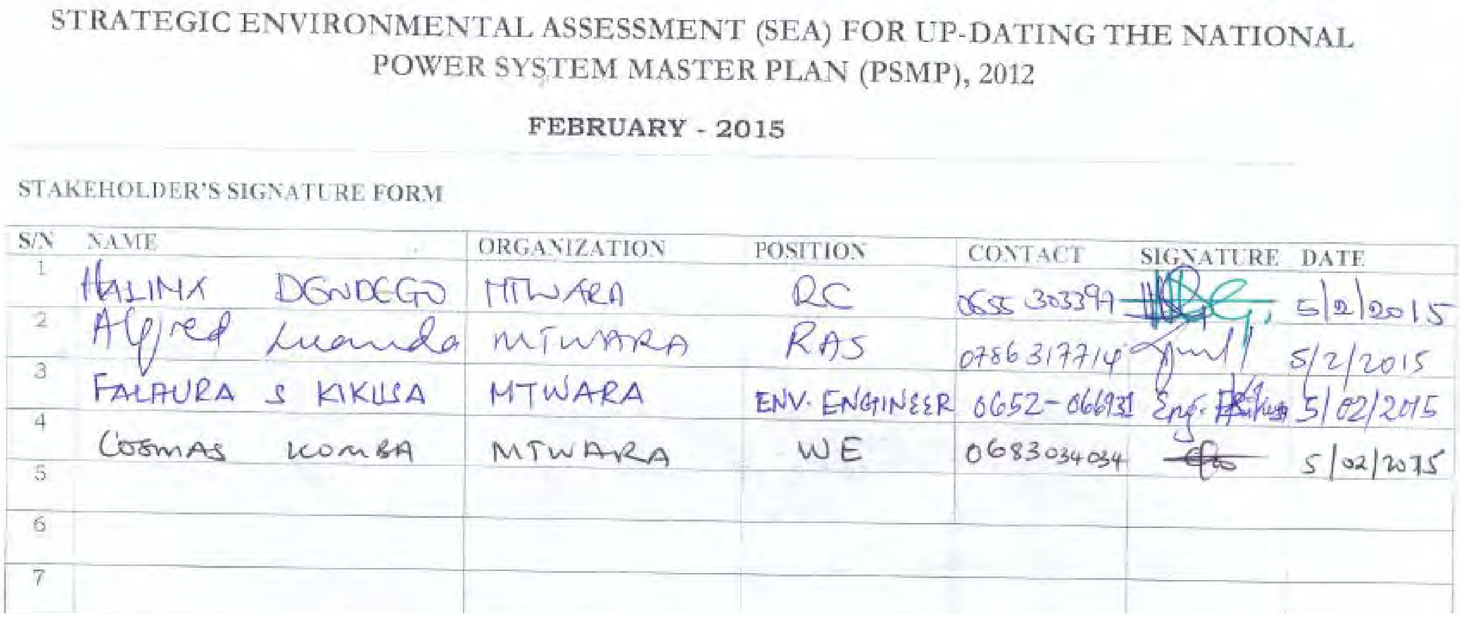
S/N	NAME	ORGANIZATION	POSITION	CONTACT	SIGNATURE	DATE
1	Daniel D. Nguno	Ministry of Lands	Ag ADMP/MA	0715/0754 302872		25/09/2014
2	ZAINABU SHELUYA	MAFC-EMU	AO	07123106 48		
3	Mary Majule	MAFC-EMU	PAO	0754626533		02/10/2014
4	Nyanda Shuli	TCME	Manager Communications & Advocacy	0764600170		06/10/2014
5	Emmanuel Jengo	TCME	Executive Secretary	0713322692		06/10/2014
6	Robert J. Mwasenga	MEM	Statistician	0763414379		08/10/2014
7	MSAFIRI J. BARAZA	MEM	Energy Engineer	0764888772		08/10/2014
8	Yusuph Mwembele	MEM	Energy Engineer	0757612279		08/10/2014
9	Leonard Mwakalebela	MEM	Information Officer	0713 532796		08/10/2014
10	Mkoma Masanyiwa	MEM	Forest Officer	0769535374		08/10/2014
11	Salma Bakary	MEM	Energy Engineer	0714880966	Bakary	08/10/2014
12	Seleman Hatibu Chombo	MEM	Energy Engineer	0754-347104		08/10/2014



STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) OF POWER SYSTEM MASTER PLAN (PSMP) IN TANZANIA- 2014

STAKEHOLDER'S SIGNATURE FORM

S/N	NAME	ORGANIZATION	POSITION	CONTACT	SIGNATURE	DATE
1	JOHN BANZGA	SARCOT	E&S.S	0655 691510		10/10/14
2						
3						
4						
5						



STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) FOR UP-DATING THE NATIONAL POWER SYSTEM MASTER PLAN (PSMP), 2012

FEBRUARY - 2015

STAKEHOLDER'S SIGNATURE FORM

S/N	NAME	ORGANIZATION	POSITION	CONTACT	SIGNATURE	DATE
1	HALIMA DENDEGO	MTWARA	RC	0655 303399		5/2/2015
2	Alfred Luanda	MTWARA	RAS	0786317714		5/2/2015
3	FALAURA S KIKUSA	MTWARA	ENV. ENGINEER	0652-066931	Eng.	5/02/2015
4	COSMAS KOMBA	MTWARA	WE	0683034034		5/02/2015
5						
6						
7						

STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) FOR UP-DATING THE NATIONAL POWER SYSTEM MASTER PLAN (PSMP), 2012

FEBRUARY - 2015

STAKEHOLDER'S SIGNATURE FORM

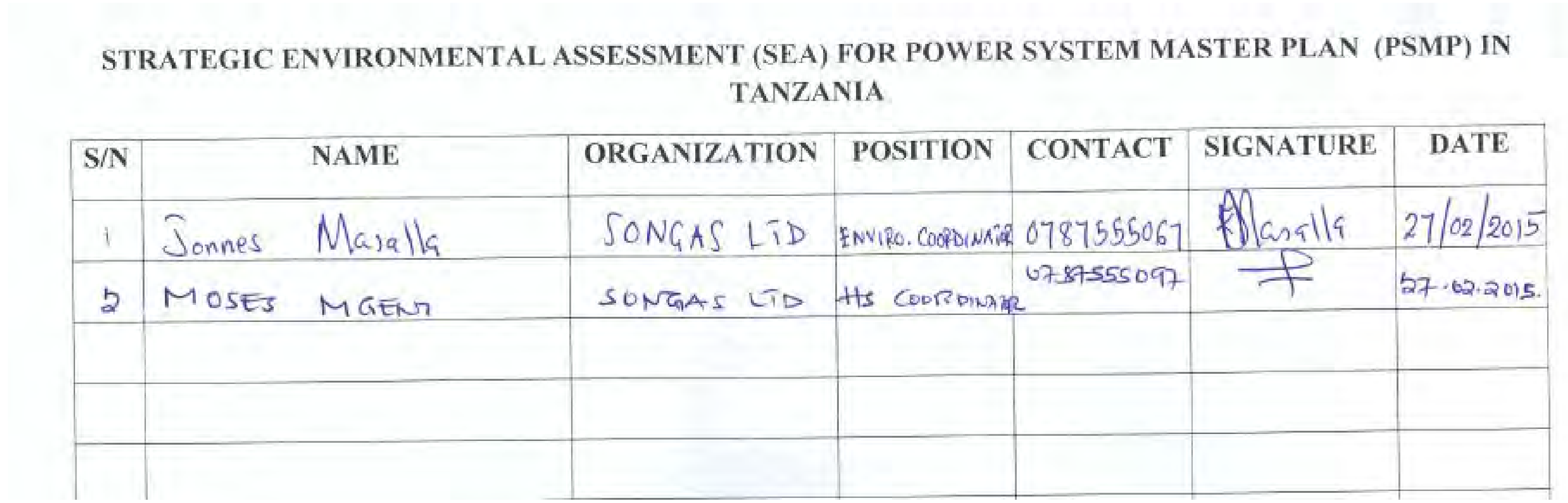
S/N	NAME	ORGANIZATION	POSITION	CONTACT	SIGNATURE	DATE
1	JUSTUS B.C. MTOLERA	TANESCO-KIDATU HPP	PLANT MANAGER	justus.mtolera@tanesco.co.tz 0784361047		2/2/2015
2	JOSEPH KUYUGU	— " —	CIVIL TECHN.	0712594764		02/02/15
3	Agnes Masanja	TANESCO HQ	SOCIOLOGIST	0789-163055		02/02/15
4	ABDULLATIF NASSOR	MEM HQ	ENVIRONMENTAL OFFICER	0788661188		02/02/15
5	Ephraim Mushi	MEM HQ	— " —	0752024337		— " —
6	Jackson Birore	MEM HQ	ENVIRONMENTAL OFFICER	0683962330		02/02/2015
7	REMNA MNANDOWA	M&P	HSE (Health Safety Environment)	0786129929		05/02/2015
8	DAUD CHANDRANICR	MP	Ops Manager	0782078456		05/02/15
9	MUSSA KONGOLA	M&P	MAINT LEAD	0788615149		— " —
10						
11						

STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) FOR UP-DATING THE NATIONAL POWER SYSTEM MASTER PLAN (PSMP), 2012

FEBRUARY - 2015

STAKEHOLDER'S SIGNATURE FORM

S/N	NAME	ORGANIZATION	POSITION	CONTACT	SIGNATURE	DATE
1	AZIZI SALUM	TANESCO	REGIONAL MANAGER	0687296584		04/02/2015
2	DANIEL M. WYANDO	TANESCO - MTWARA	MAINS ENGINEER	0784422884		04/02/2015
3	SUNIL MIZAR.	MICRONIX SYSTEM LTD MTWARA	PRODUCTION IN CHARGE	0684224658		04/02/2015
4	MKULUNGWA -A- CHINUMBA	TANESCO MTWARA POWER PLANT	PLANT MANAGER	0784504946		04/02/2015
5	ALEXANDER M. NDIBALEMA	TPA - MTWARA	Ag. Port Master	0785272272		4/2/2015
6	NORBERT J. KALEMBWE	TPA - MTWARA	SENIOR ESTATE OFFICER	0713501162		4/2/15
7	CAPT. H. KASSUGULU	T.P.A. MTWARA	H/MASTER	0713-565952		—— // ——
8	MELESSY. E. OKACHU	T.P.A - Mtwara	PORT FIRE AND SAFETY OFFICER	0784798474		4/2/15
9	JUMA MAILD	TPA - MTWARA	Ag. PORT SECURITY OFF	0789982262		4/2/2015.
10	ENG. PETER ODECK OGULO	TPA-[illegible]	PORT ENG.	0755534400		4/2/2015
11						
12						



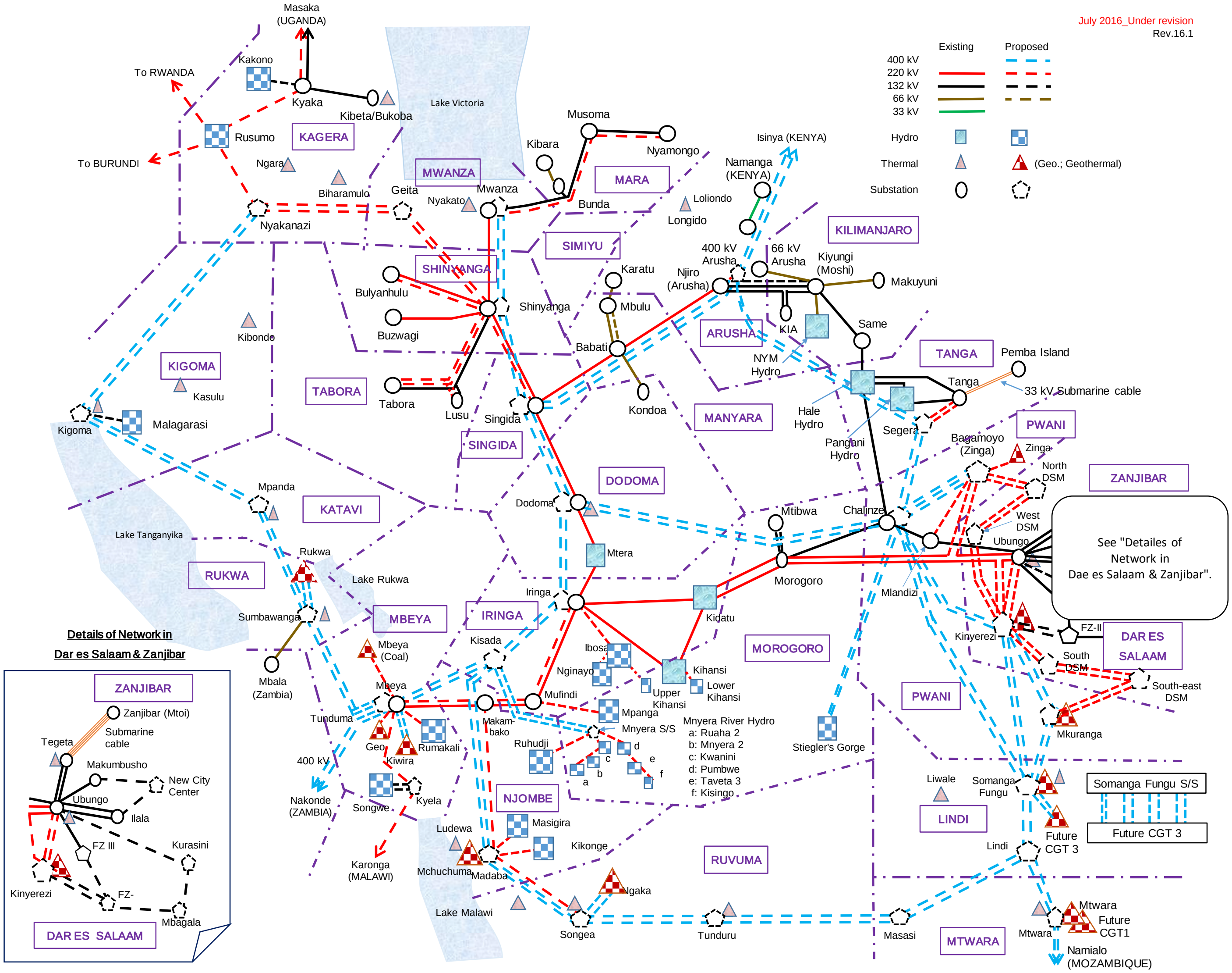
STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) FOR POWER SYSTEM MASTER PLAN (PSMP) IN TANZANIA

S/N	NAME	ORGANIZATION	POSITION	CONTACT	SIGNATURE	DATE
1	Jonnes Masalla	SONGAS LTD	ENVIRO. COORDINATOR	0787555067	Masalla	27/02/2015
2	MOSES MGENI	SONGAS LTD	HS COORDINATOR	0787555097		27.02.2015.

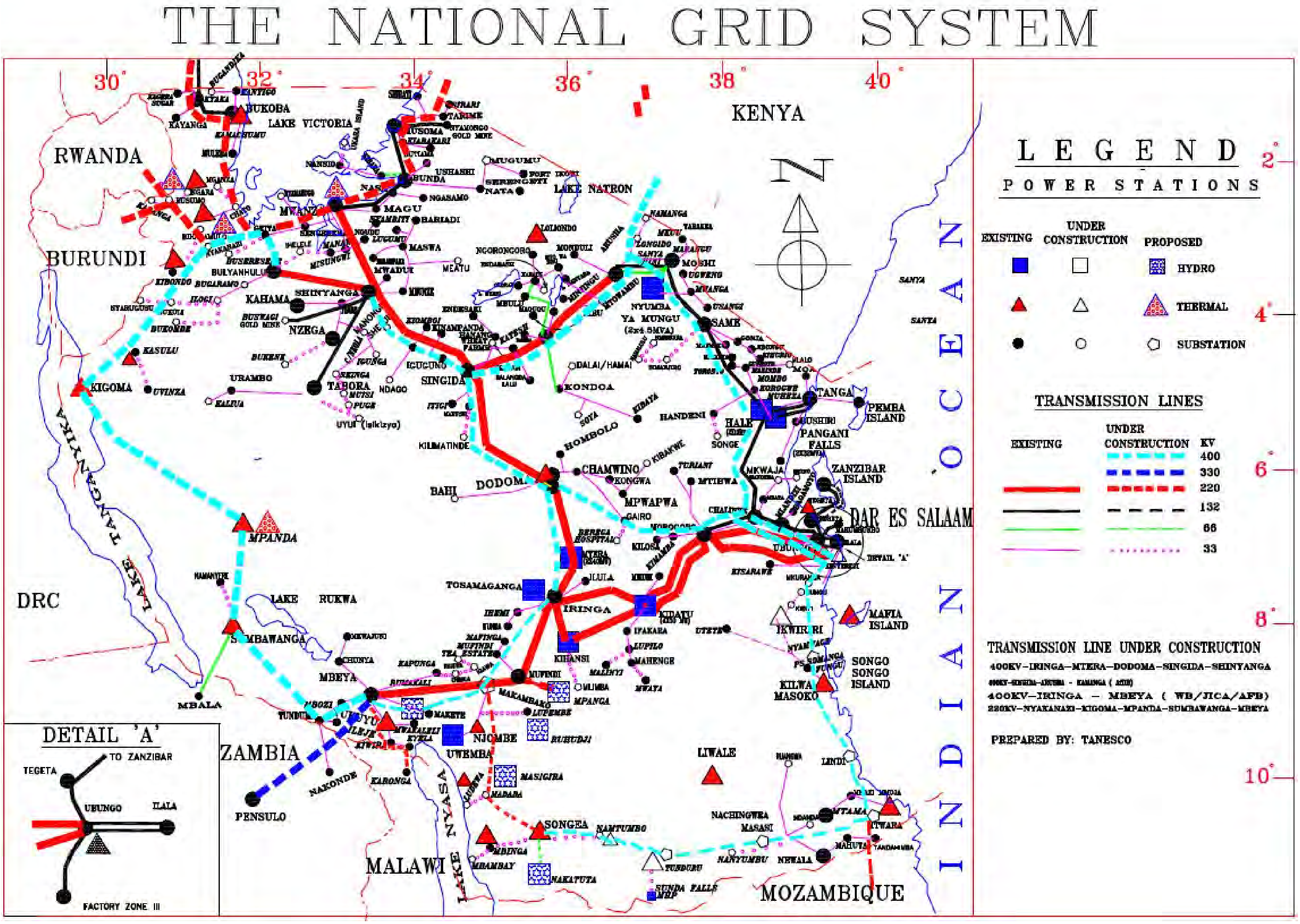
STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) FOR POWER SYSTEM MASTER PLAN (PSMP) IN TANZANIA

S/N	NAME	ORGANIZATION	POSITION	CONTACT	DATE
1.	Eng. Pakaya Mtamakaya	Kihansi Hydro Power	Plant Manager	0784283814	22.12.15
2.	Imran Zakayo	—"—	Ass. Plant Manager	0756418347	22.12.15
3.	SEVERIN MUTAKIWABA	TAWIRI-KIHANSI	RESEARCHER		22.12.2015
4.	Idrisa Msuya	RWBO	RWBO OFFICER	0754028930	23.12.15

Annex 3: Power transmission Maps



Map of the Proposed Transmission Line Development Plan Based on Scenario 2 (as of July 2016)



Map of the National Grid System (TANESCO, 2014)

Annex 4: Photo of Consultation and Visit at different sources of energy and energy users

Photo 1: Observation and Discussion with stakeholders at Kidatu Hydro Plant

Photo 2: TANESCO staff and SEA Experts visiting Kidatu Hydro Plant after Consultation

Photo 3: Consulted team from TPA - Mtwara visting Mtwara Port as one of energy users

Photo 4: Cashew nut Processing industry staff and SEA experts discussing on energy availability and use at the in Mtwara

Photo 5: Cashew nut Processing Industry using energy from Natural Gas in Mtwara Region

Photo 6: Packaged Processed Cashew nut observed during consultation

Photo 7: Stakeholders consultation and Site visit in Mnazi Bay Mtwara, the main source of energy generated from Natural Gas

Photo 8: SEA team and TAN Coal Staff visiting Ngaka Coal mining area in Songea during consultation and visit of different type of sources of energy

Photo 9: Expert from SEA team assessing the quality of coal at Ngaka area in Songea, Ruvuma Region

S-1　発電所毎の概要及び運転実績（火力、水力）

S-1-1　火力発電設備

現在稼働中の火力発電プラントを表 S-1-1.1 に示す。

火力発電設備の定格容量は合計 908.7MW であり、「タ」国の全国送電系統に連系されている発電設備（合計 1,474MW）の約 62%を占める。TANESCO 及び IPP の火力発電所は重油、ディーゼル油等の石油系燃料を使用しているユニットを含んでおり、高コスト構造となっているため、天然ガスへの燃料転換が課題である。

表 S-1-1.1　既設火力発電所

Plant	Fuel	Units	Installed Capacity MW	Available Capacity MW	Station Service %	Net Available Capacity MW	FOR %	Combined Outage Rate %	Maximum Plant Factor %	Available Energy GWh	Year Installed (Jan)	Nominal Service Life Years	Retirement Year (Dec)
IPP UNITS													
Songas 1	Gas	2	42	38.3	1.6	37.69	5	13	80	251	2004	20	2023
Songas 2	Gas	3	120	110	1.6	108.24	5	13	80	721	2005	20	2024
Songas 3	Gas	1	40	37	1.6	36.41	5	13	80	242	2006	20	2025
Tegeta IPTL	HFO	10	103	100	1.6	98.4	8	18	75	595	2002	20	2021
TPC	Biomass		17	17	1.6	16.73	5	13	50	70	2011	20	2030
TANWAT	Biomass		2.7	2.4	1.6	2.36	5	13	50	10	2010	20	2029
Subtotal			*324.7*	*304.7*		*299.82*				*1888*			
TANESCO													
Ubungo I	Gas	12	102	100	1.6	98.4	5	13	80	655	2007	20	2026
Tegeta GT	Gas	5	45	43	1.6	42.31	5	13	80	282	2009	20	2028
Ubungo II	Gas	3	105	100	1.6	98.4	5	13	80	655	2012	20	2031
Zuzu D	IDO	1	7	5	1.6	4.92	5	18	75	31			2014
Subtotal			*259*	*248*		*244.03*				*1623*			
RENTAL UNITS (IPP's)													
Symbion Ubungo	Gas/Jet A1	5	120	113.79	1.6	112	5	13	80	746	2011	2	2013
Aggreko (Ubungo)	GO		50	50	1.6	50	8	18	85	674	2011	1	2012
Aggreko (Tegeta)	GO		50	50	1.6	50	8	18	85				
Symbion Dodoma	HFO		55	55	1.6	54.12	8	18	85	371	2012	2	2014
Symbion Arusha	HFO		50	50	1.6	49.2	8	18	85	337	2012	2	2014
Subtotal			*325*	*318.79*		*315.32*				*2127*			
TOTAL			***908.7***	***871.49***		***859.18***				***5638.2***			

Avalable 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

(1)　TANESCO 所有発電所

1)　Ubungo I ガス火力発電所

2007 年運開。Wärtsilä 製ガスエンジン 12 基（Type: W20V34SG）を採用し、1 系列 6 ユニット構成（No.1: unit1–6, No.2: unit7–12）で稼動中（Output: Total 108MW (9MW×12)、11kV、0.85PF）。燃料は Songo Songo ガス田からの天然ガスを使用。TANESCO によると、資金不足によりスペアパーツを 1 セット分しか保有できていないとのことであり、定期点検時やトラブル時におけるスペアパーツの取り回し方法が課題となると思われる。

<Overview of the plant>　　<Gas Engine Unit (Wärtsilä W20V34SG)>

<Engine Status Board>　　<Machine Shop>

図 S-1-1.1　Ubungo I ガス火力発電所

2)　Ubungo II ガス火力発電所

2012 年運開。Siemens 製ガスタービン 3 基（Type: SGT-800）を採用し、1 系列 1 ユニット構成で稼動中（Simple Cycle GT、Output: Total 105MW (35MW×3)、11kV、0.85PF）。Ubungo I 同様、燃料は Songo Songo ガス田からの天然ガスを使用。運開したばかりのユニットであり、これまで大きなトラブルは経験していないが、IPP 発電所の Songas 発電所、Ubungo I&II 発電所が全機運転すると、Songo Songo ガス田からのガスの供給が不足する場合がある。

また、資金不足により、メーカー推奨のメンテナンス計画が思うように立案できていない。今後、経年的な劣化を最小限に抑えるためには、低コストで効果的なメンテナンス計画の立案が必要であろう。

<Overview of the plant>　<CRT Monitor>

<Fuel Supply Line>

図 S-1-1.2　Ubungo II ガス火力発電所

3)　**Tegeta** ガス火力発電所

2009 年運開。Ubungo I 同様、Wärtsilä 製ガスエンジン 5 基（Type: W20V34SG）を採用し、1 系列 5 ユニット構成で稼動中（Output: Total 45MW (9MW×5)、11kV、0.85PF）。燃料は Ubungo I&II 同様、Songo Songo ガス田からの天然ガスを使用しているが、供給母管が異なるため、ガス供給不足には至っていない。また、過去に Ubungo I で経験したトラブル対策を反映させたユニットであるため、これまで大きなトラブルは経験していない。Availability は 90%と高い値を維持しており、Ubungo I での O&M の知見が十分に活用されている。運開後 5 年経過した 2014 年、完全に TANESCO 側に移管(Handover)される予定。同型機である Ubungo I との総合運用を行い、スペアパーツの管理や O&M 運用の共有化を進めれば効率化が図れ、コスト削減に資すると思われる。


<Overview of the plant>


<Machine Shop>

図 S-1-1.3　Tegeta ガス火力発電所

4)　Zuzu Diesel 火力発電所

1980 年運開。1 系列 1 ユニット構成で稼動中（Output: Total 7MW）。当初 2014 年に廃止予定であったが、計画を変更し、2012 年に改修された。燃料にはディーゼル油（IDO: Industrial Diesel Oil）が使用されており、輸入により供給されている。燃料費が高騰する中、国産の燃料に転換できるかが課題である。

5)　Mtwara 火力発電所

2007 年運開。Caterpillar 製ガスエンジン 9 基（Type: G3520C）を採用して稼動中（Output: Total 18MW (2MW×9)）。「タ」国南部の Mtwara ・Lindi 地区の電力需要に対応するために開発。今後、400MW 級のガスタービン発電所を IPP により建設する予定である。燃料は Mnazi Bay ガス田からの天然ガスを使用。

6)　Nyakato（Mwanza）火力発電所

2013 年運開。Rolls Royce 製ディーゼルエンジン 10 基（Type: B32:40V16）を採用して稼動中（Output: Total 63MW(6.29MW×10)）。旧式のディーゼル発電機をリプレースすることにより、メンテナンスコストの低減を図っている。燃料には HFO（Heavy Fuel Oil）が使用されており、輸入により供給されている。燃料費が高騰する中、国産の燃料に転換できるかが課題である。

(2)　IPP 発電所

1)　Songas I～III ガス火力発電所

2004～2006 年運開。Songo Songo ガス田におけるガス開発及びガス火力発電プロジェクト（Songo Songo Gas Development and Power Generation Project）の一環として進められた。当初燃料油で運転していた ABB 製ガスタービン 2 基（Type: GT10 A、Output: Total 37MW(18.5MW×2)、1994 年設置）及び GE 製ガスタービン 2 基（Type: LM6000、Output: Total 75MW(37.5MW×2)、1995 年設置）の TANESCO 所有設備を引き継ぎ、天然ガスに転換した。更に、2 基の GE 製ガスタービン（Type: LM6000）を増設し、総発電出力 180MW の発電所として運転中。「タ」国の総発電容量の大部分を担っているため、事故等で多数のユニットの運転が停止した場合、インパクトが大きくなるのが懸念される。

2) Tegeta IPTL (Independent Power Tanzania Limited)ディーゼル火力発電所

2002年運開。Wärtsilä製ディーゼルエンジン10基（Type: 38）を採用して稼動中（Output: Total 100MW(10MW×10)）。燃料にはHFO（Heavy Fuel Oil）が使用されており、輸入により供給されている。2009年、上記Songo Songoガスプロジェクトの一環として、天然ガスへの燃料転換を図ったが頓挫。燃料費が高騰する中、国産の燃料に転換できるかが課題である。

図 S-1-1.4　Tegeta IPTL 火力発電所 (IPP)

3) TPC／TANWATバイオマス発電所

「タ」国の中で農業が盛んな地域においては、豊富なバイオマス資源を活用した発電が行われている。発電した余剰電力はSPP(Small Power Purchase)プログラムの下でTANESCOに供給している。

TANWAT（Tanganyika Wattle Company）は、1995年、「タ」国において最初に商業運転を開始した。木材の廃材を利用して発電しており、2.5MWの発電能力の約40%に相当する1.5MWをTANESCOに供給するSPPAを締結している。

TPC（Tanganyika Planting Company）は、サトウキビの処理工程で発生するごみ（バガス）を利用して発電している。17MWの発電能力のうち9MWをTANESCOに供給するSPPAを締結している。

(3) レンタルユニット（EPP）

レンタル発電設備は、渇水により水力発電電力量が著しく低下した2011年以降に順次導入されている。しかしながら、高価な石油系燃料を輸入して使用しているため、短期契約の位置づけで導入している。

1) Symbion Ubungo

2011年運開。GE製ガスタービンを採用して稼動中。燃料はSongo Songoガス田からの天然ガスを使用。IPP発電所のSongas発電所、Ubungo I&II発電所が全機運転すると、Songo Songoガス田からのガス供給が不足する場合がある。2014年9月に契約満了となったが、契約期間延長に向けた手続きを実施中である。

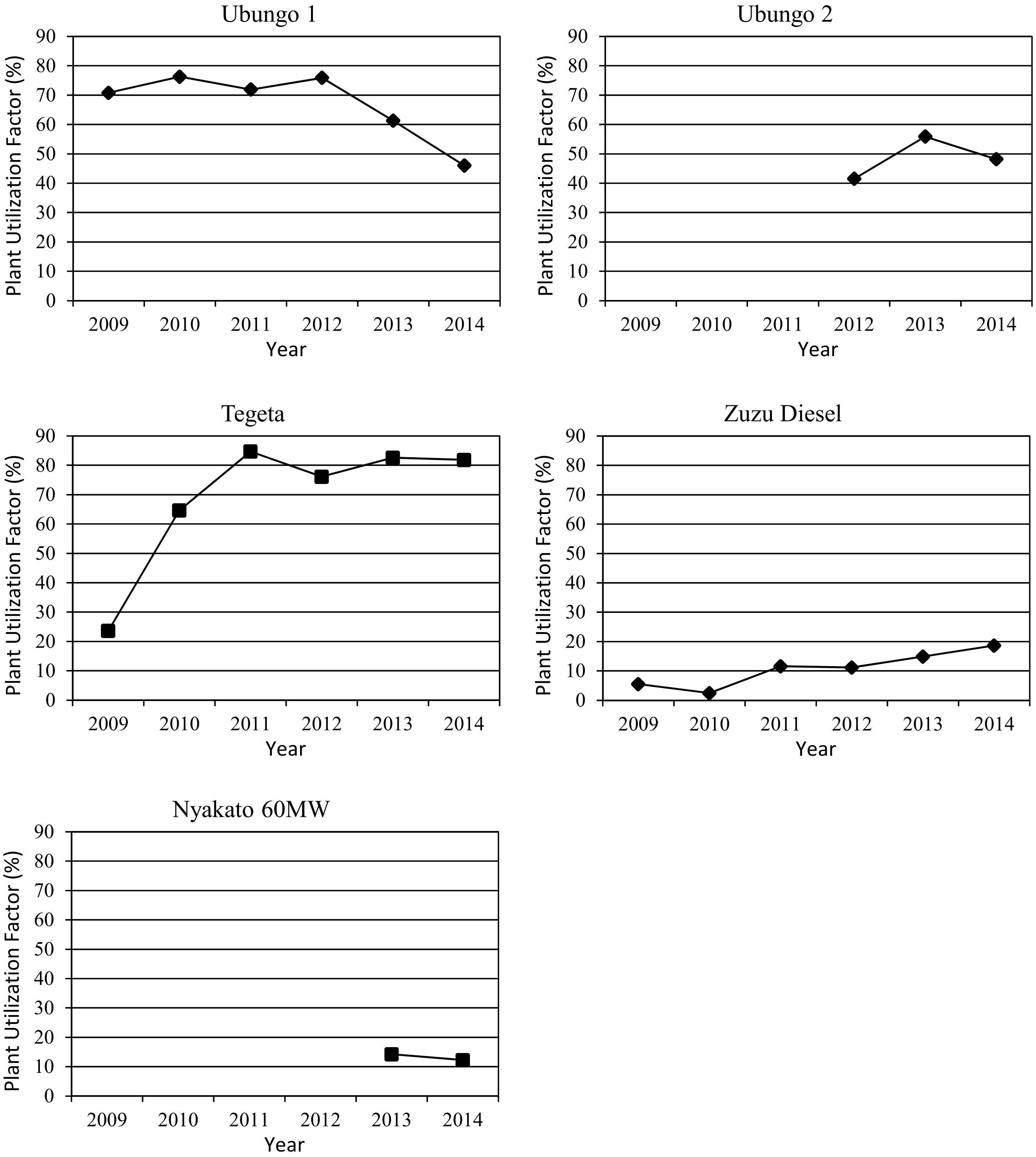
図 S-1-1.5　Symbion Ubungo 火力発電所(EPP レンタルユニット)

2)　その他レンタルユニット

Aggreko 社のレンタルユニット（燃料：軽油[Gas Oil]）が Ubungo 地区及び Tegeta 地区で、Symbion 社のレンタルユニット（燃料：HFO）が Dodoma 地区及び Arusha 地区で稼動していたが、燃料費高騰により契約満了に伴い更新はせずに運転を停止している。

(4)　主な既設火力発電所の運転状況

図 S-1-1.6 に、既設発電所の 2009 年以降の設備利用率（TANESCO 設備）を示す。運転データは、TANESCO から提供された Monthly Report データ（2009 年 1 月～2014 年 5 月）を使用した。但し、2011 年 11 月、2013 年 11 月、2014 年 5 月のデータについては、データの内容に疑義が生じたため、採用しなかった。



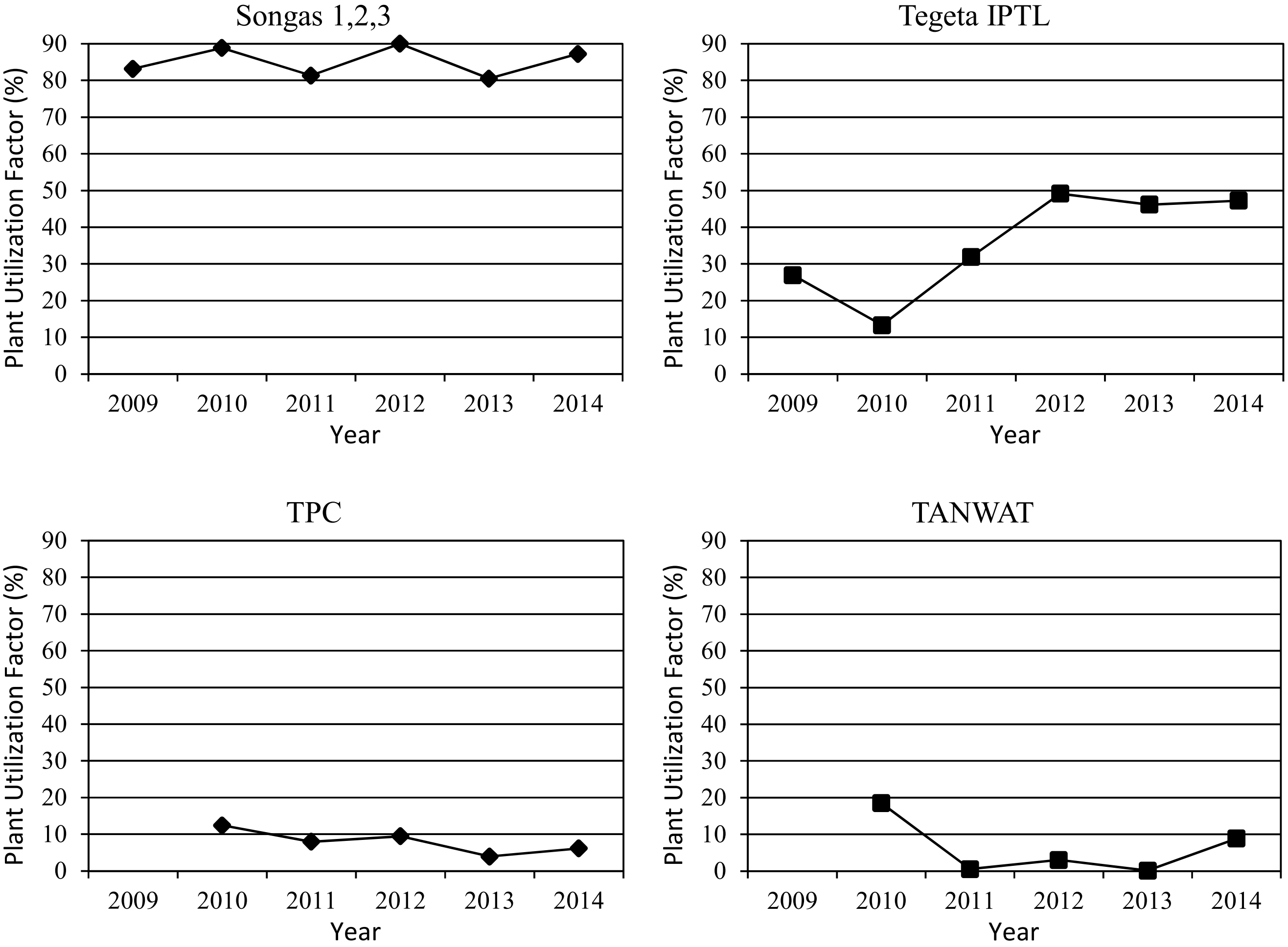
（出典）TANESCO Monthly　Report (2009-2014)より JICA 調査団作成

図 S-1-1.6　TANESCO 所有火力発電所の設備利用率

Ubungo 1 は、2009 年～2012 年は高い利用率であったが、2012 年頃から利用率が低下している。Ubungo 2 も同様に運開当初より利用率が低い。これは、先述の TANESCO からのヒアリングのとおり、Songas 発電所、Ubungo I&II 発電所が全機運転すると、Songo Songo ガス田からのガスの供給が不足する場合があるためと考えられる。一方、Tegeta は、供給母管が異なることより、高い

設備利用率を保っている。Zuzu D、Nyakatoについては、ディーゼル燃料の使用量を下げるためにも低い稼働率を維持することが望ましい。

図 S-1-1.7 に、既設発電所の 2009 年以降の設備利用率（IPP 設備）を示す。使用データは先ほどと同じデータを使用している。

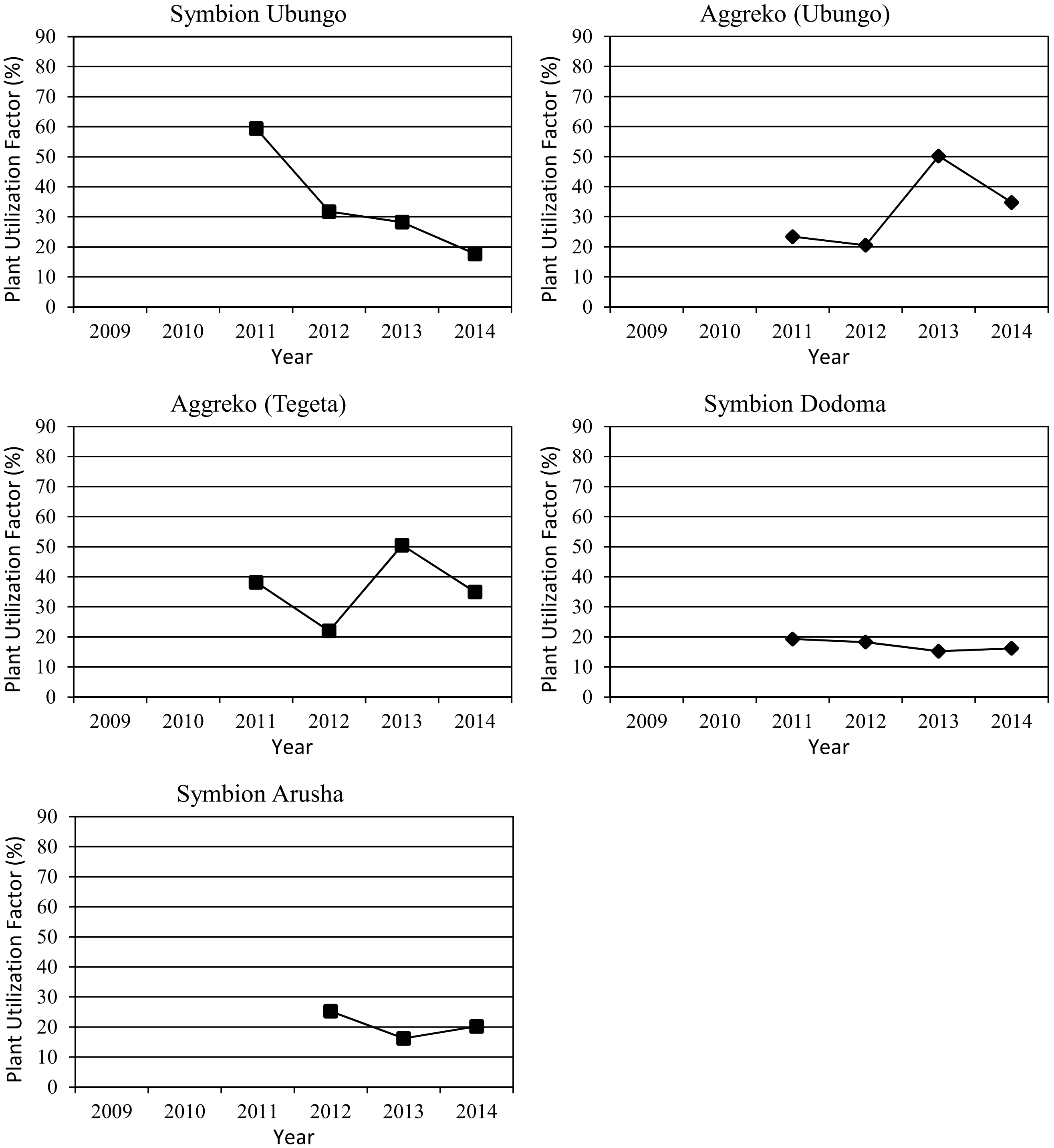


（出典）TANESCO Monthly　Report (2009-2014)より JICA 調査団作成

図 S-1-1.7　IPP 火力発電所の設備利用率

Songas 1～3 は全期間にわたり、高い利用率を維持している。これは上述のとおり、Songo Songo ガス田からのガス供給が Songas へ優先的に供給されるためであると考えられる。また、Tegeta IPTL は、重油燃料（HFO）であるため低い利用率であったが、2011 年以降は渇水の影響により稼動せざるを得ず、稼働率が高くなっており、コスト増要因となっている。TPC/TANWAT のバイオマス発電は総じて低い利用率となっている。

図 S-1-1.8 に既設発電所の 2009 年以降の設備利用率（レンタルユニット設備）を示す。使用データは先の 2 つの既設発電所と同じである。



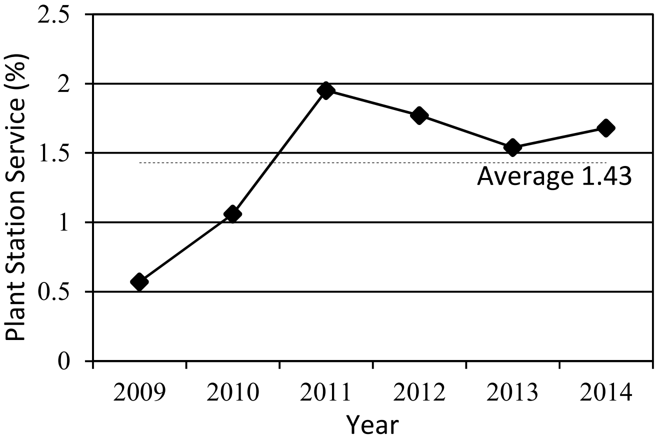
（出典）TANESCO Monthly　Report (2009-2014)より JICA 調査団作成

図 S-1-1.8　IPP 火力発電所の設備利用率(レンタルユニット)

2011 年以降、水力発電の渇水対策のために順次導入されたレンタルユニットであるが、燃料費抑制のためにも、低い稼働率の維持が望ましい。

図 S-1-1.9 に TANESCO 所有の全火力発電所（Ubungo 1,2、Tegeta、Zuzu Diesel、Nyakato）の発電所所内電力消費率を示す。発電所所内電力消費率は PSMP2012 の値 1.6%と比較して、2009 年～2014 年平均で 1.43%と大きな違いはない。これは、シンプルサイクルのガスタービンやガス

エンジン発電所が大きな補機を必要としないためである。しかしながら、今後コンバインドサイクル機や、石炭火力発電所を計画する際は、発電するために大型補機が必要となるので、所内比率を高めに設定する必要がある。



（出典）TANESCO Monthly　Report (2009-2014)より JICA 調査団作成

図 S-1-1.9　TANESCO 所有火力発電所の所内比率

表 S-1-1.2 に IPP/EPP 火力発電所の 2012 年における発電コスト実績を示す。表からもわかるとおり、重油、Jet-A1 燃料、ガスオイルの燃料費の影響により、Tegeta IPTL、Symbion Ubungo (Symbion 112)、Symbion Dodoma/Arusha のタリフが非常に高くなっている。

表 S-1-1.2　IPP/EPP 火力発電所の発電コスト実績（2012 年）

Plant Name	Plant Type	Fuel Type	Capacity Charge –US cent/kWh	Energy Charge –US cent/kWh	Total Charge – US cent/kWh
SONGAS	IPP	Natural Gas	4.03	2.21	6.24
IPTL	IPP	HFO	5.57	22.56	28.13
SYMBION,112	EPP	Natural Gas	4.99	2.50	7.49
SYMBION,112	EPP	Jet A1	6.5	50.00	56.5
SYMBION 55-DDM	EPP	GO	5.5	30.00	35.5
SYMBION 50-ARU	EPP	GO	5.5	42.00	47.5
AGGREKO	EPP	GO	3.78	37.21	40.99

（出典）TANESCO からの聞き取り

また、表 S-1-1.3 に 2014 年 1-9 月期における TANESCO 所有火力発電所（系統連系、独立系統）の発電コスト（減価償却費は含まず）を示す。

このことからも、これらユニットの稼働率を低く維持できるか、油からガスへの燃料転換できるかが課題である。

表 S-1-1.3　TANESCO 所有火力発電所の発電コスト実績（2014 年 1-9 月期）

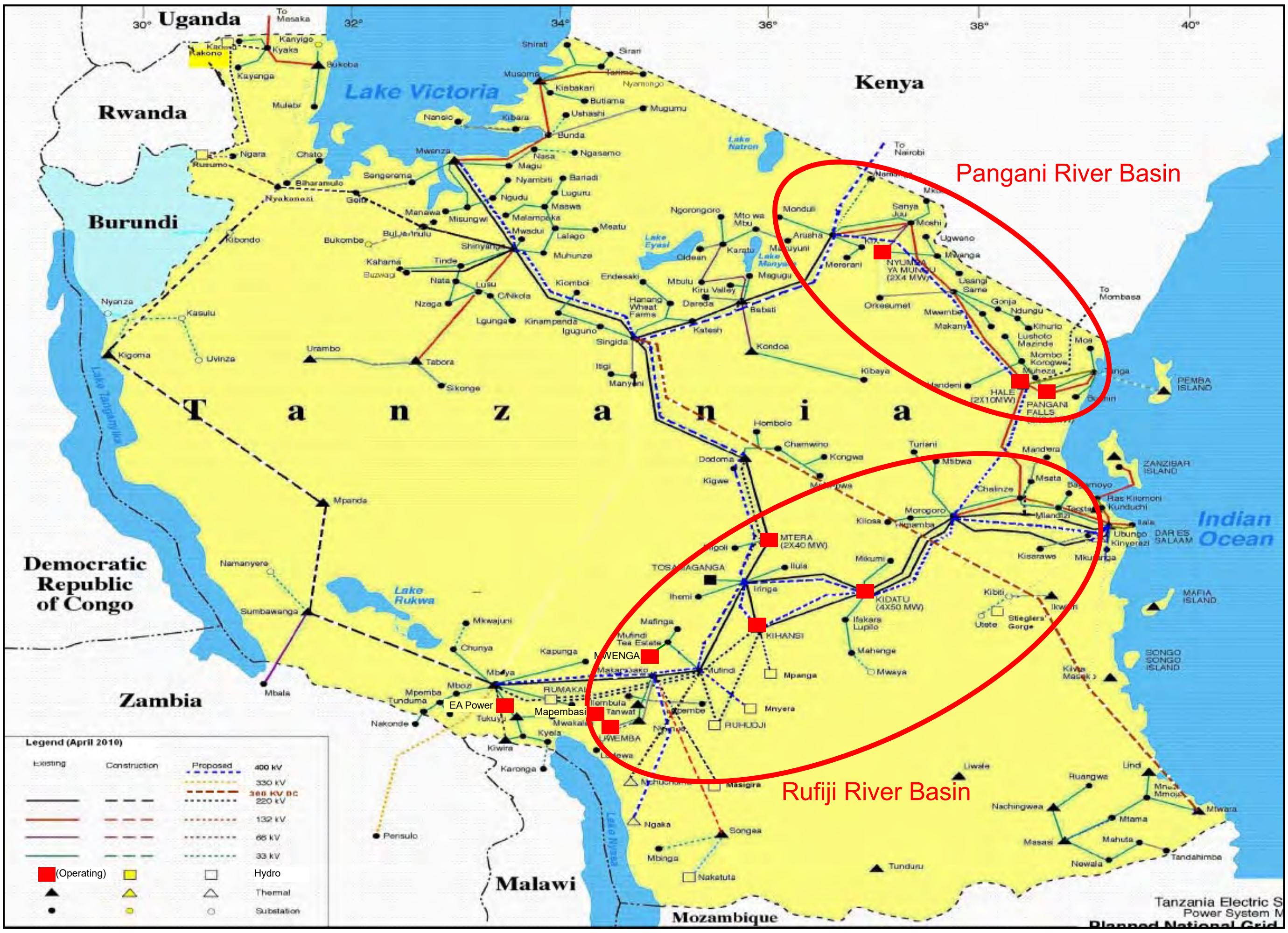
Plant Name	Generated Power [kWh]	Operating Cost [Tsh]	Per Unit Generation Cost [Tsh/kWh]
Grid Thermal Station [Total]	946,096,297	85,065,328,805	90.09
Ubungo 1 Gas	304,465,000	20,898,017,222	69.05
Tegeta Gas	230,661,500	19,630,073,299	85.12
Ubungo 2 Gas	341,631,000	19,040,358,285	55.73
Nyakato 60MW	65,483,697	22,719,210,990	346.95
Zuzu Dodoma	3,855,100	2,678,657,597	694.85
Others	0	99,011,412	0.00
Isolated Diesel Station [Total]	139,585,740	62,514,436,718	447.93
Thermal [Total] (Grid + Isolated)	1,085,682,037	147,579,765,523	136.17

S-1-2　水力発電設備

2016 年 1 月末時点で、11 水力発電所、合計出力 586MW が稼働中であり、系統連系されている（表 S-1-2.1 参照）。水系別では、パンガニ（Pangani）川水系に 3 水力発電所、合計出力 97MW が位置し、ルフィージ（Rufiji）川水系に 6 発電所、合計出力 479MW が位置し、その他水系に 2 発電所、合計出力 10MW が位置している（図 S-1-2.1 参照）。

これら既設水力発電所のうち TANESCO が所有･運転している水力発電所は 7 箇所、合計出力 562MW である。TANESCO はこの他に、2 水力発電所[1]、合計出力 2MW を所有しているが、現在は稼働していない。2000 年に Kihansi 水力発電所が運転開始して以来、TANESCO による水力開発は行われていない。

残りの 4 箇所の既設水力発電所は、小規模発電事業（SPP；Small Power Project）制度の下で、TANESCO と標準買電契約（SPPA；Standardized Power Purchase Agreement）を締結した民間事業者により所有･運転されている。



Source: TANESCO, with additions

図 S-1-2.1　系統連系されている稼働中の既設水力発電所位置図

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[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

表 S-1-2.1(1)　系統連系されている稼働中の既設水力発電所一覧（2016年1月末時点）(1)

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

表 S-1-2.1(2)　系統連系されている稼働中の既設水力発電所一覧（2016 年 1 月末時点）(2)

Item			Hydro Power Plant			
			Mwenga	Mapembasi	EA Power	Darakuta
Owner			SPP			
			Mwenga Hydro Ltd.	Mapembasi Hydro Power Co., Ltd.	EA Power Ltd.	N/A
Plant Characteristic	River Basin		Rufiji		Lake Nyasa	N/A
	Location	District	Mufindi	Njombe	Tukuyu	N/A
		Region	Iringa	Njombe	Mbeya	Manyara
	Power Generation Type		Run-off-river	Run-off-river	Run-off-river	Run-off-river
	Installation Year		2012	2016	2015	2015
	Installed Capacity (MW)		4	10	10	0.24
	Number of Units		1	3	2	N/A
	Plant Discharge (m^3/s)		8.00	30.00	N/A	N/A
	Gross Head (m)		62.00	36.00	N/A	N/A
	Annual Energy Generation (GWh)		17.10	N/A	N/A	N/A
	Plant Factor (%)		49	N/A	N/A	N/A
Facility Characteristic	Dam (Main)	Type	N/A	N/A	N/A	N/A
		Height (m)	N/A	N/A	N/A	N/A
		Crest Length (m)	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
		Low Water Level (masl)	1,126.00	N/A	N/A	N/A
		Active Storage (10^6 m^3)	-	N/A	N/A	N/A
	Headrace	Type	N/A	Channel	N/A	N/A
		Length (m)	N/A	900	N/A	N/A
		Diameter (m)	N/A	N/A	N/A	N/A
	Penstock	Type	N/A	N/A	N/A	N/A
		Length (m)	340	168 - 185	340	340
		Diameter (m)	N/A	N/A	N/A	N/A
	Powerhouse	Type	N/A	Surface	N/A	N/A
		Width (m)	N/A	N/A	N/A	N/A
		Depth (m)	N/A	N/A	N/A	N/A
		Height (m)	N/A	N/A	N/A	N/A
	Tailrace	Type	N/A	N/A	N/A	N/A
		Length (km)	N/A	N/A	N/A	N/A
		Diameter (m)	N/A	N/A	N/A	N/A
	Turbine	Type	Francis	Horizontal Francis	Horizontal Francis	N/A
		Rated Output (MW/unit)	N/A	3.238	5	N/A
	Generator	Type	Synchronous 3 Phase	Synchronous 3 Phase	N/A	N/A
		Rated Output (MVA/unit)	N/A	4.2	N/A	N/A
		Rated Voltage (kV)	6.6	6.3	N/A	N/A

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

Source: 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

S-1-2-1　主な既設水力発電所の概要

(1)　Hale 水力発電所

Hale 水力発電所は 10.5MW×2 基から成る総出力 21MW の流れ込み式発電所である（表 S-1-2.1 参照）。

同発電所は、稼働中の発電所の中で最も古く、1964 年に運転を開始した。建設当時は有効貯水容量 1.1 百万 m^3 の調整池を有していたが、現在は満砂となっており、電力需要に応じた調整運転を行うことはできていない。

最後の大規模修繕は 1987 年に行われた。その後、機器の劣化に伴って計画外停止が多発し、アベイラビリティが低下している（後述の S-1-2-2 項参照）。2014 年 7 月時点で、1 基は固定子の絶縁不具合が発生しており、運転可能なのは 10.5MW のみとなっている。

このため、2015～2018 年に大規模修繕が計画されており、2014 年 10 月までに設計コンサルタントが選定される予定である。1 基は撤去･取替が行われ、残る 1 基は修繕が行われる予定となっている。また、地下発電所への進入道路がないため、道路トンネルの建設も実施される。

(2)　Nyumba Ya Mungu 水力発電所

Nyumba Ya Mungu 水力発電所は、4MW×2 基から成る総出力 8MW の貯水池式発電所である（表 S-1-2.1 参照）。

ダムは、洪水の貯留、30,000 エーカーの灌漑、発電を目的として建設され、1966 年に完成した。有効貯水容量 600 百万 m^3 を有する貯水池は、現在では、漁業にとっても重要なものとなっている。

発電所本館および電気･機械設備の建設は 1967～1969 年に行われ、同水力発電所は 1968 年に運転を開始した。水車は Gilbert Gilkes and Gordon Ltd.社が、発電機は Bruce Peebles Ltd.社が供給した。

ノルウェイの NORAD[2]の資金による大規模補修工事が、1987～1989 年に行われた。その際、ドラフトチューブ中間部や調速機高圧ポンプの取り替え、水車ランナやガイドベーンの修繕等が行われた。

(3)　New Pangani Falls 水力発電所

New Pangani Falls 水力発電所は 34MW×2 基から成る総出力 68MW の流れ込み式発電所である（表 S-1-2.1 参照）。有効貯水容量 0.8 百万 m^3 の小規模な調整池を有するため、同発電所は数時間程度の調整運転が可能である。

同発電所は、総事業費 126 百万 USD を投じて建設され、1995 年に運転を開始した。総事業費の外貨分は、ノルウェイの NORAD、フィンランドの FINNDA[3]、スウェーデンの SIDA[4]により融資された。

(4)　Kidatu 水力発電所

Kidatu 水力発電所は 51MW[5]×4 基から成る総出力 204MW の貯水池式発電所で、国内最大規模の発電所である（表 S-1-2.1、図 S-1-2.2 参照）。有効貯水容量 125 百万 m^3 の貯水池を活用し、ピ

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[2] Norwegian Agency for Development Cooperation

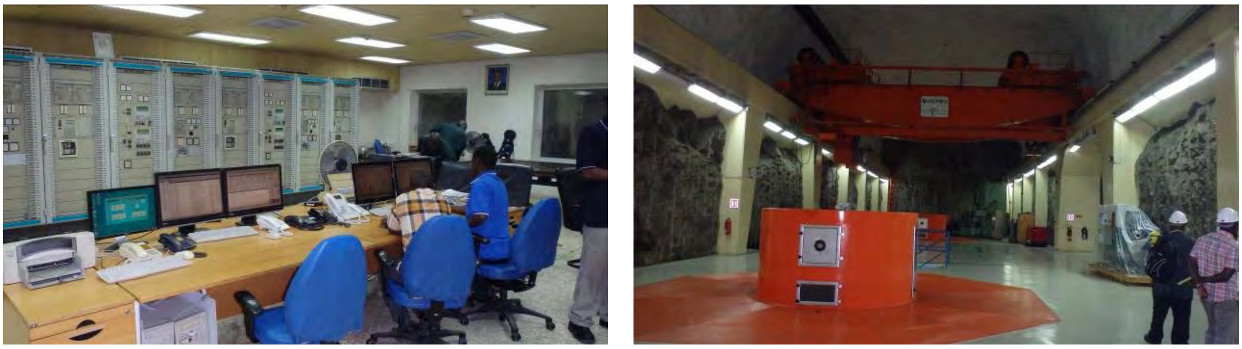
[3] Finnish International Development Agency

[4] Swedish International Development Cooperation Agency

[5] 建設当時は 50MW/基であったが、その後の補修により現在は 51MW/基に増加している

ーク対応運転が行われている。

<Reservoir and Front Face of Dam>　<Spillway of Dam>



<Control Room in Underground Powerhouse>　<Generator Floor in Underground Powerhouse>

図 S-1-2.2　Kidatu 水力発電所の設備

同水力発電所は、1970 年代初頭～1980 年代後半にかけて 3 期に分けて行われた、Great Ruaha Power Project の一環で建設された（表 S-1-2.2 参照）。水車は LITOSTROJ 社と VOITH 社が、発電機は RADE KONCAR 社が供給した。同事業の工事費は、世界銀行、国際復興開発銀行、ノルウェイの NORAD、スウェーデンの SIDA、ドイツの KfW[6]、カナダの CIDA[7]等により融資された。

これまでに 2 度の大規模補修が行われている（表 S-1-2.3 参照）。第 1 期の補修費用は 25 百万 SEK[8]で、スウェーデンの SIDA により融資された。第 2 期の補修費用は 15 百万 USD で、ノルウェイの NORAD、スウェーデンの SIDA により融資された。現在、発電所職員により第 3 期の補修が計画されているが、資金調達の目処が立たず、実施時期は未定となっている。

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[6] ドイツ復興金融公庫、Kreditanstalt für Wiederaufbau

[7] Canadian International Development Agency

[8] Swedish Krona (1 USD is approx. 6.9 SEK as of August 2014)

参照）。

表 S-1-2.2　Great Ruaha Power Project の概要

	Period	Contents	Cost
Phase 1	1970–1975	- Construction of Kidatu HPP comprised of dam, underground power station with initial capacity of 2 x 50MW, headrace tunnel and tailrace tunnel - Construction of 220kV transmission line to Morogoro and Dar es Salaam	102 million USD
Phase 2	1977–1980	- Expansion of Kidatu HPP (additional capacity of 2 x 50MW) - Construction Mtera Dam - Extension of Morogoro Substation	N/A
Phase 3	1984–1988	- Construction of Mtera HPP　comprised of underground power station with capacity of 2 x 40MW, headrace tunnel and tailrace tunnel - Construction of Grid Control Center at Ubungo	N/A

Source:　Made by JICA Study Team with reference to “Website of TANESCO” and “Presentation Material (July 2014, TANESCO/Kidatu HPP)”

表 S-1-2.3　Kidatu 水力発電所大規模補修工事の概要

	Period	Contents	Cost
Phase 1	1993–1994	- Repair of 2 turbines and generator equipment	25 million SEK
Phase 2	1999–2003	- Modernization of control and protection system - Essential repair auxiliary equipment - Protective coating on penstocks - Replacement of turbine governors unit 1 to 4 - Replacement of runners for nit 1 and 2	15 million USD
Planned Phase 3	Not decided	- Upgrading governors - Upgrading control system - Upgrading 11kV/400V switchgears - Upgrading powerhouse ventilation and cooling system - Upgrading cooling water system in powerhouse - Upgrading dewatering and drainage systems - Repairing headrace tunnel drainage system - Upgrading 220KV bus bar at switch yard by introducing double–bus bar system for switching function flexibility	N/A

Source:　Made by JICA Study Team with reference to “Presentation Material (July 2014, TANESCO/Kidatu HPP)”

(5)　Mtera 水力発電所

Mtera 水力発電所は、40MW×2 基から成る総出力 80MW の貯水池式発電所である（表 S-1-2.1 参照）。

同発電所は、Kidatu 水力発電所と同様に Great Ruaha Power Project の一環で建設された（表 S-1-2.2 参照）。水車は Kvaerner Energy A/S 社が、発電機は ABB が供給した。同発電所の建設工事費は 158 百万 USD であった。

貯水池は国内最大の有効貯水容量3,200百万 m^3を有し、平年の乾季だけでなく渇水年の乾季においても、十分な発電能力を維持することを可能としている。同貯水池で貯留された河水はMtera水力発電所で発電に利用された後、約170km下流に位置するKidatu貯水池へ流入する。このため、Mtera貯水池の貯留能力は、国内最大規模のKidatu水力発電所での発電にも活用され、乾季や渇水年の供給力に大きく貢献している。

(6) Kihansi水力発電所

Kihansi水力発電所は、60MW×3基から成る総出力180MWの流れ込み式発電所である（表S-1-2.1参照）。有効貯水容量1百万 m^3の小規模な調整池を有するため、同発電所は数時間程度の調整運転が可能である。

同発電所の建設工事は1994年に着工し、1号機は1999年に、2号機および3号機は2000年に運転を開始した。水車はKvaerner Energy A/S社が、発電機はABBが供給した。工事費は272百万USDで、外貨分は世界銀行、国際開発協会、ノルウェイのNORAD、スウェーデンのSIDA、ドイツのKfW、欧州投資銀行により融資された。

Kihansi水力発電所の職員によると、運転開始後、15年程度しか経過していないため、電気･機械設備の状態は良好である。

(7) Mwenga SPP水力発電所

Mwenga SPP水力発電所は、Mwenga Hydro Ltd.社により開発された総出力4MWの流れ込み式発電所である。

SPP制度の下で、2010年1月にTANESCOとの間で標準買電契約（SPPA；Standardized Power Purchase Agreement）が締結された。その後、建設工事が開始され、2012年9月に運転を開始した。

S-1-2-2 主な既設水力発電所の運転状況

(1) 発電電力量

表S-1-2.4にTANESCOから提供された運転実績に基づく既設発電所の平均発電電力量を示す。表S-1-2.5に発電所ごとの運転実績の詳細を示す。

「タ」国では比較的明瞭な雨季が存在し、一般に、河川流量は2月または3月～5月または6月に増加する。このため、月別の発電電力量は季節によって異なってくることが多い。この傾向は流れ込み式発電所において顕著であり、Hale水力発電所、New Pangani Falls水力発電所、Kihansi水力発電所では、月によって設備利用率が大きく異なる（図S-1-2.3参照）。一方、貯水池式発電所は河水の貯留が可能なため、Nyunba Ya Mungu水力発電所、Kidatu水力発電所、Mtera水力発電所では、年間を通じて設備利用率は大きく変動はしない。また、貯水池式水力発電所も、高負荷時間帯だけでなく、低負荷時間帯でも発電を行っているため、年間を通じて設備利用率が高い。

年間発電電力量は、降雨の多寡の影響を受けるため、年によって大きく変動している。図S-1-2.4に、既設発電所の1983年以降の設備利用率を示す。設備利用率（即ち年間発電電力量）に、顕著な増加または減少の傾向は認められない。New Pangani Falls水力発電所だけは、近年の減少傾向が見受けられるが、停止率の影響を受けている可能性があり、このデータのみからの判断はできない。

表 S-1-2.4　既設発電所の平均発電電力量

	Hydro Power Plant	Average Energy Generation (GWh)													Period of records
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
1	Hale	4.26	3.85	3.80	4.07	5.43	5.61	4.85	4.67	4.04	3.77	4.36	4.25	52.96	2005 - 2010 2013
2	Nyumba Ya Mungu	2.45	2.36	2.39	2.34	2.28	2.17	2.25	2.27	2.31	2.17	2.30	2.06	27.35	2000 - 2013
3	Kidatu	78.83	74.44	82.29	80.71	76.64	69.06	69.91	72.15	73.90	74.32	72.67	76.97	901.89	1983 - 1984 1987 - 1993 1995 - 2013
4	Mtera	27.91	26.89	28.81	22.74	25.82	25.40	27.58	32.74	34.38	35.20	32.77	28.45	348.69	1989 - 2013
5	Uwemba	0.29	0.23	0.30	0.30	0.30	0.21	0.20	0.18	0.14	0.14	0.11	0.20	2.60	2007 - 2013
6	New Pangani Falls	21.68	16.25	18.65	23.83	30.61	25.60	20.95	20.25	17.07	19.30	20.05	19.36	253.60	1995 - 2013
7	Kihansi	56.59	55.27	67.18	90.20	90.56	70.18	58.63	51.18	39.32	38.57	34.77	48.46	700.91	2000 - 2001 2003 - 2013
8	Mwenga SPP	1.20	1.22	2.02	2.11	2.38	1.81	1.38	1.40	0.98	0.90	0.65	1.05	17.10	2013

Note: The values for Mwenga SPP (No. 8) are energy purchased by TANESCO and are not energy generated.

表 S-1-2.5(1)　既設発電所の発電実績（Hale 水力発電所）

Year	Energy Generation (MWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2005	3,721	3,106	3,460	5,239	5,751	6,147	5,064	4,374	3,621	3,791	3,795	3,063	51,131
2006	2,951	2,785	4,089	4,649	6,029	6,745	6,166	5,606	4,601	4,601	6,787	7,030	62,039
2007	6,330	6,068	6,296	5,180	5,918	6,531	6,838	6,768	5,946	4,925	4,620	3,829	69,247
2008	3,075	4,695	3,378	6,064	5,942	5,856	4,575	6,339	5,678	4,711	5,180	4,691	60,184
2009	4,409	3,836	4,064	2,084	2,472	5,233	4,512	2,511	2,481	2,448	4,521	4,475	43,045
2010	6,139	4,518	1,535	1,511	6,163	5,481	4,805	4,240	3,887	3,277	3,364	4,035	48,956
2011													
2012													
2013	3,180	1,966	3,778	3,778	5,747	3,244	2,015	2,881	2,038	2,615	2,244	2,621	36,107
Average	4,258	3,853	3,800	4,072	5,432	5,605	4,853	4,674	4,036	3,767	4,359	4,249	52,958

Source: Made by JICA Study Team with reference to "Suppliers yearly kWh (TANESCO)"

表 S-1-2.5(2)　既設発電所の発電実績（Nyumba Ya Mungu 水力発電所）

Year	Energy Generation (MWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2000	4,285	4,112	4,232	4,011	3,027	2,815	2,940	2,899	2,793	2,825	2,788	2,704	39,430
2001	2,681	2,419	2,244	2,230	1,653	1,302	2,161	2,461	2,846	2,909	2,762	2,826	28,493
2002	2,820	2,187	2,489	1,564	1,448	2,035	2,060	2,223	2,238	2,537	2,095	2,069	25,764
2003	2,334	2,490	2,995	2,732	2,933	2,876	2,979	2,987	2,824	0	2,968	0	28,118
2004	2,948	2,499	2,525	2,993	3,097	2,480	2,114	1,838	1,718	1,754	2,376	1,896	28,238
2005	1,867	2,302	1,790	1,771	2,237	1,796	1,997	1,917	1,901	2,228	1,759	1,657	23,221
2006	1,702	1,496	1,092	1,267	1,222	1,703	1,442	2,063	2,818	2,428	2,201	2,283	21,717
2007	1,636	2,220	2,372	2,391	2,478	2,434	2,450	2,137	2,396	2,275	2,446	1,833	27,068
2008	1,828	2,216	1,769	1,687	1,968	1,817	1,995	1,909	2,451	2,588	2,472	2,361	25,061
2009	2,546	2,393	3,130	3,833	3,078	2,607	2,660	2,625	2,467	2,588	2,503	2,552	32,981
2010	2,604	2,326	2,301	2,317	2,562	2,452	2,525	2,540	2,455	2,515	2,483	3,001	30,081
2011	3,275	2,928	2,924	2,451	2,563	2,493	2,467	2,425	1,994	2,045	1,856	1,926	29,346
2012	1,942	1,783	1,765	1,757	1,820	1,714	1,810	1,856	1,717	1,801	1,726	1,846	21,536
2013	1,828	1,641	1,787	1,768	1,857	1,813	1,838	1,847	1,759	1,849	1,722	1,818	21,528
Average	2,450	2,358	2,387	2,341	2,282	2,167	2,246	2,266	2,313	2,167	2,297	2,055	27,327

Source: Made by JICA Study Team with reference to "Nyumba Ya Mungu Generation Status (TANESCO)"

表 S-1-2.5(3)　既設発電所の発電実績（Kidatu 水力発電所）

Year	Energy Generation (MWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1983	44,577	42,137	48,434	43,217	43,723	42,329	40,147	44,225	44,419	57,507	48,622	46,622	545,959
1984	43,510	46,456	51,142	45,267	46,706	45,248	45,068	46,347	46,645	55,028	55,587	57,409	584,413
1985													
1986													
1987	80,786	77,709	85,233	84,998	82,422	80,907	81,163	75,274	78,188	89,372	85,230	88,812	990,094
1988	88,758	85,610	96,172	80,718	78,354	59,093	65,705	71,986	68,041	69,710	72,062	70,762	906,971
1989	77,803	84,809	79,723	66,797	77,061	83,706	72,213	77,975	73,559	71,812	75,849	77,894	919,201
1990	73,822	67,330	73,094	73,577	57,189	71,546	79,008	78,927	75,849	81,821	81,674	77,635	891,472
1991	81,784	72,749	84,606	81,315	82,710	77,413	81,912	82,708	80,586	84,630	83,835	85,217	979,465
1992	88,745	84,951	90,640	94,648	92,557	91,395	95,203	89,412	64,367	63,258	62,791	68,998	986,965
1993	70,590	72,007	86,077	99,338	103,262	90,290	94,127	97,741	96,232	96,056	96,882	104,904	1,107,506
1994													
1995	62,226	60,016	86,813	84,740	78,763	67,050	70,903	71,678	76,233	77,630	66,932	52,435	855,419
1996	73,725	84,244	91,504	105,096	86,253	78,131	82,177	80,934	79,867	85,545	67,519	73,517	988,512
1997	62,814	74,365	80,157	97,748	74,645	53,396	64,073	67,511	56,991	29,101	19,615	92,114	772,530
1998	101,671	74,119	77,653	74,252	74,202	91,245	88,650	88,242	88,595	94,342	93,996	97,981	1,044,948
1999	104,036	97,108	109,384	106,113	100,829	86,980	92,324	89,691	89,592	94,610	92,031	88,309	1,151,007
2000	78,829	82,135	87,094	69,693	53,082	46,596	58,949	74,100	89,110	60,827	73,694	61,449	835,558
2001	85,529	78,338	87,562	78,702	74,616	86,387	89,518	96,885	103,117	108,575	120,805	122,335	1,132,369
2002	99,157	88,817	90,243	84,279	88,774	97,054	113,839	104,745	101,519	111,527	100,210	111,338	1,191,502
2003	109,142	95,183	112,232	109,131	112,569	96,093	77,542	82,384	89,110	71,600	97,285	96,322	1,148,593
2004	60,371	45,276	68,651	63,908	84,171	68,528	60,053	57,180	61,790	52,983	49,188	45,981	718,080
2005	70,081	69,571	55,862	53,370	45,048	50,681	43,792	49,253	54,912	58,911	67,038	62,587	681,106
2006	54,292	41,556	35,803	39,364	57,385	34,515	35,467	37,485	43,014	28,714	14,610	66,062	488,267
2007	67,861	92,926	108,342	115,790	95,705	70,357	62,944	67,332	84,529	85,437	86,496	90,968	1,028,687
2008	94,890	98,826	89,773	114,297	107,408	73,332	66,717	67,183	80,846	92,650	94,433	89,305	1,069,660
2009	96,329	92,981	103,375	97,191	83,825	76,655	79,451	86,103	96,551	107,170	87,181	91,022	1,097,834
2010	88,188	75,931	91,229	72,387	77,559	73,436	81,682	105,738	107,569	113,239	111,336	112,282	1,110,576
2011	117,703	86,866	101,763	83,413	77,150	48,458	33,872	33,081	34,154	34,045	41,625	65,471	757,601
2012	75,771	61,649	82,403	80,348	69,488	65,523	53,702	46,689	45,752	47,809	41,205	40,389	710,728
2013	54,244	50,665	49,137	60,285	40,428	27,473	47,299	49,446	58,156	57,150	47,149	16,908	558,340
Average	78,830	74,440	82,289	80,714	76,639	69,065	69,911	72,152	73,903	74,324	72,674	76,965	901,906

Source: Made by JICA Study Team with reference to "Hydro Generation Report (Kidatu HPP, TANESCO)"

表 S-1-2.5(4)　既設発電所の発電実績（Mtera 水力発電所）

Year	Energy Generation (MWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1989	13,555	7,276	25,252	34,851	24,512	18,507	28,909	34,604	30,425	35,417	33,538	33,192	320,038
1990	34,837	35,530	36,368	26,205	48,293	38,207	30,791	37,367	39,194	41,642	39,489	42,911	450,834
1991	43,142	41,143	44,607	41,069	37,161	42,285	43,445	42,248	41,479	41,684	40,280	43,344	501,887
1992	42,861	40,580	43,992	37,977	38,434	32,613	31,818	40,615	25,676	26,735	24,876	25,942	412,119
1993	27,270	19,859	24,395	29,644	23,161	36,822	39,495	43,464	43,717	47,493	43,862	52,308	431,490
1994	44,766	32,003	30,250	34,385	27,139	36,478	37,106	37,851	32,723	27,489	21,254	12,626	374,070
1995	13,107	17,667	6,381	4,765	8,164	13,793	26,485	29,437	32,834	37,858	23,888	21,623	236,002
1996	26,902	13,129	28,926	8,169	16,552	23,707	35,507	37,047	38,218	41,308	32,804	34,940	337,209
1997	23,509	25,043	24,431	5,241	25,213	18,003	21,793	29,390	25,889	6,096	270	281	205,159
1998	10,609	36,198	44,781	42,962	40,715	27,381	23,235	29,920	35,429	41,250	44,763	46,944	424,187
1999	42,806	43,456	32,224	16,089	18,858	32,380	34,699	36,519	39,452	41,156	45,780	35,119	418,538
2000	37,471	34,569	18,741	14,021	11,263	14,260	24,081	32,019	34,777	30,617	29,134	4,827	285,780
2001	25	17,574	45,164	41,206	30,130	27,797	36,260	42,911	44,935	53,596	54,855	51,385	445,838
2002	36,136	34,224	29,587	33,407	35,008	29,657	31,246	49,826	48,195	55,828	48,322	48,339	479,775
2003	43,451	45,136	51,291	40,014	52,593	47,659	35,366	42,065	44,081	49,160	49,076	31,997	531,889
2004	15,812	6,982	10,809	5	33,692	28,422	26,754	23,243	31,466	22,395	21,812	9,614	231,006
2005	24,868	23,991	6,067	4,585	7,932	15,921	14,972	21,453	26,774	21,453	30,873	26,893	225,782
2006	23,599	8,712	4,940	20	9,332	6,260	11,321	12,801	16,184	3,611	4,000	0	100,780
2007	0	34,458	55,170	52,524	34,415	24,464	25,223	28,357	38,741	45,152	42,459	41,008	421,971
2008	36,697	13,401	22,356	16,680	34,301	16,834	18,716	23,298	35,674	44,788	44,420	33,848	341,013
2009	43,905	36,989	36,407	23,174	28,529	31,390	35,257	39,343	45,744	53,082	39,873	37,422	451,115
2010	22,556	24,984	30,286	20,923	17,858	26,354	32,554	51,130	51,600	54,380	52,372	48,308	433,305
2011	50,045	34,130	32,359	13,524	19,719	12,376	6,715	8,991	9,784	10,960	15,177	15,474	229,254
2012	21,476	26,673	26,654	24,239	20,682	27,438	23,351	19,362	19,256	23,100	19,719	9,768	261,718
2013	18,437	18,609	8,738	2,849	1,855	6,099	14,404	25,242	27,292	23,683	16,233	3,236	166,677
Average	27,914	26,893	28,807	22,741	25,820	25,404	27,580	32,740	34,382	35,197	32,765	28,454	348,697

Source: Made by JICA Study Team with reference to "Mtera Historical Data (Mtera HPP, TANESCO)"

表 S-1-2.5(5)　既設発電所の発電実績（Uwemba 水力発電所）

Year	Energy Generation (MWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2007	369	304	306	203	256	286	217	193	139	113	100	214	2,700
2008	371	352	381	396	348	0	115	217	149	122	124	292	2,867
2009	397	309	330	412	402	302	246	170	123	302	141	159	3,294
2010	199	47	325	435	437	342	279	195	158	121	85	193	2,815
2011	231	153	212	135	137	131	149	175	141	141	100	212	1,917
2012	224	217	217	243	240	214	232	189	141	116	147	168	2,348
2013	226	260	295	274	289	226	170	138	111	84	60	163	2,296
Average	288	235	295	300	301	214	201	182	137	143	108	200	2,605

Source: Made by JICA Study Team with reference to "Suppliers yearly kWh (TANESCO)"

表 S-1-2.5(6)　既設発電所の発電実績（New Pangani Falls 水力発電所）

Year	Energy Generation (MWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	22,873	15,970	20,979	24,708	41,867	32,732	24,690	29,701	23,394	24,155	21,920	20,828	303,817
1996	20,345	20,389	18,708	28,659	42,316	34,160	22,645	22,916	20,716	21,687	20,798	20,644	293,984
1997	19,539	17,674	19,123	26,322	26,218	42,026	28,158	22,231	20,310	30,927	41,933	40,620	335,081
1998	38,117	32,985	37,398	35,558	35,594	31,468	43,363	45,086	38,267	34,641	28,896	27,604	428,977
1999	26,879	22,336	30,950	42,175	46,155	41,615	40,931	37,868	33,215	29,746	27,553	27,138	406,561
2000	23,735	21,422	25,354	28,584	39,186	31,817	26,670	25,052	19,771	19,591	20,152	23,168	304,502
2001	30,895	27,981	21,571	20,293	24,316	21,205	19,571	15,741	16,530	16,597	15,575	14,831	245,106
2002	16,464	14,873	19,906	24,247	17,273	14,237	13,605	15,929	18,173	20,403	34,198	21,765	231,073
2003	19,952	13,262	15,265	17,674	19,934	29,403	21,657	19,214	16,779	16,973	15,545	16,541	222,199
2004	18,821	18,359	20,108	28,452	21,773	17,293	19,561	13,609	11,044	14,403	14,491	12,978	210,892
2005	11,254	10,759	15,290	17,951	23,065	19,982	14,673	13,059	5,622	11,745	11,661	9,989	165,050
2006	9,841	9,210	12,399	14,154	33,117	24,417	17,929	15,969	13,367	30,279	41,863	42,913	265,456
2007	45,818	29,564	20,331	21,960	40,781	39,889	24,284	26,757	18,607	15,169	14,242	12,061	309,461
2008	10,449	1,780	13,577	32,943	39,850	35,243	29,964	24,063	17,255	14,665	15,046	14,157	248,990
2009	14,108	13,569	13,569	16,447	18,789	8,007	13,637	13,144	11,693	13,169	14,406	16,136	166,674
2010	29,651	10,362	11,806	21,215	36,122	22,780	14,646	13,235	12,413	11,234	11,438	13,037	207,938
2011	13,766	12,287	15,201	22,946	25,307	16,947	12,896	12,669	11,542	24,807	14,183	14,770	197,322
2012	28,922	8,662	11,631	12,120	20,434	11,683	121	9,058	8,543	7,836	9,447	9,979	138,437
2013	10,523	7,268	11,201	16,452	29,553	11,504	9,003	9,499	7,147	8,756	7,655	8,643	137,202
Average	21,682	16,248	18,651	23,835	30,613	25,600	20,948	20,253	17,073	19,304	20,053	19,358	253,617

Source: Made by JICA Study Team with reference to "New Pangani Falls Units Generated (TANESCO)" and "Suppliers yearly kWh (TANESCO)"

表 S-1-2.5(7)　既設発電所の発電実績（Kihansi 水力発電所）

Year	Energy Generation (MWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2000	41,305	39,461	57,990	64,421	72,873	59,325	52,226	46,348	33,745	31,352	34,838	56,176	590,059
2001	73,029	64,882	61,464	61,213	81,951	73,300	62,993	55,758	43,097	41,928	33,315	34,024	686,954
2002													
2003	67,285	52,954	50,872	74,378	53,961	47,980	40,076	34,923	31,529	29,741	23,531	36,117	543,346
2004	58,372	69,066	71,464	115,021	92,559	65,464	54,077	45,946	38,590	36,762	37,297	69,088	753,706
2005	69,178	55,032	63,544	81,875	76,615	58,958	50,978	43,848	35,626	31,560	27,602	23,683	618,499
2006	25,492	33,250	40,024	69,607	77,690	47,653	37,052	34,690	28,657	26,382	23,130	57,180	500,805
2007	63,052	62,229	54,701	67,797	75,515	62,743	52,303	58,236	40,565	37,879	32,173	48,800	655,993
2008	52,454	73,315	73,664	110,295	105,047	97,787	83,178	67,855	56,527	50,757	45,212	77,146	893,237
2009	59,938	66,181	95,611	117,542	116,244	87,350	73,733	62,302	23,758	45,287	46,813	50,857	845,616
2010	66,896	65,858	83,301	107,370	113,908	95,253	80,034	64,961	54,159	46,401	46,536	42,638	867,316
2011	47,104	47,186	65,254	111,730	112,208	80,861	64,519	54,032	47,484	46,821	38,749	56,898	772,845
2012	58,659	45,375	57,945	73,898	82,567	57,350	46,510	41,838	33,769	31,630	27,485	32,908	589,933
2013	52,867	43,739	97,464	117,418	116,160	78,320	64,558	54,584	43,710	44,884	35,327	44,457	793,488
Average	56,587	55,271	67,177	90,197	90,561	70,180	58,634	51,179	39,324	38,568	34,770	48,459	700,908

Source: Made by JICA Study Team with reference to "Annual Report 2000 - 2013 (Kihansi HPP, TANESCO)"

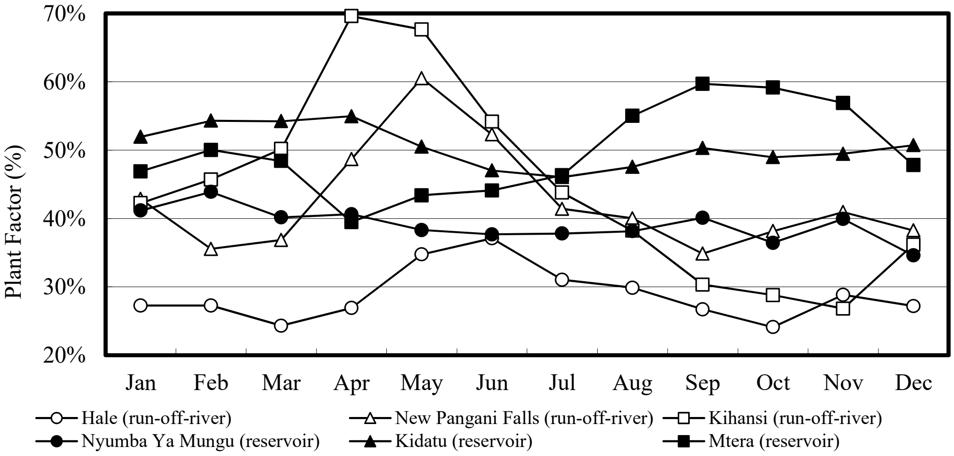


図 S-1-2.3　既設発電所の平均月別設備利用率

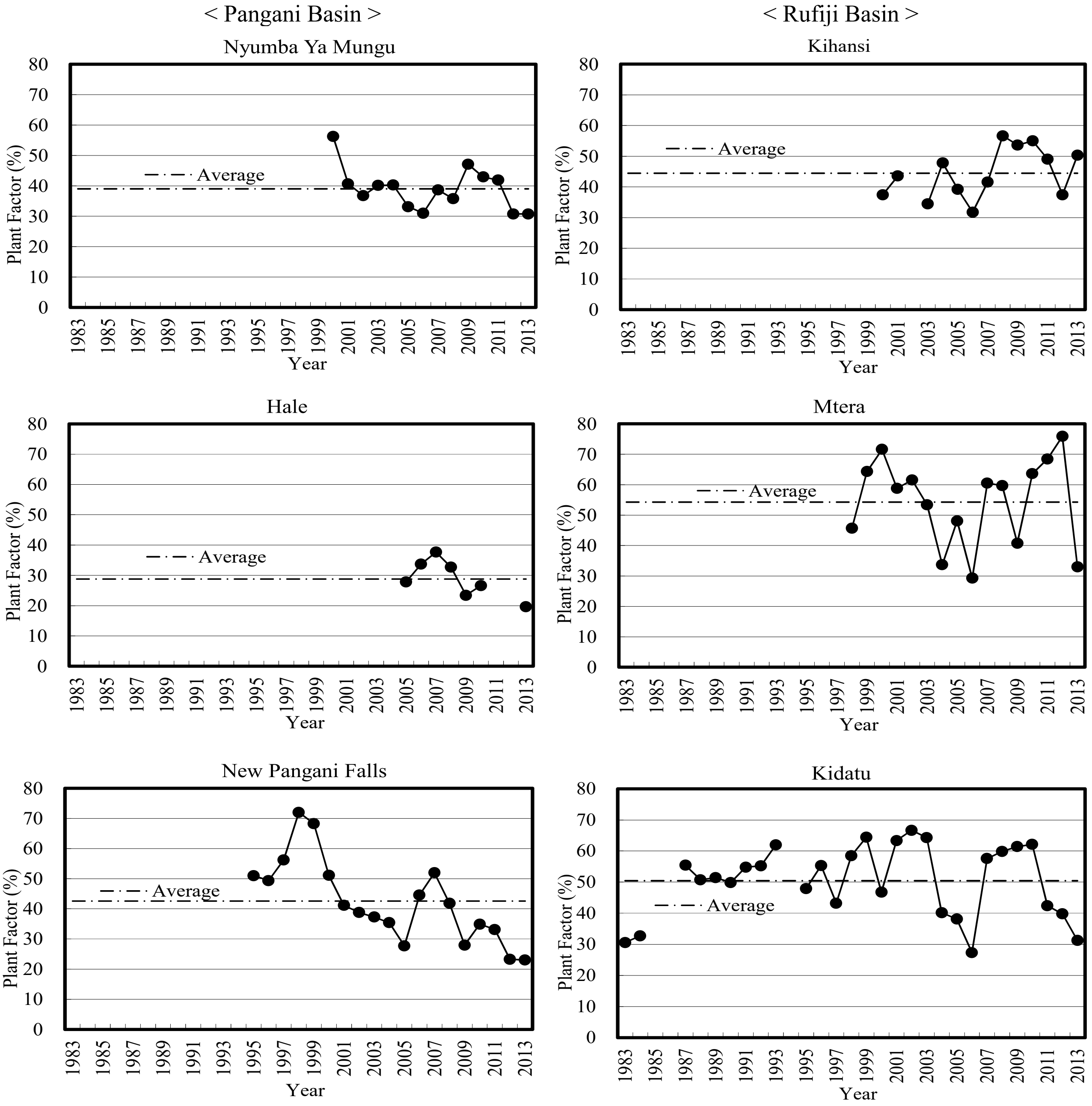


図 S-1-2.4　既設発電所の年間設備利用率実績

(2)　停止率

表 S-1-2.6 に TANESCO から提供された運転実績に基づく既設発電所の事故停止率を、表 S-1-2.7 に計画停止率を示す。表 S-1-2.8 に発電所ごとの停止実績の詳細を示す。

年間の事故停止率は全平均で 20.2%/基となり、一般的な水力発電所（約 0%）に比較して非常に大きい。ただし、運転開始後 50 年近くが経過している Hale 水力発電所と Nyunba Ya Mungu 水力発電所を除くと、事故停止率は 2.5%/基で概ね妥当な値となる。

年間の計画停止率は、全平均で 2.2%/基となっている。

表 S-1-2.6　既設発電所の事故停止率

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)"

表 S-1-2.7　既設発電所の計画停止率

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
Planned Outage Duration Time	Whole Plant (Days-Unit)	Year	1999	N/A	N/A	140.2	N/A	N/A	N/A
			2000	N/A	N/A	336.5	N/A	N/A	N/A
			2001	N/A	N/A	140.2	N/A	N/A	54.9
			2002	N/A	N/A	244.0	N/A	N/A	N/A
			2003	N/A	N/A	213.7	N/A	N/A	24.7
			2004	N/A	N/A	43.5	N/A	N/A	17.3
			2005	N/A	N/A	160.7	N/A	N/A	5.8
			2006	1.1	8.0	106.9	N/A	2.2	N/A
			2007	3.7	4.3	25.2	N/A	0.9	16.1
			2008	0.3	5.8	82.1	N/A	5.1	16.1
			2009	N/A	N/A	33.4	N/A	N/A	3.2
			2010	N/A	N/A	32.8	N/A	N/A	5.9
			2011	N/A	N/A	74.8	N/A	N/A	9.7
			2012	N/A	N/A	21.1	N/A	N/A	9.8
			2013	0.0	2.0	98.9	N/A	5.1	9.6
		Average		1.3	5.0	116.9	N/A	3.3	15.7
				28.5					
	Per Unit (Days)	Average		0.6	2.5	29.2	N/A	1.7	5.2
				7.9					
Planned Outage Rate per Unit (time per year)				0.2%	0.7%	8.0%	N/A	0.5%	1.4%
				2.2%					

Source: Made by JICA Study Team with reference to "Annual Report of each Hydro Power Plant (1999 - 2012, TANESCO)"

表 S-1-2.8(1)　既設発電所の停止実績（Hale 水力発電所）

Year	Forced Outage (Hour)			Planned Outage (Hour)		
	Unit 1	Unit 2	Total	Unit 1	Unit 2	Total
2006	8,760.0	61.5	8,821.5	0.0	25.7	25.7
2007	8,760.0	124.9	8,884.9	0.0	88.2	88.2
2008	8,784.0	562.1	9,346.1	0.0	8.0	8.0
2009						
2010						
2011						
2012						
2013	8,760.0	8,235.0	16,995.0	0.0	0.0	0.0
Average	8,766.0	2,245.9	11,011.9	0.0	30.5	30.5

Source: Made by JICA Study Team with reference to "Annual Report of Pangani Hydro System (2008 and 2013, TANESCO)"

表 S-1-2.8(2)　既設発電所の停止実績（Nyumba Ya Mungu 水力発電所）

Year	Forced Outage (Hour)			Planned Outage (Hour)		
	Unit 1	Unit 2	Total	Unit 1	Unit 2	Total
2006	16.5	662.5	679.0	96.0	96.0	192.0
2007	2,007.9	3,020.9	5,028.8	55.5	48.0	103.5
2008	7,904.7	719.9	8,624.6	66.0	74.3	140.3
2009						
2010						
2011						
2012						
2013	6,982.6	105.5	7,088.1	16.0	32.3	48.3
Average	4,227.9	1,127.2	5,355.1	58.4	62.6	121.0

Source: Made by JICA Study Team with reference to "Annual Report of Pangani Hydro System (2008 and 2013, TANESCO)"

表 S-1-2.8(3)　既設発電所の停止実績（Kidatu 水力発電所）

Year	Forced Outage (Hour)					Planned Outage (Hour)				
	Unit 1	Unit 2	Unit 3	Unit 4	Total	Unit 1	Unit 2	Unit 3	Unit 4	Total
1999	151.1	6.9	10.7	30.9	199.6	137.4	3,164.3	31.4	32.5	3,365.6
2000	11.2	114.5	353.3	70.7	549.7	5,496.0	2,405.8	122.7	51.3	8,075.8
2001	151.1	6.9	10.7	30.9	199.6	137.4	3,164.3	31.4	32.5	3,365.6
2002	56.2	25.2	30.0	30.1	141.6	2,165.0	60.0	3,493.4	137.6	5,855.9
2003	90.5	23.8	22.2	119.5	255.9	315.0	1,803.0	446.2	2,565.3	5,129.5
2004	108.4	7.8	154.7	12.1	283.0	738.4	119.1	160.9	25.8	1,044.3
2005	3.8	80.6	6.0	13.6	103.9	2,265.3	1,407.3	117.3	67.5	3,857.4
2006	86.8	140.5	83.7	59.7	370.7	681.1	514.7	1,004.1	364.6	2,564.5
2007	355.3	173.3	330.8	26.3	885.7	182.5	156.4	159.8	105.1	603.8
2008	63.6	39.4	32.8	119.1	254.8	447.0	1,272.7	102.7	147.2	1,969.6
2009	70.6	134.9	23.4	17.6	246.4	380.2	122.9	248.1	50.1	801.3
2010	38.3	1,404.8	1,156.7	15.9	2,615.7	292.9	372.3	66.2	56.5	787.9
2011	111.6	580.5	57.1	33.7	782.8	318.3	398.6	368.9	710.1	1,795.9
2012	862.2	766.3	1,289.5	634.8	3,552.8	87.4	173.9	94.4	151.7	507.4
2013	9.1	109.7	2.1	611.8	732.7	2,012.1	148.1	105.1	108.7	2,373.9
Average	144.6	241.0	237.6	121.8	745.0	1,043.7	1,018.9	436.8	307.1	2,806.6

Source: Made by JICA Study Team with reference to "Annual Report of Kidatu HPP (1999 - 2013, TANESCO)"

表 S-1-2.8(4) 既設発電所の停止実績（New Pangani Falls 水力発電所）

Year	Forced Outage (Hour)			Planned Outage (Hour)		
	Unit 1	Unit 2	Total	Unit 1	Unit 2	Total
2006	45.5	27.1	72.6	35.7	16.8	52.5
2007	19.5	18.6	38.1	14.0	7.9	21.8
2008	82.0	60.6	142.6	101.9	21.5	123.3
2009						
2010						
2011						
2012						
2013	290.2	1,498.5	1,788.7	79.8	41.8	121.6
Average	109.3	401.2	510.5	57.8	22.0	79.8

Source: Made by JICA Study Team with reference to "Annual Report of Pangani Hydro System (2008 and 2013, TANESCO)"

表 S-1-2.8(5) 既設発電所の停止実績（Kihansi 水力発電所）

Year	Forced Outage (Hour)				Planned Outage (Hour)			
	Unit 1	Unit 2	Unit 3	Total	Unit 1	Unit 2	Unit 3	Total
2001	704.0	676.0	337.0	1,717.0	529.0	550.0	238.0	1,317.0
2002								
2003	6.0	5.4	1.2	12.6	88.4	306.0	199.3	593.7
2004	9.0	1.3	108.5	118.9	102.9	248.9	64.1	415.8
2005	105.0	1.0	1.0	107.0	53.0	42.0	45.0	140.0
2006								
2007	57.8	0.0	198.0	255.8	97.6	225.7	63.6	386.9
2008	57.8	0.0	198.0	255.8	97.6	225.5	63.6	386.7
2009	603.6	97.1	24.9	725.5	26.1	26.3	24.9	77.3
2010	1,869.3	57.2	23.9	1,950.4	42.0	40.2	58.4	140.5
2011	3.6	760.1	46.8	810.4	43.5	55.1	133.5	232.1
2012	49.1	404.8	150.0	603.9	48.4	140.4	47.5	236.3
2013	244.7	140.8	23.6	409.1	44.0	117.4	67.9	229.3
Average	337.2	194.9	101.2	633.3	106.6	179.8	91.4	377.8

Source: Made by JICA Study Team with reference to "Annual Report of Kihansi HPP (2000-2001, 2003-2005, 2007-2013, TANESCO)"

(3) 発電所内電力消費率

表 S-1-2.9 に TANESCO から提供された運転実績に基づく既設発電所の発電所内電力消費率を示す。表 S-1-2.10 に発電所ごとの発電所内電力消費実績の詳細を示す。

発電所内電力消費率は、電気･機械設備の規模や修繕工事の量の差により、発電所や年によって異なる。全平均で、発電所内電力消費率は 0.79%となっている。大部分の発電所が地下式発電所であること、有人発電所で構内に宿泊施設があること等から、所内電力の消費量は比較的大きい。

表 S-1-2.9　既設発電所の所内電力消費率

Year	Hale	Nyumba Ya Mungu	Kidatu	Mtera	New Pangani Falls	Kihansi
1999	N/A	N/A	0.47%	N/A	N/A	0.39%
2000	N/A	N/A	0.72%	N/A	N/A	0.49%
2001	N/A	N/A	0.47%	N/A	N/A	0.50%
2002	N/A	N/A	0.48%	N/A	N/A	N/A
2003	N/A	N/A	0.45%	N/A	N/A	0.80%
2004	N/A	N/A	0.71%	N/A	N/A	0.45%
2005	N/A	N/A	0.70%	N/A	N/A	0.52%
2006	N/A	N/A	0.95%	N/A	N/A	N/A
2007	0.72%	0.44%	0.47%	N/A	0.35%	0.61%
2008	1.04%	0.44%	0.45%	N/A	0.44%	0.46%
2009	N/A	N/A	0.49%	N/A	N/A	0.52%
2010	N/A	N/A	0.46%	N/A	N/A	0.49%
2011	N/A	N/A	0.66%	1.35%	N/A	0.51%
2012	1.39%	0.47%	0.72%	N/A	0.91%	0.48%
2013	1.18%	0.58%	0.90%	1.52%	0.84%	0.49%
Average	1.08%	0.48%	0.61%	1.44%	0.64%	0.52%
	0.79%					

Note: Station Use Rate = { Station Used Energy / Annual Energy Generation } x 100 (%)

Source: Made by JICA Study Team with reference to "Annual Report of each Hydro Power Plant (1999 - 2013, TANESCO)"

表 S-1-2.10　既設発電所の所内電力消費実績

Year	Hale			Nyumba Ya Mungu			Kidatu			Mtera			New Pangani Falls			Kihansi		
	Annual Energy Generation (MWh)	Station Used Energy (MWh)	Station Use Rate	Annual Energy Generation (MWh)	Station Used Energy (MWh)	Station Use Rate	Annual Energy Generation (MWh)	Station Used Energy (MWh)	Station Use Rate	Annual Energy Generation (MWh)	Station Used Energy (MWh)	Station Use Rate	Annual Energy Generation (MWh)	Station Used Energy (MWh)	Station Use Rate	Annual Energy Generation (MWh)	Station Used Energy (MWh)	Station Use Rate
1999							1,151,007	5,372	0.47%	418,538			406,561			14,099	55	0.39%
2000				39,430			835,558	6,040	0.72%	285,780			304,502			590,059	2,891	0.49%
2001				28,493			1,132,369	5,372	0.47%	445,838			245,106			686,954	3,443	0.50%
2002				25,764			1,191,502	5,713	0.48%	479,775			231,073			721,658		
2003				28,118			1,148,593	5,149	0.45%	531,889			222,199			543,346	4,328	0.80%
2004				28,238			718,080	5,122	0.71%	231,006			210,892			753,706	3,362	0.45%
2005	51,131			23,221			681,106	4,760	0.70%	225,782			165,050			618,499	3,186	0.52%
2006	62,039			21,717			488,267	4,625	0.95%	100,780			265,456			500,805		
2007	69,247	501	0.72%	27,068	118	0.44%	1,028,687	4,857	0.47%	421,971			309,461	1,098	0.35%	655,993	4,029	0.61%
2008	60,184	627	1.04%	25,061	111	0.44%	1,069,660	4,857	0.45%	341,013			248,990	1,095	0.44%	893,237	4,088	0.46%
2009	43,045			32,981			1,097,834	5,325	0.49%	451,115			166,674			845,616	4,355	0.52%
2010	48,956			30,081			1,110,576	5,152	0.46%	433,305			207,938			867,316	4,216	0.49%
2011				29,346			757,601	5,007	0.66%	229,254	3,098	1.35%	197,322			772,845	3,909	0.51%
2012	31,895	443	1.39%	21,536	101	0.47%	710,728	5,150	0.72%	261,718			138,437	1,262	0.91%	589,933	2,858	0.48%
2013	36,107	426	1.18%	21,528	124	0.58%	558,340	5,007	0.90%	166,677	2,539	1.52%	137,202	1,154	0.84%	793,488	3,913	0.49%
Average		499	1.08%		114	0.48%		5,167	0.61%		2,819	1.44%		1,152	0.64%		3,433	0.52%
	0.79%																	

Source: Made by JICA Study Team with reference to "Annual Report of each Hydro Power Plant (1999 - 2013, TANESCO)"

(4)　運転･維持管理費

表 S-1-2.11 に TANESCO から提供された運転実績に基づく既設発電所の運転･維持管理費を示す。表 S-1-2.12 に発電所ごとの運転･維持管理費実績の詳細を示す。

維持管理費は、一般に、経年による設備劣化に伴って増加する。表 S-1-2.11 に示す収集データからも、経年によって発電所ごとの運転･維持管理費は増加する傾向が見られる。

図 S-1-2.5 に、既設発電所の運転開始以降の経過年（発電所年齢）別の kW 当たり運転･維持管理費を示す。全既設発電所においても、kW 当たり運転･維持管理費は、発電所年齢の増加に伴って増加する傾向がある。

ただし、発電所の所員が修繕工事を行っており、運転･維持管理費に占める所員人件費の割合が約 60%と高い（表 S-1-2.13 参照）。また、2004 年以降の一人当たり人件費は上昇している（表 S-1-2.13 参照）。このため、図 S-1-2.5 に示される経年による運転･維持管理費の増加傾向は、設備の経年劣化だけでなく、賃上げや所員年齢構成変化の影響も受けていると推察される。

表 S-1-2.11　既設発電所の運転･維持管理費実績

<table>
<tr><th colspan="3" rowspan="2">Item</th><th colspan="6">Hydro Power Plant</th></tr>
<tr><th>Kidatu</th><th>Mtera</th><th>Kihansi</th><th>Hale</th><th>Nyumba Ya Mungu</th><th>New Pangani Falls</th></tr>
<tr><td rowspan="3">Plant Characteristics</td><td colspan="2">Installation Year</td><td>1975</td><td>1988</td><td>1999</td><td>1967</td><td>1968</td><td>1995</td></tr>
<tr><td colspan="2">Installed Capacity</td><td>204</td><td>80</td><td>180</td><td>21</td><td>8</td><td>68</td></tr>
<tr><td colspan="2">Number of units</td><td>4</td><td>2</td><td>3</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td rowspan="14">O&M Cost (Million Tsh)</td><td rowspan="14">Year</td><td>2000</td><td>N/A</td><td>N/A</td><td>417</td><td colspan="3">N/A</td></tr>
<tr><td>2001</td><td>1,238</td><td>N/A</td><td>573</td><td colspan="3">N/A</td></tr>
<tr><td>2002</td><td>1,237</td><td>N/A</td><td>795</td><td colspan="3">N/A</td></tr>
<tr><td>2003</td><td>N/A</td><td>N/A</td><td>804</td><td colspan="3">N/A</td></tr>
<tr><td>2004</td><td>N/A</td><td>N/A</td><td>816</td><td colspan="3">N/A</td></tr>
<tr><td>2005</td><td>N/A</td><td>N/A</td><td>791</td><td colspan="3">N/A</td></tr>
<tr><td>2006</td><td>N/A</td><td>N/A</td><td>815</td><td colspan="3">1,657</td></tr>
<tr><td>2007</td><td>N/A</td><td>1,155</td><td>1,024</td><td colspan="3">2,239</td></tr>
<tr><td>2008</td><td>N/A</td><td>1,366</td><td>1,384</td><td colspan="3">2,646</td></tr>
<tr><td>2009</td><td>2,750</td><td>1,572</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td>2010</td><td>2,404</td><td>1,318</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td>2011</td><td>2,518</td><td>1,440</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td>2012</td><td>3,231</td><td>1,333</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td>2013</td><td>3,142</td><td>1,644</td><td>N/A</td><td colspan="3">N/A</td></tr>
<tr><td rowspan="4">Average</td><td rowspan="2">per Year</td><td>(M Tsh)</td><td>2,360</td><td>1,404</td><td>824</td><td colspan="3">2,181</td></tr>
<tr><td>(M USD)</td><td>1.47</td><td>0.88</td><td>0.52</td><td colspan="3">1.36</td></tr>
<tr><td rowspan="2">per Year-kW</td><td>(Tsh/kW)</td><td>11,569</td><td>17,549</td><td>4,579</td><td colspan="3">22,483</td></tr>
<tr><td>(USD/kW)</td><td>7.2</td><td>11.0</td><td>2.9</td><td colspan="3">14.1</td></tr>
</table>

Note:　1 USD =　1,600 Tsh

Source:　Made by JICA Study Team with reference to "Annual Report of each Hydro Power Plant (1999 - 2012, TANESCO)"

表 S-1-2.12(1)　既設発電所の運転･維持管理費内訳（Kidatu 水力発電所）

Year	Number of Employees	Expenditure (Thousand Tsh)						
		Stationary	Safari	Transport	Salaries	Rehabilitation & Maintenance Work	Others	Total
2001	189	2,383	26,483	51,367	931,702	72,881	153,566	1,238,382
2002	184	2,801	16,489	53,660	886,900	82,261	194,937	1,237,047
2003								
2004								
2005								
2006								
2007								
2008								
2009	106	3,044	57,869	89,808	1,370,496	1,003,656	224,822	2,749,695
2010	108	8,112	45,168	131,615	1,407,089	567,990	244,271	2,404,245
2011	105	14,411	54,127	146,651	1,720,793	294,060	287,556	2,517,598
2012	99	14,303	79,272	201,572	2,188,109	298,258	449,243	3,230,756
2013	102	18,956	80,375	132,850	2,472,371	273,283	164,313	3,142,149

Source: Made by JICA Study Team with reference to "Annual Report of Kidatu HPP (1999 - 2013, TANESCO)"

表 S-1-2.12(2)　既設発電所の運転･維持管理費内訳（Mtera 水力発電所）

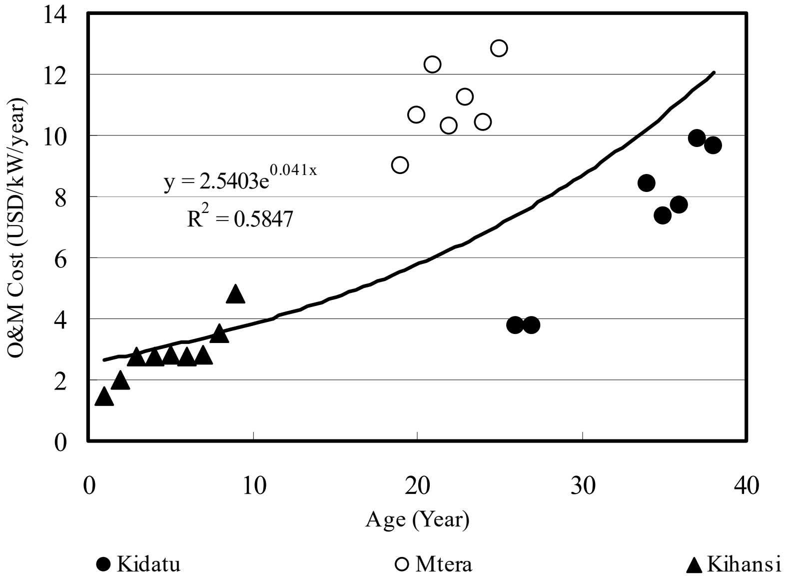
Year	Number of Employees	Expenditure (Thousand Tsh)						
		Stationary	Safari	Transport	Salaries	Repair & Maintenance Work	Others	Total
2007			45,526	103,266	556,101	125,116	324,804	1,154,813
2008	64		46,169	152,313	585,127	239,187	342,917	1,365,713
2009	65		87,915	181,149	576,461	310,716	415,582	1,571,824
2010	65		130,506	167,961	720,201	61,163	238,517	1,318,348
2011	64		114,266	117,813	820,351	155,792	232,077	1,440,298
2012			117,796	178,636	720,201	79,566	236,511	1,332,710
2013	63		211,870	156,663	870,699	114,140	290,450	1,643,822

Source: Made by JICA Study Team with reference to "Annual Report of Mtera HPP (2009-2011, 2013, TANESCO)"

表 S-1-2.12(3)　既設発電所の運転･維持管理費内訳（Kihansi 水力発電所）

Year	Number of Employees	Expenditure (Thousand Tsh)						
		Stationary	Safari	Transport	Salaries	Repair & Maintenance Work	Others	Total
2000	101	392	18,725	6,669	365,325	9,098	16,979	417,189
2001	111	7,717	22,550	67,310	403,749	48,549	22,639	572,513
2002		6,549	22,305	74,026	491,958	35,104	164,594	794,536
2003	64	1,942	21,113	83,685	518,170	37,733	141,765	804,408
2004	65	3,275	25,008	114,639	419,442	71,946	181,615	815,925
2005	61	628	38,578	112,287	398,390	57,725	183,257	790,865
2006	56	2,524	71,170	130,080	390,686	55,151	165,265	814,875
2007	63	3,867	78,768	164,383	447,349	140,689	188,983	1,024,038
2008	64	5,580	85,670	210,989	456,812	416,086	208,934	1,384,071
2009	68							
2010	72							
2011	80							
2012	77							
2013	76							

Source: Made by JICA Study Team with reference to "Annual Report of Kihansi HPP (2000-2001, 2003-2005, 2007-2013, TANESCO)"



Source: Made by JICA Study Team with reference to "Annual Report of each Hydro Power Plant (1999 - 2012, TANESCO)"

図 S-1-2.5　既設発電所の発電所年齢別の kW 当たり運転･維持管理費

表 S-1-2.13　既設発電所の人件費

Year	Proportion of Salaries in O&M Costs			Salary per Person (Thousand Tsh/person)		
	Kidatu	Mtera	Kihansi	Kidatu	Mtera	Kihansi
2000	N/A	N/A	87.6%	N/A	N/A	3,617
2001	75.2%	N/A	N/A	4,930	N/A	N/A
2002	71.7%	N/A	61.9%	4,820	N/A	N/A
2003	N/A	N/A	64.4%	N/A	N/A	8,096
2004	N/A	N/A	51.4%	N/A	N/A	6,453
2005	N/A	N/A	50.4%	N/A	N/A	6,531
2006	N/A	N/A	47.9%	N/A	N/A	6,977
2007	N/A	48%	43.7%	N/A	N/A	7,101
2008	N/A	43%	33.0%	N/A	9,143	7,138
2009	49.8%	37%	N/A	12,929	8,869	N/A
2010	58.5%	55%	N/A	13,029	11,080	N/A
2011	68.4%	57%	N/A	16,389	12,818	N/A
2012	67.7%	54%	N/A	22,102	N/A	N/A
2013	78.7%	53%	N/A	24,239	13,821	N/A
Average	67.2%	49.5%	55.0%	14,062	11,146	6,559
	57.2%			10,589		

Source: Made by JICA Study Team with reference to "Annual Report of each Hydro Power Plant (1999 - 2012, TANESCO)"

S-2　WASP 入力データの設定根拠（火力、水力）

S-2-1　火力発電設備

新規石炭火力発電所の建設地点については、PSMP2012 上では Coastal Coal、Local Coal I～VI との記載に留めてあり、建設地点も決定していない不明な計画がある。

ガス火力発電の新規建設については、現在計画中のものしか上げられておらず、将来の開発候補電源が記載されていない。

また、現在実施中／計画段階の火力発電設備についても、PSMP2012 上では算定根拠等、詳細が不明な点があり、内容の精査が必要である。

以上から、天然ガス、石炭といった有望な一次エネルギーについてモデルプラントを設定し、建設コスト、O&M コストについて電源開発計画策定ソフト（WASP: Wien Automatic System Planning Package）への入力緒元の検討を行った。

WASP 入力諸元については、PSMP2012 を始め、2011 年に SNC-Lavalin が実施した EAC REGIONAL POWER SYSTEM MASTER PLAN AND GRID CODE STUDY (以下、EAC Regional PSMP という)及び EIA の Annual Energy Outlook 2014（以下、EIA-AEO2014 という）を参考にした。

(1)　石炭火力発電所

1)　亜臨界圧石炭火力発電所

「タ」国南部において、Kiwira I&II 発電所、Mchuchuma I～III 発電所、Ngaka I&II 発電所の建設が計画されているが、現状、設備容量を 50～100MW で計画しており、PSMP2012 における計画地点のプラントヒートレートが 9,243～9,730 [kJ/kWh]であることから、亜臨界圧式での発電を検討しているものと考えられる。また、「タ」国において石炭火力発電所の導入実績が皆無であることから、まずは、亜臨界圧石炭火力発電所に関する主要緒元について検討した。

2)　超臨界圧石炭火力発電所

超臨界圧設備は、主蒸気圧力水の臨界圧力（22.064MPa）を超え、かつ主蒸気温度が水の臨界温度（374℃）より上で 566℃（1,000° F）を以下のものと認識されている。日本では 1980 年代初頭から導入が開始され、発電効率の向上に寄与している。

3)　超々臨界圧石炭火力発電所

超々臨界圧設備は、主蒸気圧力が水の臨界圧力（22.064MPa）を超え、かつ主蒸気温度が水の臨界温度（374℃）より上の 593℃（1,100° F）を超えるものと認識されている。日本では 1990 年代後半に導入が開始され、現在は、高圧化よりも高温化する方向で進化が進んでおり、最高性能のものは、主蒸気圧力 25MPa 程度、主蒸気温度 610～620℃にまで達している。「タ」国においては、超臨界圧設備の導入も未だなされていない状況ではあるが、超々臨界圧設備は、超臨界圧よりも熱効率が優れ、石炭の削減、環境負荷の低減に資することから、超々臨界圧設備の導入についても十分に考慮されることを推奨する。

また、日本国内においては、導入後、約 20 年近く経過し、従来型石炭火力の分野における日本メーカーの超々臨界圧設備に対する技術は成熟が進んでおり、本技術の導入によるメリットは期待できる。

4)　高効率亜臨界圧石炭火力発電所

高効率亜臨界圧設備は、蒸気温度を600℃級に高めることで、150-350MWの中小容量プラントにおいて、亜臨界圧ながら超臨界圧並の発電効率が得られるシステムである。通常、亜臨界圧設備ではドラムボイラが使用されているが、超臨界圧（超々臨界圧）設備で使用されている貫流ボイラを採用することで、高温化を可能とした。

中小容量プラントへ超臨界圧を適用しても、効果的な効率向上が難しいとため、送電網が脆弱で超臨界圧（単機500MW以上）の導入が難しい途上国向けに有効である。

5)　亜臨界圧ボイラと超臨界圧ボイラについて

「超臨界圧ボイラ」とは、液体の（この場合は水の）臨界圧力より高い圧力で運転されるボイラである。水の場合、臨界圧力22.064MPa（218.3気圧）および臨界温度374.2℃において、臨界点という特殊な状態をとる。

臨界圧力以下の圧力（亜臨界圧）で、液体の水を温めてゆくと、一部が蒸気（気体）になって、気泡となり、液体と気体が共存する状態が見える。一方、臨界圧力以上の圧力（超臨界圧）では、この「液体と気体が共存する状態」が見られず、水（液体）に熱を加えてゆくと、臨界温度374.2℃付近で、一瞬にして全体が蒸気（気体）になる。すなわち、「水の中に気泡の状態：共存領域」が存在しない。

ボイラの構造からは、「亜臨界圧ボイラ」は、気水分離のためのドラムが必要であったが「超臨界圧ボイラ」は、貫流ボイラである。

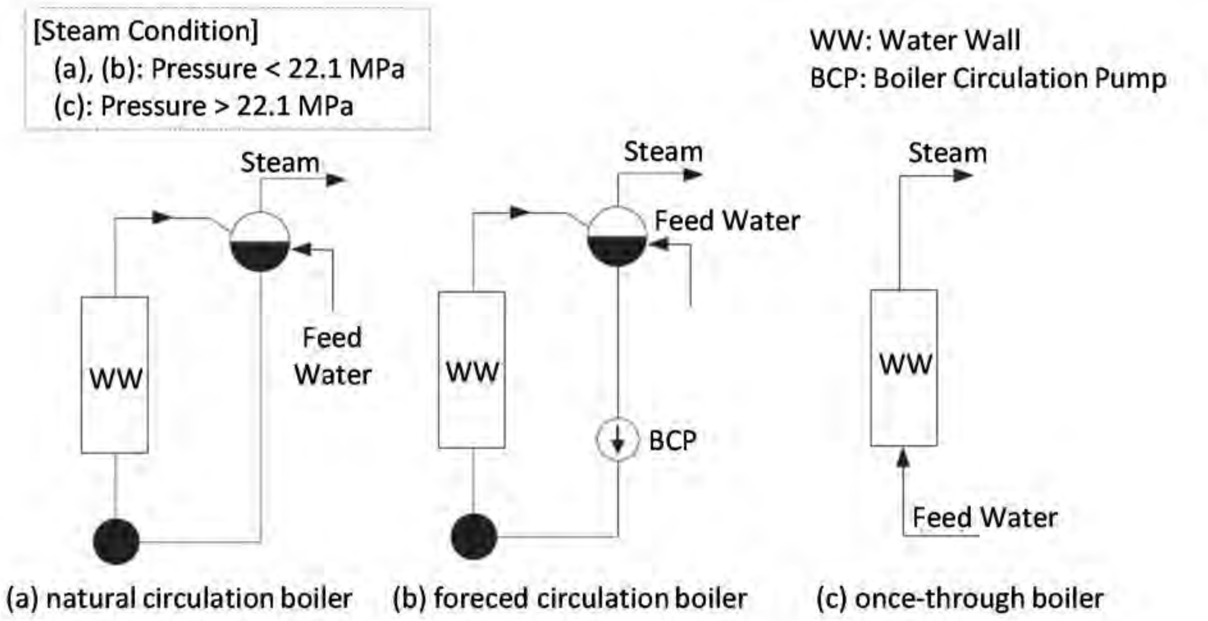


図 S-2-1.1　亜臨界圧ボイラ（ドラムボイラ）と超臨界圧ボイラ（貫流ボイラ）

(2)　天然ガス火力発電所

1)　航空機転用型ガスタービン火力発電所

航空機転用型ガスタービンは、小型・軽量・コンパクトといった特徴を有し、起動から全負荷までの到達時間が短く、急速起動停止が可能である。また、シンプルサイクルのコンバイン

ド化及びユニットの拡張・増設が容易である。

「タ」国においては、ウブンゴ II ガス火力発電所に Siemens 製ガスタービンである SGT-800 及び現在計画中のキネレジ I ガス火力発電所において、GE 製ガスタービンである LM6000PF が導入・計画されている。そのうちキネレジ I ガス火力発電所は、将来にコンバインド化の検討がなされているが、まずはシンプルサイクルでガスタービンを導入し、「タ」国の電力需給状況に応じて排熱回収ボイラ及び蒸気タービンを追設し、コンバインド化を図ることとしている。

2) 大容量ガスタービン火力発電所

エネルギー資源のより一層の有効利用を目指し、発電設備の効率向上、省エネルギー技術の開発などが積極的に進められている。コンバインドサイクルでは、主機となるガスタービンの高温・高性能化により、プラント総合効率の大幅な改善が期待されるため、信頼性向上はもとよりガスタービンの大容量・高温化が進められている。三菱重工製の最新の大型ガスタービン「1,600℃級 J 形」は、世界最高レベルの熱効率（61%以上）と電力容量（約 46 万 kW）を有している。

(3) WASP 入力緒元の検討

1) モデルユニットの選定

表 S-2-1.1 にモデルユニットの一覧を示す。

既設電源及び現在実施中／計画段階のガスタービン発電所開発計画のモデルユニットとして、PSMP には最大負荷、最大負荷時の熱効率（プラントヒートレート）しか記載がないため、既設電源に導入されているガスタービンの諸元を基に最低負荷、最低負荷時のヒートレート及び運用可能範囲を設定した。新規開発候補電源の諸元としては、航空機転用型ガスタービン及び大容量ガスタービンの中から、異なる容量（小容量～大容量）のガスタービン（シンプルサイクル、コンバインドサイクル）をモデルユニットとして設定した。

石炭火力のモデルユニットについても同様に、PSMP には最大負荷、最大負荷時の熱効率（プラントヒートレート）しか記載がないため、日本における典型的な発電所をモデルユニットとして設定した。現在実施中／計画段階の石炭火力発電所には、亜臨界圧式石炭火力発電所の諸元を使用し、新規開発候補電源の諸元として、亜臨界圧式石炭火力発電所、超々臨界圧式石炭火力発電所及び高効率亜臨界圧発電の諸元を使用した。

既設電源のガスエンジン発電所については、既設電源に導入されているガスエンジンの諸元を基に最低負荷、最低負荷時のヒートレート及び運用可能範囲を設定した。

既設電源のディーゼル火力発電所については、既設電源に導入されている機器が不明であるため、日本における典型的な発電所をモデルユニットとして設定した。

なお、ガスタービンのヒートレート算定に当たっては、「Gas Turbine World」の緒元を基に、Thermoflow 社の GT Pro Master を使用して試算した。

表 S-2-1.1　モデルユニット一覧

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	

出典: メーカーからの聞き取り
Gas Turbine World 2012 GTW Handbook (2012)

2)　ユニット停止率

ユニット停止率は、補修停止期間と事故停止期間の合計となる。

ユニット停止率の算定にあたっては、PSMP2012 及び EAC Regional PSMP の結果を比較し、各値に大きな差異が見受けられないため、PSMP2012 の値を採用した（表 S-2-1.2）。

ガスエンジンについては、ユニット停止率が設定されていなかったため、MSD の値を代用した。表 S-2-1.3 に各発電タイプのユニット停止率を示す。

表 S-2-1.2　プラント停止率比較

	PSMP2012			SNC-Lavalin EAC Regional PSMP	
Type	Scheduled maintenance in weeks per year	Forced outage in percent of time per year	Combined outae rate percent	Scheduled maintenance in weeks per year	Forced outage in percent of time per year
Simple Cycle GT	4	5	13	4	5
Gas Engine	−	−	−	−	−
Combind Cycle GT	3	5	11	3	5
Coal steam thermal	6	8	20	6	8
Medium speed diesel	5	8	18	5	8
Oil steam thermal	4	7	15	4	7

出典: MEM (May, 2013), PSMP 2012 Update
SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study

表 S-2-1.3　プラント停止率設定値

ID	Type	Scheduled maintenance in weeks per year	Forced outage in percent of time per year	Combined outae rate percent	Remarks
0	Simple Cycle GT	4	5	13	
1	Gas Engine	5	8	18	use MSD data
2	Combind Cycle GT	3	5	11	
3	Coal steam thermal	6	8	20	
4	Medium speed diesel	5	8	18	
5	Oil steam thermal	4	7	15	

出典: MEM (May, 2013), PSMP 2012 Update
SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study

3)　O&M コスト

火力発電設備の O&M コストについては、原価に占める燃料費など変動費の比重が高く、修繕費など維持運転費についても年度毎の原価変動が大きい

O&M コストの算定に当たっては、PSMP2012、EAC Regional PSMP 及び EIA-AEO2014 の値を比較した（表 S-2-1.4）。

各値に大きな差異が見られないことから、費用がより高い EAC Regional PSMP の値を採用した。表 S-2-1.5 に各発電タイプの O&M コストを示す。

表 S-2-1.4　O&M 費比較

	PSMP2012		SNC-Lavalin EAC Regional PSMP		EIA-AEO2014	
Plant Type	Fixed O&M [USD/kW/yr]	Variable O&M [USD/kWh]	Fixed O&M [USD/kW/yr]	Variable O&M [USD/kWh]	Fixed O&M [2012USD/kW/yr]	Variable O&M (incl. fuel) [2012USD/kWh]
Coal STPP	62	0.0075	50	0.0065	36.79	0.0303
Coal STPP	87	0.0075	70	0.0065	36.79	0.0303
Oil STPP	44	0.0063	30	0.0045	–	–
Oil STPP	44	0.0063	35	0.0045	–	–
OCGT	9	0.0056	10	0.005	24.53	0.082
CCGT	7	0.003	20	0.004	14.89	0.0491
MSD	29	0.015	20	0.012	–	–

表 S-2-1.5　O&M 費設定値

Plant Type	Unit Size [MW]	Fixed O&M [USD/kW/yr]	Variable O&M [USD/kWh]
Coal STPP	100-500	50	0.0065
Coal STPP	50	70	0.0065
Oil STPP	100-500	30	0.0045
Oil STPP	50	35	0.0045
OCGT	60	10	0.005
CCGT	3*60	20	0.004
MSD	50	20	0.012

出典：①MEM (May, 2013), PSMP 2012 Update, ②SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study, ③EIA (April, 2014), Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014

4)　燃料価格

表 S-2-1.6 に燃料価格を示す。

燃料価格については、EIA-AEO2014 及び PSMP2012 の値を参考にしながら、調査団で設定した。

表 S-2-1.6　燃料価格

Fuel Type	Fuel Price [USD/MMBTU]	EIA-AEO2014	PSMP 2012
Coal	3.53	2.39	–
Gas	6.00	2.75	–
Heavy Fuel Oil	18.47	–	17.51 [USD/GJ]
Industrial Diesel	22.39	–	21.22 [USD/GJ]

出典: MEM (May, 2013), PSMP 2012 Update
EIA (April, 2014), Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014

5)　発熱量

各燃料の発熱量については、一次エネルギー調査の調査結果及び EAC Regional PSMP における設定値を基に設定した。

なお、ガス燃料の発熱量の算定に当たっては、一次エネルギー調査で得られたガス組成（表 S-2-1.7）を基に、Thermoflow 社の GT Pro Master を使用して ISO6976:1995(E)に基づいて計算した。表 S-2-1.8 に各燃料の発熱量を示す。

表 S-2-1.7　タンザニア国における天然ガス組成

Component	CH_4	C_2H_6	N_2	CO_2
Volume [%]	97	1	1	1

出典: JICA 調査団からの聞き取り

表 S-2-1.8　各燃料の発熱量一覧

Fuel Type	Heating Value [HHV; kcal/kg]	Hearing from JICA Team	PSMP2012	SNC-Lavalin EAC Regional PSMP [LHV]
Coal	5,000	5,000 [kcal/kg]	4,200-6,200 [kcal/kg]	22.20 [GJ/Mt]
Gas	12,600	9,400 [kcal/Nm^3]	−	38.30 [GJ/10^{3}m^3]
Heavy Fuel Oil	9,400	−	−	6.15 [GJ/bbl]
Industrial Diesel	11,800	−	−	6.63 [GJ/bbl]

出典: MEM (May, 2013), PSMP 2012 Update
SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study

6)　大気排出基準

発電所の建設に当たっては､「タ」国における大気排出基準を満足しなければならない。他方、JICA の無償資金協力のスキーム等を活用する場合は、環境社会配慮に留意する必要があるため、窒素酸化物、硫黄酸化物等の大気排出基準について、世界銀行グループ　国際金融公社（IFC: International Finance Corporation）の環境健康安全ガイドライン（Environmental, Health, and Safety Guidelines; 以下、IFC EHS Guideline という。）の値も参照・比較し、それぞれから低い値を採用した（表 S-2-1.9）。

実際は、燃料性状、発電方式毎に採用されるユニットにより排出量は異なってくるが、最低限、この値は満足するように設計しなければならない。表 S-2-1.10 に各発電設備の大気排出基準を示す。

表 S-2-1.9　排出基準比較 (SOx, NOx)

	EIA Standard in Tanzania		IFC EHS Guideline	
Plant Type	Emitted Pollutant SOx	Emitted Pollutant Nox	Emitted Pollutant SOx	Emitted Pollutant NOx
Simple Cycle GT	35 [mg/Nm^3]	50-500MW: 300 [mg/Nm3] 500MW- : 200	−	50MW- : 25 [ppm]
Gas Engine	35 [mg/Nm^3]	50-500MW: 300 [mg/Nm3] 500MW- : 200	−	200 [mg/Nm^3]
Combind Cycle GT	35 [mg/Nm^3]	50-500MW: 300 [mg/Nm3] 500MW- : 200	−	50MW- : 25 [ppm]
Coal steam thermal	50-100MW: 850 [mg/Nm^3] 100MW- : 200	50-500MW: 600 [mg/Nm^3] 500MW- : 500	50-600MW: 900-1,500 [mg/Nm^3] 600MW- : 200-850	510 [mg/Nm^3]
Medium speed diesel	50-100MW: 850 [mg/Nm^3] 100-300MW: 400-200 300MW- : 200	50-500MW: 450 [mg/Nm^3] 500MW- : 400	50-300MW: 1,460 [mg/Nm^3] 300MW- : 740	50-300MW: 1,460 [mg/Nm^3] 300MW- : 740
Oil steam thermal	50-100MW: 850 [mg/Nm^3] 100-300MW: 400-200 300MW- : 200	50-500MW: 450 [mg/Nm^3] 500MW- : 400	50-600MW: 900-1,500 [mg/Nm^3] 600MW- : 200-850	400 [mg/Nm^3]

出典: IFC (December 2008), EHS ガイドライン (火力発電)
TANZANIA BUREAU OF STANDARDS (2005), NATIONAL ENVIRONMETAL STANDARDS COMPENDIUM

表 S-2-1.10　排出基準設定値 (SOx, NOx)

Plant Type	Emitted Pollutant SOx [ppm]	Emitted Pollutant NOx [ppm]
Simple Cycle GT	13	25
Gas Engine	13	176
Combind Cycle GT	13	25
Coal steam thermal	77	440
Medium speed diesel	77	352
Oil steam thermal	77	352

出典: IFC (December 2008), EHS ガイドライン (火力発電)
TANZANIA BUREAU OF STANDARDS (2005), NATIONAL ENVIRONMETAL STANDARDS COMPENDIUM

7)　設備寿命

各発電設備の寿命は、既設発電所及び新規計画地点の廃止期間の検討や発電原価の算定等に使用される。

設備寿命の算定に当たっては、PSMP2012、EAC Regional PSMP を比較し、各地に大きな差異が見られないことから、EAC Regional PSMP の値を採用した（表 S-2-1.11)。

併せて、日本における法定耐用年数及び 2011 年に日本にて議論された「コスト等検証委員会」の報告書も参考にした。ガスエンジンの設備寿命については、上記「コスト等検証委員会」報告書において、ディーゼルエンジンの設備寿命と同等であったことから、EAC Regional PSMP における MSD の設備寿命を採用した。表 S-2-1.12 に各発電設備の標準寿命を示す。

表 S-2-1.11　プラント設備寿命比較

Type	PSMP2012	SNC-Lavalin EAC Regional PSMP	legal durable years in Japan	Cabinet Secretariat in Japan (December, 2011)
Simple Cycle GT	20	20	15	40
Gas Engine	－	－	15	30
Combined Cycle GT	20	20	15	40
Medium speed diesel	20	20	15	30
Coal and Oil steam	25	25	15	40

出典: MEM (May, 2013), PSMP 2012 Update
SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study
コスト等検証委員会報告書 (December 19, 2011)

表 S-2-1.12　プラント設備寿命設定値

Type	Simple Cycle GT	Gas Engine	Combined Cycle GT	Medium speed diesel	Coal and Oil steam
Normal service life	20	20	20	20	25

出典: MEM (May, 2013), PSMP 2012 Update
SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study
コスト等検証委員会報告書 (December 19, 2011)

8)　建設工期

各発電設備の建設工期は、電源開発計画に組み入れられた年からプラントの運転開始の年までで算定すると、日本においては概ね 10 年程度を必要とする。この、電源開発計画への組み入れ、入札、売電契約等の準備期間は、契約の交渉期間など、未確定な要素を内包しているため、準備期間を除いて、工事の着工から運転開始の年までで算定する。

建設工期の算定に当たっては、PSMP2012、EAC Regional PSMP 及び日本における標準建設工期を比較し、各値に大きな差異が見られないことから、PSMP2012 の値を採用した（表 S-2-1.13）。

表 S-2-1.14 に各発電設備の建設工期を示す。

表 S-2-1.13　火力発電所の建設工期比較

Type	PSMP2012	SNC-Lavalin EAC Regional PSMP	Others (Japan Typical)
Simple Cycle GT	–	1	–
Gas Engine	1	–	0.5
Combined Cycle GT	2	1	2.4
Medium speed diesel	1	1	0.5
Coal and Oil steam	3	3	4

出典: MEM (May, 2013), PSMP 2012 Update
SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study
コスト等検証委員会報告書 (December 19, 2011)

表 S-2-1.14　火力発電所の建設工期設定値

Type	Simple Cycle GT	Gas Engine	Combined Cycle GT	Medium speed diesel	Coal and Oil steam
Minimum on-power lead times	1	1	2	1	3

出典: MEM (May, 2013), PSMP 2012 Update
SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study
コスト等検証委員会報告書 (December 19, 2011)

9)　建設コスト

各発電設備の建設コストの算定に当たっては、EAC Regional PSMP の設定値、EIA-AEO 及び「コスト等検証委員会」の報告書を比較し、大きな差異が見られないことから、EAC Regional PSMP の値を採用した（表 S-2-1.15）。この値は、建設利息を含んでいない。

また、ガスエンジンの建設コストについては、日本のメーカーへヒアリングを実施し、ガスエンジンの建設コストとディーゼル発電の建設コストの間で大きな乖離がないことから、EAC Regional PSMP における MSD の値を採用した。表 S-2-1.16 に各発電設備の建設コストを示す。

表 S-2-1.15　建設コスト比較

Type	PSMP	SNC-Lavalin EAC Regional PSMP	EIA-AEO 2014	Cabinet Secretariat in Japan (December, 2011)	Remarks (MW Class)
Simple Cycle GT	853	900	973	－	
Gas Engine	－	－	－	15	
Combined Cycle GT	1167	1200	－	－	60-120MW
Combined Cycle GT	－	900	917	12	250-650MW
Medium speed diesel	－	1300	－	15	
Coal	－	2800	－	－	100MW
Coal	－	2500	－	－	150MW
Coal	－	2000	3246	23	650MW

出典: MEM (May, 2013), PSMP 2012 Update
SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study
EIA (April, 2014), Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014
コスト等検証委員会報告書(December 19, 2011)

表 S-2-1.16　火力発電所建設コスト設定値

Type	Simple Cycle GT	Gas Engine	Combined Cycle GT [60-120MW]	Combined Cycle GT [250-650MW]	Medium speed diesel	Coal [100MW]	Coal [150MW]	Coal [650MW]
Construction cost [USD/kW]	900	1300	1200	900	1300	2800	2500	2000

出典: MEM (May, 2013), PSMP 2012 Update
SNC-Lavalin International Inc. (May, 2011), EAC Regional PSMP & Grid Code Study
EIA (April, 2014), Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014
コスト等検証委員会報告書(December 19, 2011)

S-2-2　水力発電設備

WASP では、既設水力発電所および水力計画地点について、次のデータを入力する必要がある。

(1) 最大出力
(2) 月別電力量供給力
(3) 月別容量供給力
(4) 建設工事費
(5) 建設工期、最短運転開始年
(6) 運転･維持管理費
(7) 耐用年数、廃止年

現地調査で収集された情報･データに基づいて、これら WASP 入力データを設定した。以下に、データの設定方法と設定値を示す。

S-2-2-1　最大出力

既設水力発電所の最大出力は、報告書本文の表 8.1.2-1 に示す値とした。2014 年 7 月時点で Hale 水力発電所の 1 基が運転不能となっているが、2015 年から撤去･取替工事が予定されているため、最大出力の変更は行わない（補足資料 S-1-2 参照）。

水力計画地点の最大出力は、報告書本文の表 8.2.2-2 に示す値とした。ただし、Rusumo 地点は、タンザニア、ルワンダ、ブルンジの 3 国へ電力供給を行う計画であるため、最大出力は 30MW（＝90MW×1/3）とした。また、Songwe Manolo (Lower)地点、Songwe Sofre (Middle)地点、Songwe Bipugu (Upper)地点は、タンザニアとマラウィの 2 国へ電力供給を行う計画であるため、最大出力はそれぞれ 89MW（＝177.9MW×1/2）、79.5MW（＝158.9MW×1/2）、14.7MW（＝29.4MW×1/2）とした。

S-2-2-2　月別電力量供給力

(1)　既設水力発電所

本調査では、25 年間の電源開発計画を策定する。このため、WASP で用いる水力の電力量供給力は、25 年間以上の水文データに基づく発電電力量計算値または発電実績とすることが望ましい。

計算値については、”Power System Master Plan 2009 Update (August 2009, SNC-LAVALIN International)”で、1995～2005 年の流量記録を用いて既設発電所の電力量計算が行われている。しかし、次の点を考慮し、本調査ではこの計算値は用いないこととした。

- 電力量計算に用いられている流量記録は月単位データで、計算の精度は高くない。
- 計算結果は 11 年間平均の年間発電電力量のみで、月別発電電力量は示されていない。
- 11 年間分の計算結果しかなく、期間が不十分である。

本調査では、月別発電実績を用いて、次式で月別電力量供給力を算定した。表 S-2-2.1 に月別電力量供給力を示す。

< 大中規模の発電所 >

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

ここに、　E_{GCi}　：i 月の電力量供給力(GWh)
E_{GRi}　：補足資料の表 S-2-2.3 に示す i 月の平均発電電力量実績(GWh)

Ru　: 発電所内電力消費率
＝補足資料の表 S-2-2.8 に示す既設発電所の平均値
＝ 0.79 (%) ≒ 1 (%)

< 小規模発電事業（SPP）の発電所 >

$E_{GCi} = E_{PRi}$

ここに、 E_{GCi} : i 月の電力量供給力(GWh)
E_{PRi} : 補足資料の表 S-2-2.3 に示す i 月の平均買電電力量実績(GWh)

表 S-2-2.1　既設発電所の月別電力量供給力

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

(2)　大中規模水力計画地点

大中規模水力計画地点の月別電力量供給力は、既往調査で行われた長期間の水文データに基づく計算値を用いて算定した。まず、(a)月別発電電力量を算定し、その後、(b)月別電力量供給力を算定した。

1)　月別発電電力量の算定

既往調査報告書の内容に応じて、ケース別に次の方法で月別発電電力量を算定した。

< 月別発電電力量が計算されている場合 >

Malagarasi Stage III 地点、Upper Kihansi 地点、Mnyera 川水力地点（Ruaha、Mnyera、Kwanini、Pumbwe、Taveta、Kisingo）の 8 地点については、既往の調査報告書で月別発電電力量が示されている。本調査では、これら報告書の記載値を月別発電電力量として採用した。

< 月別発電電力量が計算されていない場合 >

タンザニアでは、これまで年間の電力需給バランスのみを考慮して、電源開発計画の検討が行われてきた。このため、大部分の既往調査報告書には、年間発電電力量のみが示され、月別発電電力量は示されていない。

一方、TANESCO では、既設水力発電所および大中規模水力計画地点のダムサイトにおける 1971～2010 年の月単位河川流量データを整理している。この河川流量データにより、雨季や乾季の影響による発電電力量の増減傾向を把握することが、ある程度可能になる。

したがって、本調査では、この河川流量データを用いて、次式により、年間発電電力量から月別発電電力量を算定した。

$$E_{Gi} = AE_G \text{ x } F_{Di} / AF_D \leqq E_{Gimax}$$

$$E_{Gimax} = IC \text{ x } 24 \text{ x } d_i \text{ x } 1/1{,}000$$

ここに、 E_{Gi} ：i 月の発電電力量 (GWh)
AE_G ：報告書本文の表 8.2.2-2 に示す年間発電電力量 (GWh)
F_{Di} ：表 S-2-2.2 に示す i 月のダムサイトにおける河川流量 (m^3/s)
AF_D ：表 S-2-2.2 に示すダムサイトにおける年間河川流量
＝ ΣF_{Di} (m^3/s)
E_{Gimax}：i 月の可能最大発電電力量 (GWh)
IC ：最大出力 (MW)
d_i ：i 月の日数 (日)

ただし、 $E_{Gi} > E_{Gimax}$ となる場合は、余剰分（＝$E_{Gi} - E_{Gimax}$）を翌月の発電電力量に加算する。

表 S-2-2.2 ダムサイトにおける 1971～2010 年の平均河川流量

Planned Project	Mean River Flow (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rumakali	13.47	13.89	23.31	47.69	31.10	10.88	6.56	4.66	4.26	4.12	6.03	11.11	177.07
Ruhudji	30.68	37.34	52.53	68.61	55.94	41.32	32.81	25.74	20.31	16.07	12.63	19.53	413.51
Rusumo	217.92	215.94	224.89	248.75	298.53	258.28	219.88	180.66	165.04	168.67	188.60	204.94	2,592.10
Steiglers Gorge	409.35	386.10	677.02	1,636.33	1,298.85	430.44	232.28	208.61	191.26	184.31	179.08	275.53	6,109.16
Songwe	49.00	71.83	101.18	123.81	41.64	20.30	14.21	10.88	9.17	7.15	9.17	28.74	487.09
Mpanga	46.89	51.75	56.33	92.95	60.11	43.91	31.46	30.29	26.25	19.51	24.96	36.78	521.18
Masigira	44.91	50.15	63.81	69.47	46.72	36.49	31.53	29.19	26.20	23.74	24.89	35.93	483.04
Kihansi	16.24	24.36	39.12	49.74	34.14	18.03	9.81	5.82	3.80	2.74	2.27	8.75	214.83
Kakono	226.07	218.73	227.29	250.85	271.73	280.96	320.67	282.29	257.14	244.01	240.91	227.41	3,048.05
Kikonge	170.00	200.00	282.00	360.00	195.00	120.00	100.00	80.00	63.00	47.00	47.00	110.00	1,774.00
Iringa	26.09	33.39	46.63	43.68	28.14	19.21	15.07	12.17	9.43	7.43	7.61	16.59	265.42

Note: Duration of the flow data of Kikonge project is 25 years between 1972 - 1997.
Duration of the flow data of Iringa project is 36 years between 1958 - 2010.

Source: Made by JICA Study Team with reference to the "Flow Data (TANESCO)", "Ruhuhu Valley Multi-Purpose Scheme - Dams and Hydropower Report (February 2014, Climate Resilient Infrastructure Development Facility) and "Preliminary Feasibility Study on Iringa Hydropower Projects - Final Report (May 2013, K-water)"

上記の手順で算定した月別発電電力量を表 S-2-2.3 に示す。

表 S-2-2.3　水力計画地点の月別発電電力量

Planned Project	Installed Capacity (MW)	Monthly Energy Generation Potential (GWh)													Original Calculated Value	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Type	Data Source
Rumakali	222.0	100.44	103.56	165.17	159.84	165.17	159.84	165.17	110.60	31.74	30.75	44.93	82.79	1,320.00	Annual	(4)
Ruhudji	358.0	148.36	180.58	254.03	257.76	266.35	257.76	178.89	124.49	98.23	77.73	61.09	94.43	1,999.70		(9)
Rusumo	90.0	42.62	42.24	43.99	48.65	58.39	50.52	43.01	35.34	32.28	32.99	36.89	40.08	507.00		(1)
Malagarasi Stage III	44.7	16.60	17.30	22.00	25.40	25.80	22.90	17.30	10.60	6.60	5.00	5.50	11.80	186.80	Monthly	(3)
Steiglers Gorge Phase1	1,048.0	305.46	288.11	505.20	754.56	779.71	754.56	395.91	155.67	142.72	137.54	133.63	205.60	4,558.67	Annual	(14)
Songwe Manolo(Lower)	177.9	69.01	101.16	131.09	126.86	117.58	28.59	20.01	15.32	12.92	10.07	12.91	40.48	686.00		(8)
Songwe Sofre (Middle)	158.9	59.05	86.57	118.22	114.41	88.69	24.46	17.12	13.11	11.06	8.62	11.05	34.64	587.00		
Songwe Bipugu (Upper)	29.4	10.56	15.48	21.81	21.17	14.50	4.38	3.06	2.34	1.98	1.54	1.98	6.20	105.00		
Mpanga	160.0	71.62	79.04	86.03	115.20	118.56	67.07	48.04	46.27	40.09	29.79	38.11	56.18	796.00		(12)
Masigira	118.0	61.73	68.94	87.72	84.96	74.76	50.15	43.34	40.13	36.02	32.63	34.22	49.40	664.00		(5)
Lower Kihansi Expansion	120.0	5.22	7.82	12.56	15.98	10.97	5.79	3.15	1.87	1.22	0.88	0.73	2.81	69.00		
Upper Kihansi	47.0	24.06	23.65	23.50	21.68	22.11	19.08	19.34	17.60	16.30	16.22	15.36	18.15	237.05	Monthly	(10)
Kakono	87.0	42.50	41.12	42.73	47.16	51.08	52.82	60.28	53.07	48.34	45.87	45.29	42.75	573.00	Annual	(2)
Kikonge	300.0	121.51	142.95	201.56	216.00	180.72	85.77	71.48	57.18	45.03	33.59	33.59	78.62	1,268.00		(7)
Iringa - Ibosa	36.0	18.29	23.41	26.78	25.92	26.78	17.03	10.57	8.53	6.61	5.21	5.33	11.63	186.09		(13)
Iringa - Nginayo	52.0	25.83	33.05	38.69	37.44	38.69	21.45	14.92	12.04	9.34	7.35	7.53	16.42	262.75		
Mnyera - Ruaha	60.3	18.59	20.51	26.11	28.81	34.27	30.42	27.95	26.90	24.69	20.82	14.24	17.50	290.81	Monthly	(11)
Mnyera - Mnyera	137.4	51.84	54.84	69.45	75.88	77.67	63.10	56.10	51.97	46.57	39.03	29.92	45.09	661.46		
Mnyera - Kwanini	143.9	54.62	57.71	73.10	79.86	81.37	65.94	58.54	54.13	48.44	40.62	31.26	47.38	692.97		
Mnyera - Pumbwe	122.9	47.47	49.92	63.29	69.09	69.42	55.85	49.35	45.36	40.46	34.18	26.49	40.96	591.84		
Mnyera - Taveta	83.9	33.87	35.33	44.83	48.89	47.48	37.30	32.61	29.47	25.94	21.93	17.62	28.61	403.88		
Mnyera - Kisingo	119.8	48.43	50.50	64.08	69.87	67.80	53.25	46.55	42.07	37.00	31.29	25.16	40.89	576.89		

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)　月別電力量供給力

上記の月別発電電力量は、既往調査報告書の電力量計算結果に基づいている。月別電力量供給力を算定するには、発電所の停止率や所内電力消費率を考慮する必要がある。

本調査では、既設発電所の運転実績を踏まえて、PSMP2012 Update で設定された停止率および所内電力消費率を見直した（表 S-2-2.4 参照）。

表 S-2-2.4　停止率および所内電力消費率

Item		JICA Study	Reference:　PSMP2012 Update
Outage Rates	Planned Outage	2.2 – 8.0 % (Average and max in Table S-2-2.6 of Supplement S-2)	8 % (4 weeks)
	Forced Outage	2.5 % (Average in Table S-2-2.5 of Supplement S-2)	0 %
	Subtotal	4.7 - 10.5 %	8%
Plant Use Rates		0.79　% (Average in Table S-2-2.8 of Supplement S-2)	0 %
Total		10 % (Round down to the 10)	8 %

月別電力量供給力は、月別発電電力量から次式により算定した。表 S-2-2.5 に月別電力量供給力を示す。

$$E_{GCi} \;=\; E_{Gi} \;\; x \;\; \{\; 1 - \;(Ro + Ru\,)\}$$

$$Ro + Ru = 10\ \%$$

ここに、　E_{GCi}　：*i* 月の電力量供給力(GWh)

E_{Gi}　：表 S-2-2.3 に示す *i* 月の発電電力量(GWh)

Ro　：表 S-2-2.4 に示す合計停止率 (%)

Ru　：表 S-2-2.4 に示す発電所内電力消費率 (%)

表 S-2-2.5　大中規模水力計画地点の月別電力量供給力

Planned Project	Monthly Energy Generation Capability (GWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rumakali	90.40	93.20	148.65	143.86	148.65	143.86	148.65	99.54	28.57	27.68	40.44	74.51	1,188.01
Ruhudji	133.52	162.52	228.63	231.98	239.72	231.98	161.00	112.04	88.41	69.96	54.98	84.99	1,799.73
Rusumo	12.79	12.67	13.20	14.60	17.52	15.16	12.90	10.60	9.68	9.90	11.07	12.02	152.11
Malagarasi Stage III	14.94	15.57	19.80	22.86	23.22	20.61	15.57	9.54	5.94	4.50	4.95	10.62	168.12
Steiglers Gorge Phase1	274.91	259.30	454.68	679.10	701.74	679.10	356.32	140.10	128.45	123.79	120.27	185.04	4,102.80
Songwe Manolo(Lower)	31.06	45.52	58.99	57.09	52.91	12.87	9.01	6.90	5.82	4.53	5.81	18.22	308.73
Songwe Sofre (Middle)	26.58	38.96	53.20	51.49	39.91	11.01	7.71	5.90	4.98	3.88	4.98	15.59	264.19
Songwe Bipugu (Upper)	4.75	6.97	9.82	9.53	6.53	1.97	1.38	1.06	0.89	0.70	0.89	2.79	47.28
Mpanga	64.46	71.14	77.43	103.68	106.70	60.36	43.24	41.64	36.08	26.81	34.30	50.56	716.40
Masigira	55.56	62.05	78.95	76.46	67.28	45.14	39.01	36.12	32.42	29.37	30.80	44.46	597.62
Lower Kihansi Expansion	4.70	7.04	11.30	14.38	9.87	5.21	2.84	1.68	1.10	0.79	0.66	2.53	62.10
Upper Kihansi	21.65	21.29	21.15	19.51	19.90	17.17	17.41	15.84	14.67	14.60	13.82	16.34	213.35
Kakono	38.25	37.01	38.46	42.44	45.97	47.54	54.25	47.76	43.51	41.28	40.76	38.48	515.71
Kikonge	109.36	128.66	181.40	194.40	162.65	77.19	64.33	51.46	40.53	30.23	30.23	70.76	1,141.20
Iringa - Ibosa	16.46	21.07	24.10	23.33	24.10	15.33	9.51	7.68	5.95	4.69	4.80	10.47	167.49
Iringa - Nginayo	23.25	29.75	34.82	33.70	34.82	19.31	13.43	10.84	8.41	6.62	6.78	14.78	236.51
Mnyera - Ruaha	16.73	18.46	23.50	25.93	30.84	27.38	25.16	24.21	22.22	18.74	12.82	15.75	261.74
Mnyera - Mnyera	46.66	49.36	62.51	68.29	69.90	56.79	50.49	46.77	41.91	35.13	26.93	40.58	595.32
Mnyera - Kwanini	49.16	51.94	65.79	71.87	73.23	59.35	52.69	48.72	43.60	36.56	28.13	42.64	623.68
Mnyera - Pumbwe	42.72	44.93	56.96	62.18	62.48	50.27	44.42	40.82	36.41	30.76	23.84	36.86	532.65
Mnyera - Taveta	30.48	31.80	40.35	44.00	42.73	33.57	29.35	26.52	23.35	19.74	15.86	25.75	363.50
Mnyera - Kisingo	43.59	45.45	57.67	62.88	61.02	47.93	41.90	37.86	33.30	28.16	22.64	36.80	519.20

Note:　The values for Rusmo Project are one third of total generation capability.
The values for Songwe Manolo(Lower), Sofre (Middle) and Bipugu (Upper) Project are half of total generation capability.

(3)　SPP 水力計画地点

SPP 水力計画地点については、既往調査報告書を入手することができなかった。

本調査では、SPP 水力地点は既設の Mwenga SPP 水力発電所と同じ流況と仮定し、月別電力量供給力は、次式で算定した。表 S-2-2.6 に月別電力量供給力を示す。

$$\text{SPP-E}_{GCi} = \text{IC x 24 x } d_i \text{ x Mwenga-PF}_i \text{ x 1/1,000}$$

ここに、　SPP-E_{GCi}　：SPP 水力計画地点の *i* 月の月別電力量供給力 (GWh)

IC　：最大出力 (MW)

d_i　：*i* 月の日数　(日)

Mwenga-PF_i　：補足資料 S-2 の表 S-2-2.3 に示す Mwenga SPP 水力発電所の *i* 月の平均買電電力量実績から算出した設備利用率 (%)

表 S-2-2.6　SPP 水力計画地点の月別電力量供給力

Committed Project	Monthly Energy Generation Capability (GWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
EA Power SPP	3.00	3.06	5.06	5.27	5.94	4.53	3.45	3.49	2.44	2.24	1.63	2.61	42.74
Darakuta SPP	0.07	0.07	0.12	0.13	0.14	0.11	0.08	0.08	0.06	0.05	0.04	0.06	1.03
Mapembasi SPP	3.00	3.06	5.06	5.27	5.94	4.53	3.45	3.49	2.44	2.24	1.63	2.61	42.74

(4)　渇水年における月別電力量供給力

渇水が継続すると想定したシナリオで WASP シミュレーションを行うため、渇水年における月別電力量供給力を設定した。

日本では、一般に、基準渇水流量は 10 年に 1 回発生する渇水流量とされている。本調査においても同様の考えを踏襲し、渇水年の発電電力量は、10%（＝1/10）の確率で発生する、少ない発電電力量とした。

多年における発電電力量の実績または計算結果から、10%確率で発生する少量の発電電力量を直接算定する方法が考えられる。しかし、既往調査報告書では、25～60 年間の水文データを使用した電力量計算が行われているが、平均値のみが示され、Upper Kihansi 地点と Mnyera 川地点（Ruaha、Mnyera、Kwanini、Pumbwe、Taveta、Kisingo）を除いて各年の計算結果は示されていない。

したがって、本調査では、簡便的に、河川流量データから設定した“渇水低減率”を用いた（表 S-2-2.7 参照）。表 S-2-2.8 に、“渇水低減率”の設定に用いた河川流量データを示す。

具体的には、上記(1)～(3)の月別電力量供給力を平年における値と考え、次式により渇水年における月別電力量供給力を算定した。

$$E_{GCDi} = E_{GCi} \text{ x } DR_f$$

$$DR_f = AF_{DL10\%} / AF_D$$

ここに、　E_{GCDi}　：渇水年における *i* 月の電力量供給力(GWh)

E_{GCi}　：表 S-2-2.1、表 S-2-2.5、表 S-2-2.6 に示す *i* 月の電力量供給力(GWh)

DR_f　：表 S-2-2.7 に示す渇水低減率(%)

AF_D　：表 S-2-2.2 に示す 1971～2010 年の 40 年平均年間河川流量　(m^3/s)

$AF_{DL10\%}$　：表 S-2-2.8 に示す 1971～2010 年の小さい方から 4 年分の 4 年平均年間河川流量(m^3/s)

表 S-2-2.9 に、渇水年における月別電力量供給力を示す。

表 S-2-2.7　渇水低減率

	Power Plant	Mean Annual Inflow (m^3/s)		Decrease Ratio	Remarks
		A 40 years	B Lowest 4 years	B/A	
Existing	Mtera	104.8	32.7	31%	
	Kidatu	37.2	14.8	40%	
	Nymba ya Mungu	22.0	13.0	59%	
	Kihansi	17.5	9.4	54%	
	Hale	7.3	3.0	41%	Same river
	New Pangani Falls				
	Uwemba	-	-	45%	Average of values above
	Mwenga SPP				
Planned Project	Ruhudji	34.5	26.2	76%	
	Mpanga	43.4	28.9	66%	
	Stiegler's Gorge	509.1	246.3	48%	
	Malagarasi	133.9	46.3	35%	
	Rumakali	14.8	5.4	36%	
	Songwe	47.2	35.4	75%	
	Masigira	40.3	30.2	75%	Same river
	Kikonge				
	Rusumo	216.0	174.2	81%	
	Kakono	253.7	207.7	82%	
	Mnyera	24.0	18.7	78%	
	Upper/Lower Kihansi	17.5	9.4	54%	Same as existing
	Iringa	22.1	12.9	58%	
	EA Power SPP	-	-	45%	Same vale of Mwenga SPP
	Darakuta SPP				
	Mapembasi SPP				

表 S-2-2.8　渇水低減率の設定に用いた河川流量データ

Mean Annual Inflow at Dam Site: m^3/s

		Existing HPP										Planned Project																					
		Mtera		Kidatu		Nymba ya Mungu		Kihansi		Hale, New Pangani Falls		Ruhudji		Mpanga		Stiegler's Gorge		Malagarasi		Rumakali		Songwe (Lower, Middle, Upper)		Masigira, Kikonge		Rusumo		Kakono		Mnyera (Ruaha, Mnyera, Kwanini, Pumbwe, Taveta, Kisingo)		Iringa (Ibosa, Nginayo)	
		Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow	Year	Annual Inflow
Lowest 4 Years	1	2011	29.2	1971	12.3	2005	11.5	1971	6.8	2000	2.3	1977	25.4	1994	27.3	1980	212.9	2004	45.3	2009	3.7	1972	33.6	1988	27.2	2009	171.9	1994	176.3	1977	17.1	1977	10.6
	2	1971	31.8	1977	15.0	2011	12.1	2006	9.6	1993	2.5	1986	25.9	1982	28.3	2007	245.1	1994	45.7	2007	3.7	1974	35.2	1977	30.4	2005	172.2	1995	209.2	1971	18.8	1961	13.2
	3	2013	33.8	2006	15.9	2004	13.9	2012	10.5	2005	3.4	1988	26.8	1988	29.8	1986	247.5	2006	45.7	2008	5.8	1973	35.7	1992	30.7	2007	176.3	1971	221.5	1986	19.3	2004	13.7
	4	2012	36.2	1988	16.0	1976	14.3	2003	10.7	1974	3.8	1982	26.8	1981	30.2	2000	279.7	2005	48.5	1995	8.4	1977	37.2	1990	32.5	2003	176.6	1975	223.9	1982	19.8	2006	14.0
	5	2006	42.0	2008	16.3	2003	14.8	2005	11.7	2003	3.9	2003	26.9	1995	31.1	1985	302.8	1999	57.2	1983	9.4	1981	37.2	1981	34.1	1975	179.0	1976	224.0	1988	19.8	2003	14.1
	6	1991	49.1	2003	17.4	2000	15.8	2009	12.2	2004	4.4	2000	26.9	1980	31.4	2003	306.0	1984	61.1	1981	9.4	1976	37.8	1995	34.5	1976	184.7	1997	224.9	2000	19.9	1971	15.7
	7	1981	53.1	1990	17.5	1993	16.2	1999	13.0	1992	4.5	1971	27.0	1996	32.5	1982	313.9	1973	61.5	1973	9.6	1982	38.4	1993	34.7	1984	184.8	1996	226.7	2003	19.9	1966	15.8
	8	1992	53.1	1976	18.7	2012	16.4	2007	14.0	2001	4.6	1999	28.1	1978	32.6	2005	340.5	1976	64.3	2000	10.9	1975	42.5	1972	36.1	1981	190.1	2005	230.6	1972	20.5	1992	16.0
	9	2000	55.3	2007	20.5	1975	16.7	1977	14.3	1988	4.6	1976	28.3	1997	33.3	2004	371.1	1971	64.6	1992	11.1	1980	44.2	1976	36.4	2000	191.8	1977	231.9	1999	20.5	1995	16.8
	10	2009	57.4	2009	20.6	1987	17.6	1986	14.5	1987	4.7	1991	28.3	1977	33.8	1988	374.8	1975	65.9	1993	11.3	1979	45.4	2009	36.5	1987	196.9	1985	236.6	1991	20.6	1959	17.3
	11	1997	61.7	2005	20.9	1994	17.8	2000	14.6	1995	4.7	2010	28.8	1976	34.6	1994	412.5	1996	65.9	1994	11.4	2010	45.6	1997	36.5	1997	197.9	1982	240.0	1985	21.4	1969	17.6
	12	1976	65.8	1982	22.0	1979	18.6	2013	14.6	1989	4.7	2007	28.9	1975	34.8	1975	416.3	1993	69.6	1988	11.7	1978	45.7	1996	37.2	1994	201.7	2004	240.2	2004	21.7	1982	19.3
	13	1982	66.1	2004	23.7	1983	18.7	2004	14.7	2002	4.9	1985	29.7	1999	36.6	1999	418.9	2000	69.8	1991	11.8	2002	45.8	1971	37.2	2001	207.1	2010	240.5	2005	21.8	1978	19.4
	14	1974	66.4	1994	24.4	2001	19.0	1976	15.1	1994	5.0	2004	30.3	2000	36.7	2006	430.6	2003	70.6	1971	12.1	2006	45.8	1978	37.3	1995	209.3	1972	241.9	1994	22.1	1994	19.7
	15	2004	70.5	1993	24.8	2009	19.3	2001	15.1	1976	5.1	2005	30.5	1971	39.9	1990	430.9	1997	77.7	1976	12.4	2005	46.2	1980	37.5	1986	210.0	1988	241.9	1997	22.2	1989	19.8
	16	2010	70.5	1991	26.5	1995	19.3	1994	15.4	1973	5.2	1994	31.2	1983	40.4	1991	441.9	1982	85.8	2003	12.9	2004	46.2	1991	37.7	2008	212.9	1987	243.6	1981	22.2	1980	20.0
	17	1977	70.8	2000	26.6	2013	20.3	1988	15.6	1991	5.2	1981	31.3	1993	40.4	1971	446.1	2008	95.8	1980	12.9	1998	46.4	2010	37.7	1991	213.4	1999	244.4	1976	22.4	2007	20.7
	18	2005	70.8	1981	28.3	2002	20.5	1985	16.2	1985	5.2	1997	31.5	1987	40.6	2002	461.7	1980	97.1	1984	13.7	1993	46.4	1994	37.9	2004	213.5	2000	247.1	1992	23.2	1965	20.9
	19	1986	71.2	1992	29.6	1991	20.6	2011	16.3	1999	5.2	1974	31.8	2006	41.1	1981	465.3	1985	99.8	2005	14.2	1992	47.0	2000	38.4	1980	214.1	2008	250.5	2006	23.7	1972	20.9
	20	2003	74.8	1975	29.8	1984	20.7	1991	17.1	1983	5.4	1975	33.1	2003	41.6	1972	484.5	1974	100.2	1996	14.3	1994	47.1	2008	38.7	2002	214.5	2002	250.6	2007	23.7	1981	21.2
	21	1980	75.5	1996	30.0	1992	21.0	2002	17.3	1996	5.5	1992	33.2	2005	42.2	1978	490.1	2009	102.7	2004	14.7	2008	47.1	2006	39.9	1971	214.9	1974	252.7	2009	23.7	1973	21.7
Ranking	22	1995	89.4	1973	31.8	2010	21.2	1974	17.6	1977	6.2	2006	33.8	1984	42.3	2009	491.2	1991	105.4	1975	14.8	1997	47.2	2007	40.0	1992	215.4	2009	254.7	1990	23.8	1958	22.3
	23	1973	90.9	1983	32.1	1996	21.5	1975	17.7	1986	6.6	1990	34.4	2008	42.6	1977	495.5	1992	108.8	1986	15.1	1999	47.3	1975	40.7	1982	216.3	2003	254.7	1995	23.9	1993	22.3
	24	1983	91.8	1999	32.3	1977	22.0	1990	18.2	1975	6.6	1995	34.5	2001	43.2	1993	500.0	1995	109.5	1990	15.5	2000	47.5	1999	41.0	1996	216.5	1981	255.9	1974	24.0	1979	22.4
	25	2008	94.3	1980	33.2	1985	22.7	1981	18.3	2006	6.8	1993	35.9	2004	43.5	1987	500.8	1986	111.1	1987	16.0	1988	47.6	2003	41.3	1993	216.8	2006	255.9	1993	24.6	1970	22.6
	26	1999	98.2	2002	33.2	1974	23.1	1982	18.5	1982	7.1	2002	36.4	2009	44.5	1976	518.6	1977	113.9	2006	16.1	2003	47.6	1989	41.8	2010	217.8	1973	256.7	2002	24.9	1967	23.6
	27	1988	111.0	1995	33.9	1980	23.1	1992	18.6	1980	7.1	1984	37.1	2002	45.6	2010	520.2	1972	114.3	2001	16.4	1987	47.7	1982	42.5	1983	218.5	1986	257.4	1984	25.2	1975	24.3
	28	1975	114.2	1974	35.9	1988	23.6	2010	18.7	1972	7.5	1996	37.3	2007	46.5	2001	534.0	1981	115.8	2002	16.5	1991	47.9	2005	43.1	2006	218.5	2007	258.9	1996	25.3	1974	24.4
	29	1993	115.4	2001	36.6	1973	24.2	1993	19.2	1984	7.5	2001	37.9	1985	47.2	1997	546.0	2007	119.7	1985	16.6	1990	48.1	2004	43.3	1999	228.4	2001	259.0	2001	25.6	1960	26.7
	30	1984	124.6	1997	39.4	1997	24.6	1984	19.4	1981	7.6	1983	38.1	1989	47.6	1983	572.1	1988	127.8	1982	17.4	1996	48.2	2001	43.6	1985	228.5	1993	262.2	2008	25.6	1963	29.5
	31	1990	129.2	1985	41.6	1999	24.8	1996	19.5	1990	10.5	1978	38.2	2010	47.8	1984	598.7	1983	139.7	1989	17.8	1986	48.2	1985	43.7	1972	230.8	1978	264.2	1983	25.8	1964	30.0
	32	1985	130.0	1984	42.2	1986	25.1	1995	19.8	1978	10.8	2009	38.4	1992	48.7	1996	612.7	1987	202.8	1997	18.8	2009	48.5	2002	44.0	1989	234.7	1992	274.1	1980	26.2	2008	31.4
	33	1989	135.8	1986	43.5	1972	26.2	1983	20.4	1979	11.4	1987	38.8	1974	52.8	2008	623.5	2001	203.1	1972	20.2	1985	48.8	1973	44.4	1974	235.3	1998	274.8	1987	26.2	2010	33.6
	34	1972	143.7	1978	46.1	1982	27.5	2008	20.6	1971	11.7	1980	38.9	1972	55.2	1995	705.1	1978	212.0	1978	20.6	1995	49.0	1974	46.8	1988	237.5	1980	280.4	2010	27.0	2009	35.6
	35	1994	153.5	2013	48.6	1981	27.9	1980	21.0	1997	12.5	2008	39.8	1979	56.5	1992	705.6	1989	221.3	1999	21.6	1984	49.6	1984	47.4	1973	238.8	1984	282.4	1975	27.5	1962	38.4
	36	2002	159.6	1972	56.4	1989	28.5	1997	21.7	2009	14.7	1973	40.6	1998	56.9	1974	738.7	2002	242.9	1977	23.0	2007	50.2	1987	48.0	1977	239.7	1979	285.1	1978	28.6	1968	40.7
	37	2007	167.6	1987	56.7	1998	28.6	1973	21.8	1998	15.1	1972	40.8	1973	58.6	1973	754.4	1990	316.9	1998	25.5	2001	50.4	1998	48.5	1998	245.1	1983	286.5	1973	29.0		
	38	2001	169.0	2011	57.7	2007	28.7	1978	22.0	2008	18.3	1989	46.1	1986	61.0	1979	814.4	1979	374.6	1979	26.8	1989	51.6	1986	51.5	1990	273.1	1991	302.2	1989	29.9		
	39	1987	174.5	2012	60.1	1971	30.2	1987	22.2	2007	22.4	1979	58.7	1991	76.4	1989	834.9	1998	787.2	1974	31.7	1971	65.0	1983	51.6	1978	288.2	1990	329.3	1979	34.1		
	40	1979	180.5	1998	75.3	1978	32.9	1972	22.2	2010	-	1998	62.0	1990	81.4	1998	1,404.3	2010	-	2010	-	1983	99.2	1979	58.0	1979	307.1	1989	355.3	1998	38.2		
	41	1978	187.2	2010	84.0	1990	35.8	1989	24.8	2011	-	2011	-	2011	-	2011	-	2011	-	2011	-	2011	-	2011	-	2011	-	2011	-	2011	-		
	42	1996	221.2	1989	109.3	2006	38.2	1979	30.6	2012	-	2012	-	2012	-	2012	-	2012	-	2012	-	2012	-	2012	-	2012	-	2012	-	2012	-		
	43	1998	420.2	1979	111.3	2008	-	1998	30.8	2013	-	2013	-	2013	-	2013	-	2013	-	2013	-	2013	-	2013	-	2013	-	2013	-	2013	-		
Whole	Average		104.8		37.2		22.0		17.5		7.3		34.5		43.4		509.1		133.9		14.8		47.2		40.3		216.0		253.7		24.0		22.1
Lowest 4 years	Average Flow		32.7		14.8		13.0		9.4		3.0		26.2		28.9		246.3		46.3		5.4		35.4		30.2		174.2		207.7		18.7		12.9
	Decrease ratio		31%		40%		59%		54%		41%		76%		66%		48%		35%		36%		75%		75%		81%		82%		78%		58%
Average of Decrese rate		45%																															

表 S-2-2.9　渇水年における月別電力量供給力

< Existing Hydro Power Plant >

Hydro Power Plant	Decrease Ratio	Monthly Energy Generation Capability in Dry Year (GWh)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hale	41%	1.73	1.56	1.54	1.65	2.21	2.28	1.97	1.89	1.64	1.53	1.77	1.73	21.50
Nyumba Ya Mungu	59%	1.43	1.38	1.40	1.37	1.33	1.27	1.32	1.33	1.35	1.27	1.35	1.20	16.00
Kidatu	40%	31.22	29.48	32.59	31.96	30.35	27.35	27.68	28.57	29.26	29.43	28.78	30.48	357.15
Mtera	31%	8.57	8.25	8.84	6.98	7.92	7.80	8.46	10.05	10.55	10.80	10.06	8.73	107.01
Uwemba	50%	0.15	0.12	0.15	0.15	0.15	0.11	0.10	0.09	0.07	0.07	0.06	0.10	1.32
New Pangani Falls	41%	8.80	6.60	7.57	9.67	12.42	10.39	8.50	8.22	6.93	7.84	8.14	7.86	102.94
Kihansi	54%	30.25	29.55	35.92	48.22	48.41	37.52	31.34	27.36	21.02	20.62	18.59	25.91	374.71
Mwenga SPP	50%	0.60	0.61	1.01	1.06	1.19	0.91	0.69	0.70	0.49	0.45	0.33	0.53	8.57

< Planned Large and Medium-Scale Hydro Power Project >

Planned Project	Monthly Energy Generation Capability in Dry Year (GWh)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rumakali	32.54	33.55	53.51	51.79	53.51	51.79	53.51	35.83	10.29	9.96	14.56	26.82	427.66
Ruhudji	101.48	123.52	173.76	176.30	182.19	176.30	122.36	85.15	67.19	53.17	41.78	64.59	1,367.79
Rusumo	10.36	10.26	10.69	11.83	14.19	12.28	10.45	8.59	7.84	8.02	8.97	9.74	123.22
Malagarasi Stage III	5.23	5.45	6.93	8.00	8.13	7.21	5.45	3.34	2.08	1.58	1.73	3.72	58.85
Steiglers Gorge Phase1	131.96	124.46	218.25	325.97	336.84	325.97	171.03	67.25	61.66	59.42	57.73	88.82	1,969.36
Songwe Manolo(Lower)	23.30	34.14	44.24	42.82	39.68	9.65	6.76	5.18	4.37	3.40	4.36	13.67	231.57
Songwe Sofre (Middle)	19.94	29.22	39.90	38.62	29.93	8.26	5.78	4.43	3.74	2.91	3.74	11.69	198.16
Songwe Bipugu (Upper)	3.56	5.23	7.37	7.15	4.90	1.48	1.04	0.80	0.67	0.53	0.67	2.09	35.49
Mpanga	42.54	46.95	51.10	68.43	70.42	39.84	28.54	27.48	23.81	17.69	22.64	33.37	472.81
Masigira	41.67	46.54	59.21	57.35	50.46	33.86	29.26	27.09	24.32	22.03	23.10	33.35	448.24
Lower Kihansi Expansion	2.54	3.80	6.10	7.77	5.33	2.81	1.53	0.91	0.59	0.43	0.36	1.37	33.54
Upper Kihansi	11.69	11.50	11.42	10.54	10.75	9.27	9.40	8.55	7.92	7.88	7.46	8.82	115.20
Kakono	31.37	30.35	31.54	34.80	37.70	38.98	44.49	39.16	35.68	33.85	33.42	31.55	422.89
Kikonge	82.02	96.50	136.05	145.80	121.99	57.89	48.25	38.60	30.40	22.67	22.67	53.07	855.91
Iringa - Ibosa	9.55	12.22	13.98	13.53	13.98	8.89	5.52	4.45	3.45	2.72	2.78	6.07	97.14
Iringa - Nginayo	13.49	17.26	20.20	19.55	20.20	11.20	7.79	6.29	4.88	3.84	3.93	8.57	137.20
Mnyera - Ruaha	13.05	14.40	18.33	20.23	24.06	21.36	19.62	18.88	17.33	14.62	10.00	12.29	204.17
Mnyera - Mnyera	36.39	38.50	48.76	53.27	54.52	44.30	39.38	36.48	32.69	27.40	21.01	31.65	464.35
Mnyera - Kwanini	38.34	40.51	51.32	56.06	57.12	46.29	41.10	38.00	34.01	28.52	21.94	33.26	486.47
Mnyera - Pumbwe	33.32	35.05	44.43	48.50	48.73	39.21	34.65	31.84	28.40	23.99	18.60	28.75	415.47
Mnyera - Taveta	23.77	24.80	31.47	34.32	33.33	26.18	22.89	20.69	18.21	15.40	12.37	20.09	283.52
Mnyera - Kisingo	34.00	35.45	44.98	49.05	47.60	37.39	32.68	29.53	25.97	21.96	17.66	28.70	404.97

Note:　The values for Rusmo Project are one third of total generation capability.
The values for Songwe Manolo(Lower), Sofre (Middle) and Bipugu (Upper) Project are half of total generation capability.

< Committed Small Hydro Power Project >

Committed Project	Decrease Ratio	Monthly Energy Generation Capability in Dry Year (GWh)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
EA Power SPP	45%	1.35	1.38	2.28	2.37	2.67	2.04	1.55	1.57	1.10	1.01	0.73	1.17	19.22
Darakuta SPP	45%	0.03	0.03	0.05	0.06	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.03	0.46
Mapembasi SPP	45%	1.35	1.38	2.28	2.37	2.67	2.04	1.55	1.57	1.10	1.01	0.73	1.17	19.22

S-2-2-3 月別容量供給力

(1) 平年における月別容量供給力

既往調査報告書の内容に応じて、ケース別に次の方法で月別容量供給力を算定した。

<月別ピーク発電力が計算されている場合>

Upper Kihansi 地点については、既往の調査報告書で月別ピーク発電力が示されている。本調査では、この報告書の記載値を月別容量供給力として採用した。

<月別ピーク発電力が計算されていない場合 >

タンザニアでは、これまで年間の電力需給バランスのみを考慮して、電源開発計画の検討が行われてきた。このため、Upper Kihansi 地点以外は、既往調査で月別ピーク発電力が計算されていない。

したがって、月別電力量供給力を用いて、次式により月別容量供給力を月平均出力として算定した。ただし、常時出力が計算されている場合は、これを下限値とした。

$C_{Ai} > FO$ のとき

$C_{Ci} = C_{Ai}$

$C_{Ai} = E_{GCi} / (24 \text{ x } d_i) \text{ x } 1{,}000$

$C_{Ai} \leqq FO$ のとき

$C_{Ci} = FO$

ここに、 C_{Ci} : i 月の容量供給力(MW)

FO : 常時出力 (MW)

C_{Ai} : i 月の平均出力(MW)

E_{GCi} : 表 S-2-2.5、表 S-2-2.6、補足資料 S-2 の表 S-2-2.3 に示す i 月の電力量供給力(GWh)

d_i : i 月の日数 (日)

表 S-2-2.10 に、平年における月別容量供給力を示す。

(2) 渇水年における月別容量供給力

前述の“S-2-2.2 月別電力量供給力”と同様に、河川流量データを基に設定した渇水低減率を用いて、渇水年における月別容量供給力を算定した。

なお、一般に、常時出力は 95%の期間保証される出力であり、本調査で想定している渇水年よりも少ない流量を対象に計算されている。本調査では、渇水年における月別容量供給力は、常時出力を下回らないものとした。

$C_{CDi} = C_{Ci} \text{ x } DR_f$

$C_{CDi} \geqq FO$

ここに、 C_{CDi} : 渇水年における i 月の容量供給力(MW)

C_{Ci} : 表 S-2-2.10 に示す i 月の容量供給力(MW)

DR_f : 表 S-2-2.7 に示す渇水低減率(%)

FO : 常時出力 (MW)

表 S-2-2.11 に、渇水年における月別容量供給力を示す。

表 S-2-2.10　平年における月別容量供給力

< Existing Hydro Power Plant >

Hydro Power Plant	Installed Capacity (MW)	Firm Output (MW)	Capacity Capability (MW)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hale	21	N/A	5.7	5.7	5.1	5.7	7.3	7.8	6.5	6.3	5.6	5.1	6.1	5.7
Nyumba Ya Mungu	8	N/A	3.3	3.5	3.2	3.3	3.1	3.0	3.0	3.0	3.2	2.9	3.2	2.8
Kidatu	204	N/A	106.0	110.8	110.6	112.1	103.0	95.9	94.0	97.0	102.6	99.9	100.9	103.4
Mtera	80	N/A	37.5	40.0	38.7	31.6	34.7	35.3	37.1	44.0	47.8	47.3	45.5	38.2
Uwemba	0.843	N/A	0.4	0.3	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.3
New Pangani Falls	68	N/A	29.1	24.2	25.1	33.1	41.1	35.6	28.2	27.2	23.7	25.9	27.9	26.0
Kihansi	180	N/A	76.1	82.2	90.3	125.3	121.7	97.5	78.8	68.8	54.6	51.8	48.3	65.1
Mwenga SPP	4	N/A	1.6	1.8	2.7	2.9	3.2	2.5	1.9	1.9	1.4	1.2	0.9	1.4

< Planned Large and Medium-Scale Hydro Power Project >

Planned Project	Installed Capacity (MW)	Firm Output (MW)	Capacity Capability (MW)												Data Source of Firm Output
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Rumakali	222.0	214.0	214.0	214.0	222.0	222.0	222.0	222.0	222.0	214.0	214.0	214.0	214.0	214.0	(3)
Ruhudji	358.0	283.0	283.0	283.0	341.4	358.0	358.0	358.0	283.0	283.0	283.0	283.0	283.0	283.0	(4)
Rusumo	30.0	N/A	19.1	21.0	19.7	22.5	26.2	23.4	19.3	15.8	14.9	14.8	17.1	18.0	-
Malagarasi Stage III	44.7	5.1	22.3	25.7	29.6	35.3	34.7	31.8	23.3	14.2	9.2	6.7	7.6	15.9	(2)
Steiglers Gorge Phase1	1,048.0	N/A	410.6	428.7	679.0	1,048.0	1,048.0	1,048.0	532.1	209.2	198.2	184.9	185.6	276.3	-
Songwe Manolo(Lower)	89.0	N/A	46.4	75.3	88.1	88.1	79.0	19.9	13.5	10.3	9.0	6.8	9.0	27.2	-
Songwe Sofre (Middle)	79.5	N/A	39.7	64.4	79.5	79.5	59.6	17.0	11.5	8.8	7.7	5.8	7.7	23.3	-
Songwe Bipugu (Upper)	14.7	N/A	7.1	11.5	14.7	14.7	9.8	3.1	2.1	1.6	1.4	1.1	1.4	4.2	-
Mpanga	160.0	N/A	96.3	117.6	115.6	160.0	159.4	93.2	64.6	62.2	55.7	40.0	52.9	75.5	-
Masigira	118.0	N/A	83.0	102.6	117.9	118.0	100.5	69.7	58.3	53.9	50.0	43.9	47.5	66.4	-
Lower Kihansi Expansion	120.0	N/A	7.0	11.6	16.9	22.2	14.7	8.0	4.2	2.5	1.7	1.2	1.0	3.8	-
Upper Kihansi	47.0	36.9	42.1	40.8	40.7	43.1	45.4	45.8	45.6	45.3	44.9	43.9	42.7	42.5	(5)
Kakono	87.0	46.0	57.1	61.2	57.4	65.5	68.7	73.4	81.0	71.3	67.1	61.7	62.9	57.5	(1)
Kikonge	300.0	N/A	163.3	212.7	270.9	300.0	242.9	119.1	96.1	76.9	62.5	45.1	46.7	105.7	-
Iringa - Ibosa	36.0	N/A	24.6	34.8	36.0	36.0	36.0	23.7	14.2	11.5	9.2	7.0	7.4	15.6	-
Iringa - Nginayo	52.0	N/A	34.7	49.2	52.0	52.0	52.0	29.8	20.1	16.2	13.0	9.9	10.5	22.1	-
Mnyera - Ruaha	60.3	N/A	25.0	30.5	35.1	40.0	46.1	42.3	37.6	36.2	34.3	28.0	19.8	23.5	-
Mnyera - Mnyera	137.4	N/A	69.7	81.6	93.3	105.4	104.4	87.6	75.4	69.9	64.7	52.5	41.6	60.6	-
Mnyera - Kwanini	143.9	N/A	73.4	85.9	98.3	110.9	109.4	91.6	78.7	72.8	67.3	54.6	43.4	63.7	-
Mnyera - Pumbwe	122.9	N/A	63.8	74.3	85.1	96.0	93.3	77.6	66.3	61.0	56.2	45.9	36.8	55.1	-
Mnyera - Taveta	83.9	N/A	45.5	52.6	60.3	67.9	63.8	51.8	43.8	39.6	36.0	29.5	24.5	38.5	-
Mnyera - Kisingo	119.8	N/A	65.1	75.1	86.1	97.0	91.1	74.0	62.6	56.5	51.4	42.1	34.9	55.0	-

Note: The values for Rusmo Project are one third of total generation capability.

The values for Songwe Manolo(Lower), Sofre (Middle) and Bipugu (Upper) Project are half of total generation capability.

The values for Upper Kihansi are a calculated peak output.

Source: (1) Feasibility Study of Kakono Hydropower Project and Transmission Line - Draft Final Feasibility Report (September 2014, Norplan)

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

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

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

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

< Committed Small Hydro Power Project >

Committed Project	Installed Capacity (MW)	Firm Output (MW)	Capacity Capability (MW)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EA Power SPP	10	N/A	4.0	4.6	6.8	7.3	8.0	6.3	4.6	4.7	3.4	3.0	2.3	3.5
Darakuta SPP	0.24	N/A	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Mapembasi SPP	10	N/A	4.0	4.6	6.8	7.3	8.0	6.3	4.6	4.7	3.4	3.0	2.3	3.5

表 S-2-2.11　渇水年における月別容量供給力

< Existing Hydro Power Plant >

Hydro Power Plant	Installed Capacity (MW)	Firm Output (MW)	Capacity Capability in Dry Year (MW)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hale	21	N/A	2.3	2.3	2.1	2.3	3.0	3.2	2.7	2.6	2.3	2.1	2.5	2.3
Nyumba Ya Mungu	8	N/A	1.9	2.1	1.9	1.9	1.8	1.8	1.8	1.8	1.9	1.7	1.9	1.7
Kidatu	204	N/A	42.4	44.3	44.2	44.8	41.2	38.4	37.6	38.8	41.0	40.0	40.4	41.4
Mtera	80	N/A	11.6	12.4	12.0	9.8	10.8	10.9	11.5	13.6	14.8	14.7	14.1	11.8
Uwemba	0.843	N/A	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2
New Pangani Falls	68	N/A	11.9	9.9	10.3	13.6	16.9	14.6	11.6	11.2	9.7	10.6	11.4	10.7
Kihansi	180	N/A	41.1	44.4	48.8	67.7	65.7	52.7	42.6	37.2	29.5	28.0	26.1	35.2
Mwenga SPP	4	N/A	0.8	0.9	1.4	1.5	1.6	1.3	1.0	1.0	0.7	0.6	0.5	0.7

< Planned Large and Medium-Scale Hydro Power Project >

Planned Project	Installed Capacity (MW)	Decrease Ratio	Capacity Capability in Dry Year (MW)											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rumakali	222.0	36%	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0
Ruhudji	358.0	76%	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0
Rusumo	30.0	81%	15.5	17.0	16.0	18.3	21.2	19.0	15.6	12.8	12.1	12.0	13.8	14.6
Malagarasi Stage III	44.7	35%	7.8	9.0	10.4	12.4	12.1	11.1	8.2	5.1	5.1	5.1	5.1	5.6
Steiglers Gorge Phase1	1,048.0	48%	197.1	205.8	325.9	503.0	503.0	503.0	255.4	100.4	95.1	88.8	89.1	132.6
Songwe Manolo(Lower)	89.0	75%	34.8	56.5	66.1	66.1	59.3	14.9	10.1	7.8	6.7	5.1	6.7	20.4
Songwe Sofre (Middle)	79.5	75%	29.8	48.3	59.6	59.6	44.7	12.8	8.7	6.6	5.8	4.4	5.8	17.5
Songwe Bipugu (Upper)	14.7	75%	5.4	8.7	11.0	11.1	7.3	2.3	1.6	1.2	1.1	0.8	1.1	3.1
Mpanga	160.0	66%	63.6	77.6	76.3	105.6	105.2	61.5	42.6	41.1	36.8	26.4	34.9	49.8
Masigira	118.0	75%	62.3	77.0	88.4	88.5	75.4	52.3	43.7	40.4	37.5	32.9	35.6	49.8
Lower Kihansi Expansion	120.0	54%	3.8	6.3	9.1	12.0	7.9	4.3	2.3	1.4	0.9	0.6	0.5	2.1
Upper Kihansi	47.0	54%	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9
Kakono	87.0	82%	46.8	50.2	47.1	53.7	56.3	60.2	66.4	58.5	55.0	50.6	51.6	47.2
Kikonge	300.0	75%	122.5	159.5	203.2	225.0	182.2	89.3	72.1	57.7	46.9	33.8	35.0	79.3
Iringa - Ibosa	36.0	58%	14.3	20.2	20.9	20.9	20.9	13.7	8.2	6.7	5.3	4.1	4.3	9.0
Iringa - Nginayo	52.0	58%	20.1	28.5	30.2	30.2	30.2	17.3	11.7	9.4	7.5	5.7	6.1	12.8
Mnyera - Ruaha	60.3	78%	19.5	23.8	27.4	31.2	36.0	33.0	29.3	28.2	26.8	21.8	15.4	18.3
Mnyera - Mnyera	137.4	78%	54.4	63.6	72.8	82.2	81.4	68.3	58.8	54.5	50.5	41.0	32.4	47.3
Mnyera - Kwanini	143.9	78%	57.3	67.0	76.7	86.5	85.3	71.4	61.4	56.8	52.5	42.6	33.9	49.7
Mnyera - Pumbwe	122.9	78%	49.8	58.0	66.4	74.9	72.8	60.5	51.7	47.6	43.8	35.8	28.7	43.0
Mnyera - Taveta	83.9	78%	35.5	41.0	47.0	53.0	49.8	40.4	34.2	30.9	28.1	23.0	19.1	30.0
Mnyera - Kisingo	119.8	78%	50.8	58.6	67.2	75.7	71.1	57.7	48.8	44.1	40.1	32.8	27.2	42.9

Note: The values for Rusmo Project are one third of total generation capability.
The values for Songwe Manolo(Lower), Sofre (Middle) and Bipugu (Upper) Project are half of total generation capability.

< Committed Small Hydro Power Project >

Committed Project	Installed Capacity (MW)	Firm Output (MW)	Decrease Ratio	Capacity Capability in Dry Year (MW)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EA Power SPP	10	N/A	45%	1.8	2.1	3.1	3.3	3.6	2.8	2.1	2.1	1.5	1.4	1.0	1.6
Darakuta SPP	0.24	N/A	45%	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Mapembasi SPP	10	N/A	45%	1.8	2.1	3.1	3.3	3.6	2.8	2.1	2.1	1.5	1.4	1.0	1.6

S-2-2-4　建設工事費

大中規模水力計画地点の建設工事費と既設水力発電所の主機取替工事費の積算を行った。

SPP 水力計画地点については、次の理由から建設工事費を積算せず、運転･維持管理費として考慮することとした。

- TANESCO にとっては、建設時に工事費や建設中利子を現金で支払う必要がない
- TANESCO にとっては、買電料金の支払いが毎年の支出になる

(1)　価格年および価格補正方法

1)　価格年

工事費の価格年は、2014 年価格で積算した。

2)　価格補正指標

既往調査報告書では、ほとんどの水力計画地点の工事費は、内貨と外貨の区別が行われてなく、USD の外貨で示されている。

本調査では、PSMP2009 Update や PSMP2012 Update と同様に、アメリカ内務省土地改良局（US Bureau of Reclamation ; USBR）の”Construction Indexes”を価格補正指標として用いた。1996 年以降に積算された工事費は、同指標の”Composite trend”を使用した。それ以前の工事費は、”Composite trend”が示されていないため、工事別の指標を使用した。

具体的には、次式により、既往調査報告書の工事費または工事単価を 2014 年価格に換算した。

$$C_{2014} = C_i \times USBR_{2014} / USBR_i$$

ここに、　C_{2014}　: 2014 年の工事費または工事単価
I　: 既往調査報告書の工事費または工事単価の積算価格年
C_i　: *i* 年の工事費または工事単価
$USBR_{2014}$　: 表 S-2-2.12 に示す 2014 年の指標
$USBR_i$　: 表 S-2-2.12 に示す *i* 年の指標

表 S-2-2.12　使用した価格補正指標（USBR Construction Index）

Legend ▨ : Used for JICA Study

Item		Year									
		1977	1989	1996	1997	2004	2010	2011	2012	2013	2014
Composite trend		100	-	212	218	274	342	360	368	374	379
Earth dams		100	153	176	179	233	304	324	332	335	340
Concrete dams		100	174	203	208	257	327	341	350	356	361
Diversion dams		100	173	207	212	261	325	339	347	353	357
Power plants	Structures and improvements	100	166	209	210	262	326	341	347	353	359
	Equipment	100	191	228	233	269	335	344	351	358	362
Steel pipelines		100	182	222	231	287	359	369	378	385	390
Tunnels		100	185	226	233	288	353	365	377	384	389
Secondary roads		100	208	237	258	291	416	444	457	462	469

Note:　The values are for October of each year except 2014. The values of 2014 are for April.
Sorce:　Made by JICA Study Team with refference to "Construction Cost Trends (USBR)"

(2) 大中規模水力計画地点の建設工事費

1) 参照した既往調査報告書

精度よく工事費を 2014 年価格に換算するため、本調査では、工事費内訳書が示されている個別地点の調査報告書（即ちオリジナルの工事費）を優先的に参照した。PSMP2012 Update のようなマスタープラン調査報告書は、総工事費のみしか示されていないため、やむを得ない場合のみ参照した。

2) 除外する工事費目

既往調査報告書の工事費に、次の費用が含まれている場合は、これを除外した。

- 送電線工事費（電力系統計画にて積算）
- 変電所工事費（電力系統計画にて積算）
- 建設中利子（WASP シミュレーションにて積算）
- 資金調達コスト

3) 追加する工事費目

PSMP2009 Update および PSMP2012 Update では、オリジナルの工事費に緩和対策費を追加している。

本調査においても同様に、総工事費の 5%を緩和対策費として加算した。なお、オリジナルの工事費に緩和対策費が織り込まれている場合は、これを除外した上で総工事費を算定し、その上で緩和対策費を追加した。

4) 価格補正方法

精度よく工事費を 2014 年価格に換算するため、オリジナル工事費の内訳の内容に応じて、次の補正方法を採用した。

<費目別の工事費が示されている場合 >

オリジナル工事費から上記(b)費用を除外し、USBR Construction Index で 2014 年価格に換算した後、上記(c)の費用を加算した。

< 総工事費のみ示されている場合 >

USBR Construction Index で総工事費を 2014 年価格に換算し、上記(c)の費用を加算した。

5) 価格補正結果

表 S-2-2.13 に、上記の方法で 2014 年価格に換算した工事費を示す。表 S-2-2.14 に計画地点毎の工事費内訳を示す。

表 S-2-2.13　大中規模水力計画地点の工事費

Planned Project	JICA Study					PSMP 2012 Update
	Installed Capacity (MW)	Construction Cost (Price Level : 2014)		Original Source		
		Million USD	USD/kW	Price Level (Year)	Construction Cost (Million USD)	Construction Cost (Million USD)
Rumakali	222.0	559.87	2,521.9	1997	336.67	740.00
Ruhudji	358.0	666.02	1,860.4		407.39	1,220.00
Rusumo	90.0	150.32	1,670.2	2004	92.00	339.00
Malagarasi Stage III	44.7	165.20	3,695.7	2011	149.47	153.24
Steiglers Gorge Phase 1	1,048.0	2,455.99	2,343.5	2012	2,361.70	938.49
Songwe Manolo (Lower)	177.9	469.18	2,637.3	2013	473.40	278.88
Songwe Sofre (Middle)	158.9	468.28	2,947.0		458.45	274.28
Songwe Bipugu (Upper)	29.4	200.57	6,822.1		198.26	90.41
Mpanga	160.0	420.23	2,626.4	2010	426.98	274.09
Masigira	118.0	261.20	2,213.6	1996	171.40	225.30
Lower Kihansi Expansion	120.0	220.75	1,839.6		121.20	116.52
Upper Kihansi	47.0	519.89	11,061.4	1989	261.00	-
Kakono	87.0	383.88	4,412.4	2014	379.40	96.86
Kikonge	300.0	670.68	2,235.6	2013	722.49	-
Iringa - Ibosa	36.0	123.06	3,418.3		130.40	-
Iringa - Nginayo	52.0	125.46	2,412.7		132.91	-
Mnyera - Ruaha	60.3	255.08	4,230.2	2012	271.26	-
Mnyera - Mnyera	137.4	274.07	1,994.7		291.50	-
Mnyera - Kwanini	143.9	164.12	1,140.5		174.55	-
Mnyera - Pumbwe	122.9	219.15	1,783.2		233.07	-
Mnyera - Taveta	83.9	205.75	2,452.3		218.77	-
Mnyera - Kisingo	119.8	313.53	2,617.1		333.42	-

表 S-2-2.14(1)　大中規模水力計画地点の工事費内訳（Rumakali）

			Previous Study	Escalated Cost	Remarks
Price Level:			1997	2014	
USBR Construction Cost Index			218	379	
Work Item			Amount (M US$)	Amount (M US$)	
A	Access Road		34.901	60.68	
B	Civil Works		174.307	303.02	
	B1	Storage Dam	53.728	93.41	
	B2	Intake	1.115	1.94	
	B3	Headrace Tunnel (Unlined)	7.153	12.44	
	B4	Headrace Tunnel (Lined)	6.340	11.02	
	B5	Surge Shaft	1.967	3.42	
	B6	Penstock Tunnel (Unlined)	5.360	9.32	
	B7	Pressure Shaft	6.812	11.84	
	B8	Powerhouse	4.667	8.11	
	B9	Transformer Hall	1.045	1.82	
	B10	Access / Cable Tunnel	17.413	30.27	
	B11	Tailrace Tunnel / Outlet	12.110	21.05	
	B12	Outlet	0.106	0.18	
	B13	Switchyard	0.708	1.23	
	B14	Indirect Cost	29.631	51.51	(B1 to B12) x 25%
	B15	Contingencies (Underground Work)	15.717	27.32	(B3 to B11) x 1.2 x 15%
	B16	Contingencies (Above Ground Work)	10.436	18.14	(B1 to B2 + B12 to B13) x 1.25 x 15%
C	Electro/Mechanical Equipment		84.744	121.32	
	C1	Hydraulic Steelworks	18.010	31.31	
	C2	Mechanical Equipment	13.860	24.10	
	C3	Electrical Equipment (Powerhouse)	31.115	54.09	
	C4	Electrical Equipment (Transmission Line)	13.600	0.00	excluded in MP Study
	C5	Contingencies (Electro/Mechanical Equipment)	7.659	10.95	(C1 to C4) x 10%
	C6	Freight and Insurance	0.500	0.87	
D	Environmental Mitigation Measures		15.000	0.00	added after total
E	Engineering / Supervision		25.905	45.04	
F	Owner's Cost (administration))		1.813	3.15	
Total			**336.670**	**533.21**	
Additional Mitigation Cost				**26.66**	**Project Cost x 5%**
Grand Total				**559.87**	

Previous Study :　Tanzania Power VI Project Feasibility Studies for RumakaliHydropower Project - Final Report
(May 1998, SwedPower and Norconsult)

表 S-2-2.14(2)　大中規模水力計画地点の工事費内訳（Ruhudji）

			Previous Study	Escalated Cost	Remarks
Price Level:			1997	2014	
USBR Construction Cost Index			218	379	
Work Item			Amount (M US$)	Amount (M US$)	
A	Access Road		48.730	84.720	
B	Civil Works		184.041	319.980	
	B1	Storage Dam	60.670	105.480	
	B2	Intake Dam	15.821	27.510	
	B3	Intake	0.953	1.660	
	B4	Headrace Tunnel	20.222	35.160	
	B5	Surge Shaft	2.818	4.900	
	B6	Pressure Shaft	4.845	8.420	
	B7	Powerhouse	6.688	11.630	
	B8	Transformer Hall	1.292	2.250	
	B9	Access Tunnel and Cable Culvert	7.752	13.480	
	B10	Tailrace Tunnel	9.355	16.260	
	B11	Outlet	0.199	0.350	
	B12	Switchyard	0.825	1.430	
	B13	Indirect Cost	32.860	57.130	(B1 to B12) x 25%
	B14	Contingencies (Underground Work)	9.932	17.270	(B4 to B10) x 1.25 x 15%
	B15	Contingencies (Above Ground Work)	9.809	17.050	(B1 to B3 + B11 to B12) x 1.25 x 10%
C	Electro/Mechanical Equipment		125.235	166.280	
	C1	Hydraulic Steelworks	13.530	23.520	
	C2	Mechanical Equipment	26.190	45.530	
	C3	Electrical Equipment (Powerhouse)	46.775	81.320	
	C4	Electrical Equipment (Transmission Line)	26.900	0.000	excluded in MP Study
	C5	Contingencies (Electro/Mechanical Equipment)	11.340	15.040	(C1 to C4) x 10%
	C6	Freight and Insurance	0.500	0.870	
D	Environmental Mitigation Measures		10.000	0.000	added after total
E	Engineering / Supervision		35.801	57.100	(A+B+C) x 10%
F	Owner's Cost (administration))		3.580	6.220	
Total			**407.386**	**634.300**	
Additional Mitigation Cost				**31.72**	**Project Cost x 5%**
Grand Total				**666.02**	

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

表 S-2-2.14(3)　大中規模水力計画地点の工事費内訳（Rusumo）

	Previous Study	Escalated Cost	Remarks
Price Level:	2004	2014	
USBR Construction Cost Index	274	379	
Installed Capacity (MW)	80	90	
Work ItemItem	Amount (M US$)	Amount (M US$)	
Total Construction Cost	**92.00**	**143.16**	Escalation and Capacity Increase are considered
Additional Mitigation Cost		**7.16**	**Project Cost x 5%**
Grand Total		**150.32**	

Previous Study : SSEA Report (2004)
Source of Costs : Power System Master Plan 2012 Update (May 2013, Ministry of Energy and Minerals)

表 S-2-2.14(4)　大中規模水力計画地点の工事費内訳（Malagarasi Stage III）

		Previous Study	Escalated Cost	Remarks
Price Level:		2011	2014	
USBR Construction Cost Index		360	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	Infrastructure - Common	5.77	6.07	
B	Civil Works	57.22	60.23	
	Dam and Diversion	16.06	16.91	
	Intake and Transition	1.38	1.45	
	Headrace Culvert	22.78	23.98	
	Surge Tank	3.34	3.52	
	Penstock and Inlet Civil	2.31	2.43	
	Powerhouse Complex	9.93	10.45	
	Tailrace Canal	1.42	1.49	
C	Hydraulic Steelworks	8.72	9.18	
D	Mechanical	16.94	17.83	
E	Electrical	32.5	34.22	
F	Environmental Monitoring	1.82	1.91	(A to E) x 1.5%
G	Contingencies	15.45	16.26	(A + B) x 15% + (C to F) x 10%
H	Engineering under EPC	7.37	7.75	(A + B) x 8% + (C to E) x 4%
I	Owner's Cost (management, supervision and design review)	3.69	3.88	(A to F) x 3%
Total		**149.48**	**157.33**	
Additional Mitigation Cost			**7.87**	**Project Cost x 5%**
Grand Total			**165.20**	

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

表 S-2-2.14(5)　大中規模水力計画地点の工事費内訳（Steiglers Gorge Phase 1）

		Previous Study	Escalated Cost	Remarks
Price Level:		2012	2014	
USBR Construction Cost Index		368	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	General Services	464.48	478.36	
B	Embankment	128.42	132.25	
C	RCC Concrete	9.00	9.27	
D	Concrete	114.74	118.17	
E	Steel Reinforcing	60.01	61.80	
F	Talus & Soil Excavation	49.74	51.23	
G	Rock Excavation	227.65	234.45	
H	Underground Rock Excavation	5.37	5.53	
I	Treatments	59.28	61.05	
J	Transmission Line	90.54	0.00	excluded in MP Study
K	Switchyard & Substation	50.30	51.80	
L	Powerhouse Equipment	941.62	969.76	
M	Design	130.78	134.69	
N	Environmental Impact Study	24.14	24.87	
O	Geological & Geotechnical Evaluation	3.63	3.74	
P	Instrumentation	2.01	2.07	
Total		**2,361.70**	**2,339.04**	
Additional Mitigation Cost			**116.95**	**Project Cost x 5%**
Grand Total			**2,455.99**	

Previous Study :　Stieglr's Gorge Hydropower Project - Report and Proposal of Development (2012, Odebrecht)

表 S-2-2.14(6)　大中規模水力計画地点の工事費内訳（Songwe Lower）

		Previous Study	Escalated Cost	Remarks
Price Level:		2013	2014	
USBR Construction Cost Index		374	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	Civil Works	245.26	248.53	
	Site Installations	33.99	34.44	
	Permanent Access Roads	28.94	29.33	
	Dam Structures	108.20	109.64	
	Main Hydropower Plant	70.43	71.37	
	Service Area	3.71	3.75	
B	Equipment Main HPP	134.60	110.72	
	Hydro-Mechanical Equipment	22.40	22.70	
	Mechanical Equipment	18.17	18.42	
	Electrical Equipment	66.66	67.55	
	Transmission Lines and Substations	25.34	0.00	excluded in MP Study
	HVAC	2.02	2.05	
C	Equipment Small Hydropower Station	5.95	6.03	
	Hydro-Mechanical Equipment	1.06	1.08	
	Mechanical Equipment	1.86	1.88	
	Electrical Equipment	3.03	3.07	
D	Contingencies	38.57	37.81	
	Civil Work (Underground Structures)	10.56	10.71	15%
	Civil Work (Surface Structures)	20.98	21.26	12%
	Equipment Main HPP	6.73	5.54	5%
	Equipment Small HPS	0.30	0.30	5%
E	Environmental Mitigation Costs	3.06	0.00	added after total
F	Social Mitigation Costs	3.52	3.57	
G	Engineering / Supervision	30.86	29.22	(A to C) x 8%
H	Administration	11.57	10.96	(A to C) x 3%
Total		**473.40**	**446.84**	
Additional Mitigation Cost			**22.34**	**Project Cost x 5%**
Grand Total			**469.18**	

Previous Study :　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)

表 S-2-2.14(7)　大中規模水力計画地点の工事費内訳（Songwe Middle）

		Previous Study	Escalated Cost	Remarks
Price Level:		2013	2014	
USBR Construction Cost Index		374	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	Civil Works	252.19	255.56	
	Site Installations	33.63	34.08	
	Permanent Access Roads	53.40	54.12	
	Dam Structures	108.52	109.97	
	Main Hydropower Plant	53.29	54.00	
	Service Area	3.35	3.39	
B	Equipment Main HPP	112.28	100.12	
	Hydro-Mechanical Equipment	15.48	15.69	
	Mechanical Equipment	16.69	16.91	
	Electrical Equipment	64.81	65.67	
	Transmission Lines and Substations	13.48	0.00	excluded in MP Study
	HVAC	1.82	1.85	
C	Equipment Small Hydropower Station	4.27	4.33	
	Hydro-Mechanical Equipment	0.77	0.78	
	Mechanical Equipment	1.30	1.32	
	Electrical Equipment	2.20	2.23	
D	Contingencies	37.69	37.52	
	Civil Work (Underground Structures)	7.99	8.10	15%
	Civil Work (Surface Structures)	23.87	24.19	12%
	Equipment Main HPP	5.61	5.01	5%
	Equipment Small HPS	0.21	0.22	5%
E	Environmental Mitigation Costs	2.74		added after total
F	Social Mitigation Costs	8.73	8.85	
G	Engineering / Supervision	29.50	28.80	(A to C) x 8%
H	Administration	11.06	10.80	(A to C) x 3%
Total		**458.45**	**445.98**	
Additional Mitigation Cost			**22.30**	**Project Cost x 5%**
Grand Total			**468.28**	

Previous Study : 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)

表 S-2-2.14(8)　大中規模水力計画地点の工事費内訳（Songwe Upper）

		Previous Study	Escalated Cost	Remarks
Price Level:		2013	2014	
USBR Construction Cost Index		374	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	Civil Works	109.33	110.78	
	Site Installations	15.54	15.75	
	Permanent Access Roads	40.87	41.42	
	Dam Structures	32.93	33.37	
	Main Hydropower Plant	17.12	17.34	
	Service Area	2.87	2.90	
B	Equipment Main HPP	39.13	33.13	
	Hydro-Mechanical Equipment	9.07	9.20	
	Mechanical Equipment	6.11	6.19	
	Electrical Equipment	16.94	17.17	
	Transmission Lines and Substations	6.44	0.00	excluded in MP Study
	HVAC	0.57	0.57	
C	Equipment Small Hydropower Station	2.83	2.86	
	Hydro-Mechanical Equipment	0.51	0.52	
	Mechanical Equipment	0.93	0.94	
	Electrical Equipment	1.38	1.40	
D	Contingencies	15.73	15.61	
	Civil Work (Underground Structures)	2.57	2.60	15%
	Civil Work (Surface Structures)	11.07	11.21	12%
	Equipment Main HPP	1.96	1.66	5%
	Equipment Small HPS	0.14	0.14	5%
E	Environmental Mitigation Costs	2.27	0.00	added after total
F	Social Mitigation Costs	12.34	12.50	
G	Engineering / Supervision	12.10	11.74	(A to C) x 8%
H	Administration	4.54	4.40	(A to C) x 3%
Total		**198.26**	**191.02**	
Additional Mitigation Cost			**9.55**	**Project Cost x 5%**
Grand Total			**200.57**	

Previous Study :　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)

表 S-2-2.14(9)　大中規模水力計画地点の工事費内訳（Mpanga）

		Previous Study	Escalated Cost	Remarks
Price Level:		2010	2014	
USBR Construction Cost Index		342	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	General Items	17.70	19.61	
B	Civil Works	244.10	270.51	
C	Electro-Mechanical Equipment & Installation	4.68	5.18	
D	Metal Structure/Equipment & Installation	45.89	50.85	
E	110kV Switch Station	1.68	1.87	
F	Power Transmission	57.17	0.00	excluded in MP Study
G	Provisional Sum	55.76	52.20	(A to F) x 15%
Total		**426.98**	**400.22**	
Additional Mitigation Cost			**20.01**	**Project Cost x 5%**
Grand Total			**420.23**	

Previous Study :　Mpanga ydropower Project - Project Proposal Annex 9 (June 2010, Sinohydro Corporation Ltd.)

表 S-2-2.14(10)　大中規模水力計画地点の工事費内訳（Masigira）

			Previous Study	Escalated Cost	Remarks
Price Level:			1996	2014	
USBR Construction Cost Index			212	379	
Work Item			Amount (M US$)	Amount (M US$)	
A	Civil Work		84.60	151.24	
B	Electro-mechanical and Transmission Work		69.30	73.74	
		Power House	41.25	73.74	
		Transmission Line	28.05	0.00	excluded in M/P study
C	Engineering, Supervision		13.30	23.78	
D	Environmental Mitigation		4.20	0.00	added after total
Total			**171.40**	**248.76**	
Additional Mitigation Cost				**12.44**	**Project Cost x 5%**
Grand Total				**261.20**	

Previous Study :　Tanzania Power VI Project Feasibility Studies for Hydropower Project - Interim Report No.2 Final Volume 1 (March 1997, SwedPower and Norconsult)

表 S-2-2.14(11)　大中規模水力計画地点の工事費内訳（Lower Kihansi Expansion）

			Previous Study	Escalated Cost	Remarks
Price Level:			1996	2014	
USBR Construction Cost Index			212	379	
Work Item			Amount (M US$)	Amount (M US$)	
A	N1 Dam		83.20	142.30	
		Civil Work	72.20	129.07	
		Electri-mechanical work	1.30	2.32	
		Engineering, Supervision	6.10	10.91	
		Environmental Mitigation	3.60		added after total
B	Lower Kihansi HPP 2*60MW additional		38.00	67.94	
		Civil Work	6.90	12.34	
		Electri-mechanical work	28.60	51.13	
		Engineering, Supervision	2.50	4.47	
		Environmental Mitigation	0.00		
Total			**121.20**	**210.24**	
Additional Mitigation Cost				**10.51**	**Project Cost x 5%**
Grand Total				**220.75**	

Previous Study :　Tanzania Power VI Project Feasibility Studies for Hydropower Project - Interim Report No.2 Final Volume 1 (March 1997, SwedPower and Norconsult)

表 S-2-2.14(12)　大中規模水力計画地点の工事費内訳（Upper Kihansi）

		Previous Study		Escalated Cost		Remarks
Price Level:		1989		2014		
Work Item		USBR Construction Cost Index	Amount (M US$)	USBR Construction Cost Index	Amount (M US$)	Used Cost Index
A	Preparatory Work	153	4.60	340	10.22	Earth dams
B	Compensation and Others	153	1.70	340	3.78	Earth dams
C	Civil Work		162.30		358.87	
	Diversion & Coffer Dam	173	2.70	357	5.57	Divershon dams
	Dam and Spillway	153	141.40	340	314.22	Earth dams
	Intake	166	4.70	359	10.16	Powerplants-Structures and improvements
	Headrace Tunnel	185	2.30	389	4.84	Tunnels
	Penstock	166	2.20	359	4.76	Powerplants-Structures and improvements
	Powerhouse and Switchyard	166	5.70	359	12.33	Powerplants-Structures and improvements
	Tailrace Tunnel	185	2.50	389	5.26	Tunnels
	Tailrace Outlet	166	0.80	359	1.73	Powerplants-Structures and improvements
D	Hydraulic Equipment	182	2.50	390	5.36	Steel pipeline
E	Electro-mechanical Equipment	187	14.10	362	27.30	Powerplants-Equipment
F	Transmission Line		0.12			to be estimated in Power System Development Plan
G	Engineering and Administrations		13.90		30.41	(A, C, D, E, F) x 7.5%
H	Physical Contingency		26.96		59.20	(A to C) x 15% + (D to F) x 10%
I	Inturest during Construction		34.80			to be estimated in WASP
Total			**260.98**		**495.13**	
Additional Mitigation Cost					**24.76**	**Project Cost x 5%**
Grand Total					**519.89**	

Previous Study :　Kihansi Hydro Power Development Project Study Final Report (October 1990, JICA)

表 S-2-2.14(13)　大中規模水力計画地点の工事費内訳（Kakono）

			Previous Study	Escalated Cost	Remarks
Price Level:			2014	2014	
USBR Construction Cost Index			379	379	
Work Item			Amount (M US$)	Amount (M US$)	
A	Civil and Transmission		256.50	242.70	
	A1	Infrastructure	18.10	18.10	
	A2	Reservoir	3.37	3.37	
	A3	Diversion	5.94	5.94	
	A4	Dam and Power Station	183.77	183.77	
	A5	Energy Dissipation	5.52	5.52	
	A6	Transmission	12.32	0.00	excluded in MP Study
	A7	Administration / Engineering	27.48	26.00	(A1 to A6) x 12%
B	Hydraulic Steel Structures & Electromechanical Equipment		96.70	96.70	
	B1	Hydraulic Steel	24.18	24.18	
	B2	Electromechanical Equipment	62.18	62.18	
	B3	Administration / Engineering	10.34	10.34	(B1 to B2) x 12%
C	Environmental & Social Management Plan		26.20	26.20	
Total			**379.40**	**365.60**	
Additional Mitigation Cost				**18.28**	**Project Cost x 5%**
Grand Total				**383.88**	

Previous Study :　Feasibility Study of Kakono Hydropower Project and Transmission Line - Draft Final Feasibility Report Volume I Main Report (September 2014, Norplan)

表 S-2-2.14(14)　大中規模水力計画地点の工事費内訳（Kikonge）

			Previous Study	Escalated Cost	Remarks
		Price Level:	2013	2014	
		USBR Construction Cost Index	374	379	
		Work Item	Amount (M US$)	Amount (M US$)	
A		Site Establishment P&G	34.37	25.65	(B to I) x 10%
B		Intake Structure	13.21	13.39	
C		Tunnel	30.32	30.73	
D		Surge Shaft	3.97	4.03	
E		Penstocks	24.42	24.75	
F		Power Station (Civil)	20.24	20.51	
G		Power Station (M&E)	144.90	146.84	
H		Switchyard, Trabsfomer, Transmission Line	101.67	11.15	
	H1	Site Preparation, Foundation	2.00	2.03	
	H2	S/Y Electrical Equipment (T/f, CBs, etc.)	8.00	8.11	
	H3	Transmission Line (400kV x 200km)	75.60	0.00	excluded in MP Study
	H4	Substation Connection (@Makambako)	6.83	0.00	excluded in MP Study
		Others	9.24	1.01	(H1 to H4) x 10%
I		Environmental and Social Management	5.00	5.07	
J		Engineering and PM	27.50	20.52	(B to I) x 8%
K		Contingencies	74.25	55.40	(B to J) x 20%
L		Dam	262.00	265.50	
M		Roads	15.00	15.20	
		Total	**756.86**	**638.74**	
		Additional Mitigation Cost		**31.94**	**Project Cost x 5%**
		Grand Total		**670.68**	

Previous Study :　Ruhuhu Valley Multi-Purpose Scheme - Dams and Hydropower Report 'February 2014, Climate Resilient Infrastructure Development Facility)

表 S-2-2.14(15)　大中規模水力計画地点の工事費内訳（Iringa - Ibosa）

			Previous Study	Escalated Cost	Remarks
		Price Level:	2013	2014	
		USBR Construction Cost Index	374	379	
		Work Item	Amount (M US$)	Amount (M US$)	
A		EPC Costs	105.85	107.26	
	A1	Civil Works	61.42	62.24	
	A2	Mechanical & Electrical Works	41.63	42.18	
	A3	Engineering Works	2.80	2.84	
B		Development Costs	9.82	9.94	
	B1	Land Acquisition & Compensation	0.50	0.50	
	B2	SPV's Advisor	3.81	3.86	SPV: Special Purpose Vehicle
	B3	Lenders' Advisor	1.09	1.10	
	B4	SPV Management	1.98	2.01	
	B5	O&M Commissioning	0.50	0.50	
	B6	Insurance during Construction	1.95	1.97	
C		Financial Costs	1.75	0.00	excluded in MP Study
D		Interests during Construction	12.98	0.00	to be estimated in WASP
		Total	**130.40**	**117.20**	
		Additional Mitigation Cost		**5.86**	**Project Cost x 5%**
		Grand Total		**123.06**	

Previous Study :　Preliminary Feasibility Study on Iringa Hydropower Project (May 2013, K-water)

Note :　EPC costs, financial costs and interests during construction estimated in the previous study are divided to Ibosa Site and Nginayo Site.

表 S-2-2.14(16)　大中規模水力計画地点の工事費内訳（Iringa - Nginayo）

			Previous Study	Escalated Cost	Remarks
		Price Level:	2013	2014	
		USBR Construction Cost Index	374	379	
		Work Item	Amount (M US$)	Amount (M US$)	
A	EPC Costs		107.89	109.34	
	A1	Civil Works	58.76	59.55	
	A2	Mechanical & Electrical Works	46.27	46.89	
	A3	Engineering Works	2.86	2.90	
B	Development Costs		10.01	10.15	
	B1	Land Acquisition & Compensation	0.50	0.51	
	B2	SPV's Advisor	3.89	3.94	SPV: Special Purpose Vehicle
	B3	Lenders' Advisor	1.11	1.13	
	B4	SPV Management	2.02	2.05	
	B5	O&M Commissioning	0.50	0.51	
	B6	Insurance during Construction	1.99	2.01	
C	Financial Costs		1.78	0.00	excluded in MP Study
D	Interests during Construction		13.23	0.00	to be estimated in WASP
		Total	**132.91**	**119.49**	
		Additional Mitigation Cost		**5.97**	**Project Cost x 5%**
		Grand Total		**125.46**	

Previous Study : Preliminary Feasibility Study on Iringa Hydropower Project (May 2013, K-water)

Note : EPC costs, financial costs and interests during construction estimated in the previous study are divided to Ibosa Site and Nginayo Site.

表 S-2-2.14(17)　大中規模水力計画地点の工事費内訳（Mnyera - Ruaha）

		Previous Study	Escalated Cost	Remarks
	Price Level:	2012	2014	
	USBR Construction Cost Index	368	379	
	Work Item	Amount (M US$)	Amount (M US$)	
A	General Installation	1.20	1.24	
B	Camp Site	4.09	4.21	
C	Concrete without cement	11.37	11.71	
D	Cement	8.24	8.49	
E	Steel Reinforcing	3.86	3.97	
F	RCC concrete	77.52	79.83	
G	Shotcrete	1.40	1.44	
H	Soil Excavation	3.53	3.63	
I	Rock Excavation	2.76	2.84	
J	Underground Rock Escavation	24.73	25.47	
K	Enbankment	0.33	0.34	
L	Powerhouse Equipment	29.96	30.85	
M	Electric Equipment	6.04	6.22	
N	Treatments	37.16	38.27	
O	General Equipment and Steel Lining	10.65	10.97	
P	Engineering and Administration	13.06	13.45	
Q	Interests During Construction	35.38	0.00	to be estimated in WASP
	Total	**271.26**	**242.93**	
	Additional Mitigation Cost		**12.15**	**Project Cost x 5%**
	Grand Total		**255.08**	

Previous Study : Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao of Brazil)

表 S-2-2.14(18)　大中規模水力計画地点の工事費内訳（Mnyera - Mnyera）

		Previous Study	Escalated Cost	Remarks
Price Level:		2012	2014	
USBR Construction Cost Index		368	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	General Installation	2.16	2.22	
B	Camp Site	5.16	5.32	
C	Concrete without cement	10.40	10.71	
D	Cement	8.23	8.48	
E	Steel Reinforcing	7.37	7.59	
F	RCC concrete	40.03	41.22	
G	Shotcrete	2.73	2.81	
H	Soil Excavation	2.49	2.56	
I	Rock Excavation	2.56	2.64	
J	Underground Rock Escavation	58.98	60.74	
K	Enbankment	0.46	0.47	
L	Powerhouse Equipment	54.87	56.50	
M	Electric Equipment	11.06	11.39	
N	Treatments	5.27	5.42	
O	General Equipment and Steel Lining	28.44	29.29	
P	Engineering and Administration	13.26	13.66	
Q	Interests During Construction	38.02	0.00	to be estimated in WASP
Total		**291.50**	**261.02**	
Additional Mitigation Cost			**13.05**	**Project Cost x 5%**
Grand Total			**274.07**	

Previous Study :　Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao of Brazil)

表 S-2-2.14(19)　大中規模水力計画地点の工事費内訳（Mnyera - Kwanini）

		Previous Study	Escalated Cost	Remarks
Price Level:		2012	2014	
USBR Construction Cost Index		368	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	General Installation	2.19	2.25	
B	Camp Site	3.15	3.25	
C	Concrete without cement	4.07	4.19	
D	Cement	3.55	3.66	
E	Steel Reinforcing	4.88	5.02	
F	RCC concrete	1.21	1.25	
G	Shotcrete	1.43	1.47	
H	Soil Excavation	1.08	1.11	
I	Rock Excavation	1.45	1.49	
J	Underground Rock Escavation	28.92	29.79	
K	Enbankment	0.14	0.14	
L	Powerhouse Equipment	56.69	58.38	
M	Electric Equipment	11.43	11.77	
N	Treatments	0.26	0.26	
O	General Equipment and Steel Lining	23.45	24.15	
P	Engineering and Administration	7.88	8.12	
Q	Interests During Construction	22.77	0.00	to be estimated in WASP
Total		**174.55**	**156.30**	
Additional Mitigation Cost			**7.82**	**Project Cost x 5%**
Grand Total			**164.12**	

Previous Study :　Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao of Brazil)

表 S-2-2.14(20)　大中規模水力計画地点の工事費内訳（Mnyera - Pumbwe）

		Previous Study	Escalated Cost	Remarks
Price Level:		2012	2014	
USBR Construction Cost Index		368	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	General Installation	1.98	2.04	
B	Camp Site	4.20	4.32	
C	Concrete without cement	8.17	8.41	
D	Cement	6.64	6.84	
E	Steel Reinforcing	6.63	6.82	
F	RCC concrete	11.55	11.90	
G	Shotcrete	2.39	2.46	
H	Soil Excavation	2.04	2.10	
I	Rock Excavation	1.61	1.66	
J	Underground Rock Escavation	53.39	54.98	
K	Enbankment	0.60	0.61	
L	Powerhouse Equipment	54.38	56.01	
M	Electric Equipment	10.96	11.29	
N	Treatments	0.93	0.95	
O	General Equipment and Steel Lining	26.68	27.47	
P	Engineering and Administration	10.54	10.85	
Q	Interests During Construction	30.40	0.00	to be estimated in WASP
Total		**233.07**	**208.71**	
Additional Mitigation Cost			**10.44**	**Project Cost x 5%**
Grand Total			**219.15**	

Previous Study : Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao of Brazil)

表 S-2-2.14(21)　大中規模水力計画地点の工事費内訳（Mnyera - Taveta）

		Previous Study	Escalated Cost	Remarks
Price Level:		2012	2014	
USBR Construction Cost Index		368	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	General Installation	1.52	1.57	
B	Camp Site	3.81	3.92	
C	Concrete without cement	9.82	10.12	
D	Cement	8.15	8.40	
E	Steel Reinforcing	9.05	9.32	
F	RCC concrete	11.89	12.25	
G	Shotcrete	2.06	2.12	
H	Soil Excavation	2.59	2.67	
I	Rock Excavation	2.37	2.44	
J	Underground Rock Escavation	35.78	36.85	
K	Enbankment	1.68	1.73	
L	Powerhouse Equipment	49.22	50.70	
M	Electric Equipment	9.92	10.22	
N	Treatments	6.80	7.01	
O	General Equipment and Steel Lining	25.54	26.31	
P	Engineering and Administration	10.02	10.32	
Q	Interests During Construction	28.54	0.00	to be estimated in WASP
Total		**218.77**	**195.95**	
Additional Mitigation Cost			**9.80**	**Project Cost x 5%**
Grand Total			**205.75**	

Previous Study : Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao of Brazil)

表 S-2-2.14(22)　大中規模水力計画地点の工事費内訳（Mnyera - Kisingo）

		Previous Study	Escalated Cost	Remarks
Price Level:		2012	2014	
USBR Construction Cost Index		368	379	
Work Item		Amount (M US$)	Amount (M US$)	
A	General Installation	1.97	2.03	
B	Camp Site	6.01	6.19	
C	Concrete without cement	12.52	12.89	
D	Cement	11.63	11.98	
E	Steel Reinforcing	16.28	16.77	
F	RCC concrete	4.93	5.08	
G	Shotcrete	1.93	1.99	
H	Soil Excavation	2.31	2.37	
I	Rock Excavation	5.02	5.17	
J	Underground Rock Escavation	63.74	65.65	
K	Enbankment	0.48	0.50	
L	Powerhouse Equipment	56.91	58.61	
M	Electric Equipment	11.47	11.82	
N	Treatments	0.66	0.68	
O	General Equipment and Steel Lining	79.00	81.36	
P	Engineering and Administration	15.06	15.51	
Q	Interests During Construction	43.49	0.00	to be estimated in WASP
Total		**333.42**	**298.60**	
Additional Mitigation Cost			**14.93**	**Project Cost x 5%**
Grand Total			**313.53**	

Previous Study : Mnyera River - Implantation of Hydroelectric Developments - Technical Preliminary Feasibility Studies (June 2012, Queiroz Galvao of Brazil)

(3) 既設水力発電所の主機取替工事費

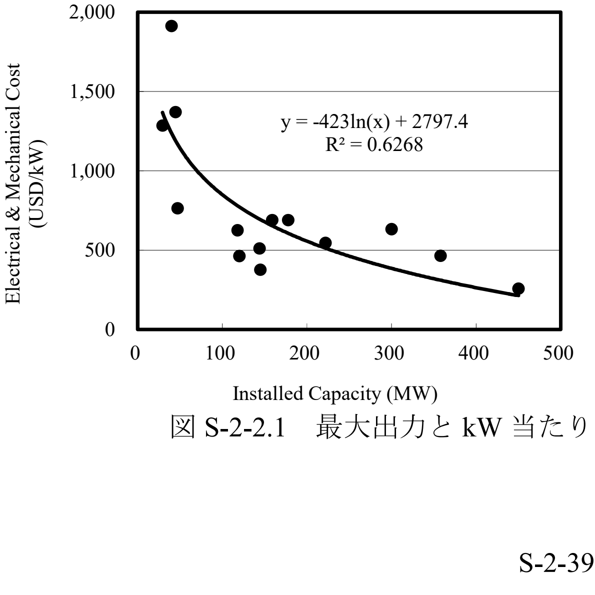
本調査における電源開発計画の策定は 2015～2040 年である。この間に既設水力発電所は、主機の取替等の大規模な改修を行い、設備を更新する必要がある。実際に、Hale 水力発電所は、2015 年から大規模改修工事に着工する予定である。

本調査では、水車、発電機、主要変圧器といった主機の取替工事費を次の方法で算定した。

1) kW 当たり工事単価の設定

前項で 2014 年価格を算定した、大中規模水力計画地点の電気･機械工事費について、kW 当たり工事単価の分析を行った。この結果、図 S-2-2.1 に示すように、電気･機械工事費の kW 当たり工事単価と最大出力との間に明瞭な相関関係が見られた。

本調査では、図 S-2-2.1 により kW 当たり工事単価を使用して、主機取替工事費を算定することとした。



Planned Project	Installed Capacity (MW)	Electrical & Mechanical Cost	
		Million USD	USD/kW
Rumakali	222.0	121.32	546
Ruhudji	358.0	166.28	464
Malagarasi Stage III	44.7	61.23	1,370
Songwe Manolo (Lower)	177.9	122.59	689
Songwe Sofre (Middle)	158.9	109.68	690
Songwe Bipugu (Upper)	29.4	37.79	1,285
Ikondo	450.0	115.58	257
Taveta	145.0	54.51	376
Mpanga	144.0	73.49	510
Masigira	118.0	73.74	625
Lower Kihansi Expansion	120.0	55.60	463
Upper Kihansi	47.0	35.92	764
Kakono	40.0	76.54	1,913
Kikonge	300.0	189.59	632

Note: The values of Mpanga and Kakono Project are based on the old study reports.

図 S-2-2.1　最大出力と kW 当たり電気･機械工事費単価の関係

2) 主機取替工事費の算定

図 S-2-2.1 から、主機の取替、つまり電気･機械設備の新設工事費を算定した。表 S-2-2.15 に、主機取替工事費の算定結果を示す。

表 S-2-2.15　主機取替工事費

Existing Plant	Installed Capacity (MW)	Electrical & Mechanical Cost	
		Million USD	USD/kW
Hale	21	31.71	1,509.8
Nyumba Ya Mungu	8	15.34	1,918.0
Kidatu	204	111.85	548.3
Mtera	80	75.54	944.2
Uwemba	0.843	2.42	2,869.7
New Pangani Falls	68	68.88	1,012.9

S-2-2-5　建設工期および最短運開年

(1)　大中規模水力計画地点

1)　リードタイム設定基準の見直し

PSMP2012 Update では、プロジェクトの進行段階別および最大出力別に、標準的な(i)着工準備期間と(ii)入札･建設期間が設定されている。

しかし、水力の建設期間や調査期間は、ダムの高さや体積、水路の長さ、アクセス状況等、設備やサイトの状況で大きく異なる。本調査では、個別地点の既往調査報告書で検討された結果を優先的に採用するよう、見直しを行った。また、入札に要する期間は不明なため、1 年間と仮定した。表 S-2-2.16 にリードタイム設定基準を示す。

表 S-2-2.16　リードタイム設定基準

	Project Status	Installed Capacity	Lead Time (years)		
			Preparation	Tender	Construction
JICA Study	Preliminary	< 70MW	(i) Same as previous study report (ii) Same as PSMP2012	1	(i) Same as previous study report (ii) Same as PSMP2012
		< 150MW			
		150MW<			
	Pre-F/S	< 70MW			
		< 150MW			
		150MW<			
	F/S	< 70MW			
		< 150MW			
		150MW<			
	Design, Tender Documents	< 70MW			
		< 150MW			
		150MW<			
Reference: PSMP 2012	Preliminary	< 70MW	3	4	
		< 150MW	4	5	
		150MW<	4	6	
	Pre-F/S	< 70MW	2	4	
		< 150MW	3	5	
		150MW<	3	6	
	F/S	< 70MW	2	4	
		< 150MW	2	5	
		150MW<	2	6	
	Design, Tender Documents	< 70MW	1	4	
		< 150MW	1	5	
		150MW<	1	6	

2) 建設工期および最短運開年

表 S-2-2.17 に、上記の基準に基づいて設定した建設工期および最短運開年を示す。

表 S-2-2.17　大中規模水力計画地点の建設工期および最短運開年

Planned Project	Installed Capacity (MW)	Current Status	JICA M/P Study				PSMP 2012 Update
			Preparation	Tender	Construction	Earliest Installation Year	Earliest Installation Year
Rumakali	222.0	Committed (F/S)	2	1	6	2023	2020
Ruhudji	358.0	F/S	2	1	6	2023	2019
Rusumo	90.0	Committed	-	1	4	2019	2018
Malagarasi Stage IIII	44.7	Committed (F/S)	2	1	3	2020	2018
Steiglers Gorge Phase 1	1,048.0	Pre-F/S	3	1	9	2027	2022
Songwe Manolo (Lower)	176.2	F/S	2	1	5	2022	2021
Songwe Sofre (Middle)	158.9		2	1	5	2022	2022
Songwe Bipugu (Upper)	29.4		2	1	3	2020	2019
Mpanga	160.0	Pre-F/S	3	1	5	2023	2021
Masigira	118.0	Pre-F/S	3	1	5	2023	2021
Lower Kihansi Expansion	120.0	Pre-F/S	1	1	2	2018	-
Upper Kihansi	47.0	Pre-F/S	5	1	5	2025	2020
Kakono	87.0	F/S	2	1	5	2022	2018
Kikonge	300.0	Reconnaissance study	4	1	6	2025	-
Iringa - Ibosa	36.0	Pre-F/S	2	1	3	2020	-
Iringa - Nginayo	52.0		2	1	3	2020	-
Mnyera - Ruaha	60.3	Pre-F/S	2	1	3	2020	-
Mnyera - Mnyera	137.4		3	1	3	2021	-
Mnyera - Kwanini	143.9		3	1	3	2021	-
Mnyera - Pumbwe	122.9		3	1	3	2021	-
Mnyera - Taveta	83.9		3	1	3	2021	-
Mnyera - Kisingo	119.8		3	1	3	2021	-

(2) SPP 水力計画地点

SPP 水力計画地点の 3 地点は、TANESCO との買電契約も締結済みで、工事中の段階である。報告書本文の表 8.2.2-1 に示すように、2015 年 2 月～2016 年 1 月に運転開始する予定である。

S-2-2-6　運転･維持管理費

WASP シミュレーションでは、2 種類の kW 当たり運転･維持管理費しか設定できない。本調査では、(1) 大中規模水力発電所･計画地点と(2) SPP 水力発電所･計画地点の 2 種類の運転･維持管理費を設定した。

(1) 大中規模水力発電所･計画地点

1) 運転･維持管理費の水準

一般に、維持管理費は設備の量に比例するため、建設費に対する割合で示されることが多い。「タ」国および日本で次の実績があるため、年間の運転･維持管理費は建設費の 1%程度が妥当な水準と考えられる

- 既往の実行可能性調査（7 地点）では、運転･維持管理費は建設費の 0.5～1%で見積もられている。
- 日本では、運転･維持管理費は建設費の 0.9%程度（固定資産税を除く）として、水力開発計画の検討を行われることが多い（表 S-2-2.18 参照）。

表 S-2-2.18　日本における計画段階での水力の運転･維持管理費推定方法

Item		Annual Cost	
Direct Cost	Salaries work for plant operation and maintenance	Construction Cost x	0.170%
	Repair cost for plant equipment/facilities	Construction Cost x	0.310%
	Other cost (outsourcing expenses, compensation cost, water usage charge, etc.)	Construction Cost x	0.310%
Indirect Cost	General administrative cost	Construction Cost x	0.095%
Total		Construction Cost x	0.885%

Note: Fixed asset tax and increasing rate of repair cost are not considered.

2) kW 当たり運転･維持管理費の算定

実行可能性調査が完了している 7 地点について、建設費の 1%として運転･維持管理費を算定した結果を表 S-2-2.19 に示す。kW 当たりの運転･維持管理費の値は一定ではなく、最大出力に反比例する傾向にある。

本調査では､kW 当たり運転･維持管理費は単純平均値を採用することとし､2.6 USD/kW-month とした。

表 S-2-2.19　実行可能性調査完了 7 地点の kW 当たり運転･維持管理費

Planned Project	Installed Capacity (MW)	Construction Cost (Million USD)	O&M Cost		
			Million USD /year	USD/kW-year	USD/kW-month
Rumakali	222.0	559.9	5.60	25.2	2.1
Ruhudji	358.0	666.0	6.66	18.6	1.6
Rusumo	90.0	150.3	1.50	16.7	1.4
Malagarasi Stage III	44.7	165.2	1.65	36.9	3.1
Songwe Manolo (Lower)	177.9	469.2	4.69	26.4	2.2
Songwe Sofre (Middle)	158.9	468.3	4.68	29.5	2.5
Songwe Bipugu (Upper)	29.4	200.6	2.01	68.4	5.7
Average	154.4	382.8	3.8	31.7	2.6

なお、この kW 当たり運転･維持管理費は、PSPM 2012 Update の方法で算定した場合と比較して同程度～やや高い金額水準となる（表 S-2-2.20 参照）。

表 S-2-2.20　運転･維持管理費の算定ケーススタディ

Criteria Case Study	PSMP 2012 Update				JICA Study
	Fixed O&M	Other Annual Costs		Total	2.6USD/kW-month x 12 = 31.2USD/kW-year
		Interim Replacement	Insurance		
	16 USD/kW-year	Capital Cost x 0.25%	Capital Cost x 0.1%		
Malagarasi Stage III	16 USD x 44,700kW =715,200USD	165.2MUSD x 0.25% =413,000USD	165.2MUSD x 0.1% =165,200USD	1,293,400USD	31.2 USD x 44,700kW =1,394,640USD
Rusumo	16 USD x 90,000kW =1,440,000USD	150.3MUSD x 0.25% =375,750USD	150.3MUSD x 0.1% =150,300USD	1,966,050USD	31.2USD x 90,000kW =2,808,000USD
Rumakali	16 USD x 222,000kW =3,552,000USD	559.9MUSD x 0.25% =1,399,750USD	559.9MUSD x 0.1% =559,900USD	5,511,650USD	31.2 USD x 222,000kW =6,926,400USD

また、補足資料 S-1 の図 S-1-2.4 に示した既設水力発電所の運転･維持管理費は、収集データが少なく、オーバーホール等の定期点検や大規模修繕費用が含まれていない可能性があり、費用を過小評価する恐れがあるため、実績データは用いないこととした。

(2)　SPP 水力発電所･計画地点

SPP 水力発電所･計画地点の運転･維持管理費は、TANESCO の買電費用として算定した。

水力計画地点の調査報告書を入手することができなかったため、唯一稼働中の Mwenga SPP 水力発電所の実績買電電力量と、現行の買電料金（2013 年 9 月以降に適用）を用いて、買電費用を算定した。この結果、買電料金は 1,811 千 USD/年となり、平均で 37.72USD/kW-month となった（表 S-2-2.21 参照）。

表 S-2-2.21　Mwenga SPP 水力発電所からの買電費用

Hydro Power Plant: Mwenga SPP
Installed Capacity : 4 MW
1 USD = 1,600 Tsh

	Tariff after Sep. 2013 (Tsh/kWh)		Purchased Energy (kWh)	Power Purchase Cost	
				(1000Tsh)	(USD)
Jan	Rainy Season	157.4	1,198,600	188,660	117,913
Feb		157.4	1,223,480	192,576	120,360
Mar		157.4	2,024,470	318,652	199,158
Apr		157.4	2,109,400	332,020	207,513
May		157.4	2,377,020	374,143	233,839
Jun		157.4	1,813,980	285,520	178,450
Jul		157.4	1,379,460	217,127	135,704
Aug	Dry Season	209.87	1,397,570	293,308	183,318
Sep		209.87	977,270	205,100	128,188
Oct		209.87	897,720	188,404	117,753
Nov		209.87	651,580	136,747	85,467
Dec	Rainy Season	157.4	1,045,690	164,592	102,870
Total			17,096,240	2,896,849	1,810,533
Average (USD/kW-month)			-	-	37.72

Note: Purchased Energy is actual record in 2013.

S-2-2-7　耐用年数および廃止年

(1)　耐用年数

1)　大中規模水力発電所･計画地点

PSMP2012 Update で水力発電の耐用年数は 50 年とされている。この設定値は次の点から妥当であるため、本調査においても耐用年数は 50 年とした。

- 日本でも、ほぼ同程度の耐用年数で計画されている。
- Hale 水力発電所は、実際に運転開始後 50 年を迎えている。

2)　SPP 水力発電所･計画地点

SPP 水力発電所･計画地点の耐用年数は、最長買電期間として、20 年間として設定した。

TANESCO によると、当初の標準買電契約に基づく契約期間は 15 年間と規定されていたが、現在は、25 年を超えない範囲で延長が可能となっている。しかし、TANESCO の内規では、火力 IPP との契約期間と同じ 20 年間までとなっている。

(2)　廃止年

前述の耐用年数が経過した時点で廃止することを基本とする。

このため、既設水力発電所のほとんどは、本調査の電源開発計画策定期間中に廃止することになる。しかし、SPP 水力発電所･計画地点以外は、実際には 50 年経過後の運転が可能であるため、水車や発電機等の電気･機械設備の取替工事を行った上で継続利用するものとした。

表 S-2-2.22 に耐用年数および廃止年を示す。

表 S-2-2.22　水力の耐用年数および廃止年

	Existing Plant or Planned Project	Installation Year	Plant Life (year)	Retirement Year
Large and Medium-Scale Hydro Power Plant	Hale	1967	49	2016
	Nyumba Ya Mungu	1968	50	2018
	Kidatu	1975	50	2025
	Mtera	1988	50	2038
	Uwenba	1991	50	2041
	New Pangani Falls	1995	50	2045
	Kihansi	2000	50	2050
SPP Hydro Power Plant	Mwenga SPP	2012	20	2032
	EA Power SPP	2015	20	2035
	Darakuta SPP	2015	20	2035
	Mapembasi SPP	2016	20	2036

S-2-2-8　WASP 入力データのまとめ

上記で設定した WASP 入力データの一覧表を表 S-2-2.23 に示す。

表 S-2-2.23(1)　WASP 入力データ一覧（平年）

Hydro Plant			Power Supply Capability																										O&M Cost ($/kW-month)	Construction			Retirement	
			Installed Capacity (MW)	Storage Capacity (GWh)	Inflow Energy (GWh)												Average Capacity (MW)													Capital Cost (US$/kW)	Construction time (Year)	Actual or estimated Earliest Installation Year	Plant Life (Year)	Retirement Year
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec						
1	Existing	Hale	21	52.96	4.22	3.81	3.76	4.03	5.38	5.55	4.80	4.62	4.00	3.73	4.32	4.21	5.7	5.7	5.1	5.7	7.3	7.8	6.5	6.3	5.6	5.1	6.1	5.7	2.60	-	-	1967	49	2016
2		Nyumba Ya Mungu	8	27.35	2.43	2.34	2.37	2.32	2.26	2.15	2.23	2.25	2.29	2.15	2.28	2.04	3.3	3.5	3.2	3.3	3.1	3.0	3.0	3.0	3.2	2.9	3.2	2.8	2.60	-	-	1968	50	2018
3		Kidatu	204	901.89	78.04	73.70	81.47	79.90	75.87	68.37	69.21	71.43	73.16	73.58	71.94	76.20	106.0	110.8	110.6	112.1	103.0	95.9	94.0	97.0	102.6	99.9	100.9	103.4	2.60	-	-	1975	50	2025
4		Mtera	80	348.69	27.63	26.62	28.52	22.51	25.56	25.15	27.30	32.41	34.04	34.85	32.44	28.17	37.5	40.0	38.7	31.6	34.7	35.3	37.1	44.0	47.8	47.3	45.5	38.2	2.60	-	-	1988	50	2038
5		Uwemba	0.843	2.60	0.29	0.23	0.30	0.30	0.30	0.21	0.20	0.18	0.14	0.14	0.11	0.20	0.4	0.3	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.3	2.60	-	-	1991	50	2041
6		New Pangani Falls	68	253.60	21.46	16.09	18.46	23.59	30.30	25.34	20.74	20.05	16.90	19.11	19.85	19.17	29.1	24.2	25.1	33.1	41.1	35.6	28.2	27.2	23.7	25.9	27.9	26.0	2.60	-	-	1995	50	2045
7		Kihansi	180	700.91	56.02	54.72	66.51	89.30	89.65	69.48	58.04	50.67	38.93	38.18	34.42	47.98	76.1	82.2	90.3	125.3	121.7	97.5	78.8	68.8	54.6	51.8	48.3	65.1	2.60	-	-	2000	50	2050
8		Mwenga SPP	4	17.10	1.20	1.22	2.02	2.11	2.38	1.81	1.38	1.40	0.98	0.90	0.65	1.05	1.6	1.8	2.7	2.9	3.2	2.5	1.9	1.9	1.4	1.2	0.9	1.4	37.72	-	-	2012	20	2032
1	New Candidate Project	Rumakali	222	1,188.01	90.40	93.20	148.65	143.86	148.65	143.86	148.65	99.54	28.57	27.68	40.44	74.51	214.0	214.0	222.0	222.0	222.0	222.0	222.0	214.0	214.0	214.0	214.0	214.0	2.60	2,521.9	6	2023	50	-
2		Ruhudji	358	1,799.73	133.52	162.52	228.63	231.98	239.72	231.98	161.00	112.04	88.41	69.96	54.98	84.99	283.0	283.0	341.4	358.0	358.0	358.0	283.0	283.0	283.0	283.0	283.0	283.0	2.60	1,860.4	6	2023	50	-
3		Rusumo	30	152.11	12.79	12.67	13.20	14.60	17.52	15.16	12.90	10.60	9.68	9.90	11.07	12.02	19.1	21.0	19.7	22.5	26.2	23.4	19.3	15.8	14.9	14.8	17.1	18.0	2.60	1,670.2	3	2019	50	-
4		Malagarasi Stage III	44.7	168.12	14.94	15.57	19.80	22.86	23.22	20.61	15.57	9.54	5.94	4.50	4.95	10.62	22.3	25.7	29.6	35.3	34.7	31.8	23.3	14.2	9.2	6.7	7.6	15.9	2.60	3,695.7	3	2020	50	-
5		Steiglers Gorge Phase 1	1,048	4,102.80	274.91	259.30	454.68	679.10	701.74	679.10	356.32	140.10	128.45	123.79	120.27	185.04	410.6	428.7	679.0	1,048.0	1,048.0	1,048.0	532.1	209.2	198.2	184.9	185.6	276.3	2.60	2,343.5	9	2027	50	-
6		Songwe Manolo(Lower)	89.0	308.73	31.06	45.52	58.99	57.09	52.91	12.87	9.01	6.90	5.82	4.53	5.81	18.22	46.4	75.3	88.1	88.1	79.0	19.9	13.5	10.3	9.0	6.8	9.0	27.2	2.60	2,662.8	5	2022	50	-
7		Songwe Sofre (Middle)	79.5	264.19	26.58	38.96	53.20	51.49	39.91	11.01	7.71	5.90	4.98	3.88	4.98	15.59	39.7	64.4	79.5	79.5	59.6	17.0	11.5	8.8	7.7	5.8	7.7	23.3	2.60	2,947.0	5	2022	50	-
8		Songwe Bipugu (Upper)	14.7	47.28	4.75	6.97	9.82	9.53	6.53	1.97	1.38	1.06	0.89	0.70	0.89	2.79	7.1	11.5	14.7	14.7	9.8	3.1	2.1	1.6	1.4	1.1	1.4	4.2	2.60	6,822.1	3	2020	50	-
9		Mpanga	160	716.40	64.46	71.14	77.43	103.68	106.70	60.36	43.24	41.64	36.08	26.81	34.30	50.56	96.3	117.6	115.6	160.0	159.4	93.2	64.6	62.2	55.7	40.0	52.9	75.5	2.60	2,626.4	5	2023	50	-
10		Masigira	118	597.62	55.56	62.05	78.95	76.46	67.28	45.14	39.01	36.12	32.42	29.37	30.80	44.46	83.0	102.6	117.9	118.0	100.5	69.7	58.3	53.9	50.0	43.9	47.5	66.4	2.60	2,213.6	5	2023	50	-
11		Lower Kihansi Expansion	120	62.10	4.70	7.04	11.30	14.38	9.87	5.21	2.84	1.68	1.10	0.79	0.66	2.53	7.0	11.6	16.9	22.2	14.7	8.0	4.2	2.5	1.7	1.2	1.0	3.8	2.60	1,839.6	4	2022	50	-
12		Upper Kihansi (JICA Site)	47	213.35	21.65	21.29	21.15	19.51	19.90	17.17	17.41	15.84	14.67	14.60	13.82	16.34	42.1	40.8	40.7	43.1	45.4	45.8	45.6	45.3	44.9	43.9	42.7	42.5	2.60	11,061.4	5	2025	50	-
13		Kakono	87	515.71	38.25	37.01	38.46	42.44	45.97	47.54	54.25	47.76	43.51	41.28	40.76	38.48	57.1	61.2	57.4	65.5	68.7	73.4	81.0	71.3	67.1	61.7	62.9	57.5	2.60	4,412.4	5	2022	50	-
14		Kikonge	300	1,141.20	109.36	128.66	181.40	194.40	162.65	77.19	64.33	51.46	40.53	30.23	30.23	70.76	163.3	212.7	270.9	300.0	242.9	119.1	96.1	76.9	62.5	45.1	46.7	105.7	2.60	2,235.6	6	2025	50	-
15		Iringa - Ibosa	36	167.49	16.46	21.07	24.10	23.33	24.10	15.33	9.51	7.68	5.95	4.69	4.80	10.47	24.6	34.8	36.0	36.0	36.0	23.7	14.2	11.5	9.2	7.0	7.4	15.6	2.60	3,418.3	3	2020	50	-
16		Iringa - Nginayo	52	236.51	23.25	29.75	34.82	33.70	34.82	19.31	13.43	10.84	8.41	6.62	6.78	14.78	34.7	49.2	52.0	52.0	52.0	29.8	20.1	16.2	13.0	9.9	10.5	22.1	2.60	2,412.7	3	2020	50	-
17		Mnyera - Ruaha	60.3	261.74	16.73	18.46	23.50	25.93	30.84	27.38	25.16	24.21	22.22	18.74	12.82	15.75	25.0	30.5	35.1	40.0	46.1	42.3	37.6	36.2	34.3	28.0	19.8	23.5	2.60	4,230.2	3	2020	50	-
18		Mnyera - Mnyera	137.4	595.32	46.66	49.36	62.51	68.29	69.90	56.79	50.49	46.77	41.91	35.13	26.93	40.58	69.7	81.6	93.3	105.4	104.4	87.6	75.4	69.9	64.7	52.5	41.6	60.6	2.60	1,994.7	3	2021	50	-
19		Mnyera - Kwanini	143.9	623.68	49.16	51.94	65.79	71.87	73.23	59.35	52.69	48.72	43.60	36.56	28.13	42.64	73.4	85.9	98.3	110.9	109.4	91.6	78.7	72.8	67.3	54.6	43.4	63.7	2.60	1,140.5	3	2021	50	-
20		Mnyera - Pumbwe	122.9	532.65	42.72	44.93	56.96	62.18	62.48	50.27	44.42	40.82	36.41	30.76	23.84	36.86	63.8	74.3	85.1	96.0	93.3	77.6	66.3	61.0	56.2	45.9	36.8	55.1	2.60	1,783.2	3	2021	50	-
21		Mnyera - Taveta	83.9	363.50	30.48	31.80	40.35	44.00	42.73	33.57	29.35	26.52	23.35	19.74	15.86	25.75	45.5	52.6	60.3	67.9	63.8	51.8	43.8	39.6	36.0	29.5	24.5	38.5	2.60	2,452.3	3	2021	50	-
22		Mnyera - Kisingo	119.8	519.20	43.59	45.45	57.67	62.88	61.02	47.93	41.90	37.86	33.30	28.16	22.64	36.80	65.1	75.1	86.1	97.0	91.1	74.0	62.6	56.5	51.4	42.1	34.9	55.0	2.60	2,617.1	3	2021	50	-
1	Replacement of Electrical & Mechanical Equipment	Hale	21	52.96	4.22	3.81	3.76	4.03	5.38	5.55	4.80	4.62	4.00	3.73	4.32	4.21	5.7	5.7	5.1	5.7	7.3	7.8	6.5	6.3	5.6	5.1	6.1	5.7	2.60	1,509.8	3	2018	50	2068
2		Nyumba Ya Mungu	8	27.35	2.43	2.34	2.37	2.32	2.26	2.15	2.23	2.25	2.29	2.15	2.28	2.04	3.3	3.5	3.2	3.3	3.1	3.0	3.0	3.0	3.2	2.9	3.2	2.8	2.60	1,918.0	2	2018	50	2068
3		Kidatu	204	901.89	78.04	73.70	81.47	79.90	75.87	68.37	69.21	71.43	73.16	73.58	71.94	76.20	106.0	110.8	110.6	112.1	103.0	95.9	94.0	97.0	102.6	99.9	100.9	103.4	2.60	548.3	4	2025	50	2075
4		Mtera	80	348.69	27.63	26.62	28.52	22.51	25.56	25.15	27.30	32.41	34.04	34.85	32.44	28.17	37.5	40.0	38.7	31.6	34.7	35.3	37.1	44.0	47.8	47.3	45.5	38.2	2.60	944.2	2	2038	50	2088
5		Uwemba	0.843	2.60	0.29	0.23	0.30	0.30	0.30	0.21	0.20	0.18	0.14	0.14	0.11	0.20	0.4	0.3	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.3	2.60	2,869.7	3	2041	50	2091
6		New Pangani Falls	68	253.60	21.46	16.09	18.46	23.59	30.30	25.34	20.74	20.05	16.90	19.11	19.85	19.17	29.1	24.2	25.1	33.1	41.1	35.6	28.2	27.2	23.7	25.9	27.9	26.0	2.60	1,012.9	2	2045	50	2095
1	SPP	EA Power SPP	10	42.74	3.00	3.06	5.06	5.27	5.94	4.53	3.45	3.49	2.44	2.24	1.63	2.61	4	4.6	6.8	7.3	8	6.3	4.6	4.7	3.4	3	2.3	3.5	37.72	-	1	2015	20	2035
2		Darakuta SPP	0.24	1.03	0.07	0.07	0.12	0.13	0.14	0.11	0.08	0.08	0.06	0.05	0.04	0.06	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	37.72	-	1	2015	20	2035
3		Mapembasi SPP	10	42.74	3.00	3.06	5.06	5.27	5.94	4.53	3.45	3.49	2.44	2.24	1.63	2.61	4	4.6	6.8	7.3	8	6.3	4.6	4.7	3.4	3	2.3	3.5	37.72	-	1	2016	20	2036

表 S-2-2.23(2)　WASP 入力データ一覧（渇水年）

Hydro Plant			Installed Capacity (MW)	Storage Capacity (GWh)	Power Supply Capability																								O&M Cost ($/kW-month)	Construction			Retirement	
					Inflow Energy (GWh)												Average Capacity (MW)													Capital Cost (US$/kW)	Construction time (Year)	Actual or estimated Earliest Installation Year	Plant Life (Year)	Retirement Year
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec						
1	Existing	Hale	21	52.96	1.73	1.56	1.54	1.65	2.21	2.28	1.97	1.89	1.64	1.53	1.77	1.73	2.3	2.3	2.1	2.3	3.0	3.2	2.7	2.6	2.3	2.1	2.5	2.3	2.60	-	-	1967	49	2016
2		Nyumba Ya Mungu	8	27.35	1.43	1.38	1.40	1.37	1.33	1.27	1.32	1.33	1.35	1.27	1.35	1.20	1.9	2.1	1.9	1.9	1.8	1.8	1.8	1.8	1.9	1.7	1.9	1.7	2.60	-	-	1968	50	2018
3		Kidatu	204	901.89	31.22	29.48	32.59	31.96	30.35	27.35	27.68	28.57	29.26	29.43	28.78	30.48	42.4	44.3	44.2	44.8	41.2	38.4	37.6	38.8	41.0	40.0	40.4	41.4	2.60	-	-	1975	50	2025
4		Mtera	80	348.69	8.57	8.25	8.84	6.98	7.92	7.80	8.46	10.05	10.55	10.80	10.06	8.73	11.6	12.4	12.0	9.8	10.8	10.9	11.5	13.6	14.8	14.7	14.1	11.8	2.60	-	-	1988	50	2038
5		Uwemba	0.843	2.60	0.15	0.12	0.15	0.15	0.15	0.11	0.10	0.09	0.07	0.07	0.06	0.10	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2	2.60	-	-	1991	50	2041
6		New Pangani Falls	68	253.60	8.80	6.60	7.57	9.67	12.42	10.39	8.50	8.22	6.93	7.84	8.14	7.86	11.9	9.9	10.3	13.6	16.9	14.6	11.6	11.2	9.7	10.6	11.4	10.7	2.60	-	-	1995	50	2045
7		Kihansi	180	700.91	30.25	29.55	35.92	48.22	48.41	37.52	31.34	27.36	21.02	20.62	18.59	25.91	41.1	44.4	48.8	67.7	65.7	52.7	42.6	37.2	29.5	28.0	26.1	35.2	2.60	-	-	2000	50	2050
8		Mwenga SPP	4	17.10	0.60	0.61	1.01	1.06	1.19	0.91	0.69	0.70	0.49	0.45	0.33	0.53	0.8	0.9	1.4	1.5	1.6	1.3	1.0	1.0	0.7	0.6	0.5	0.7	37.72	-	-	2012	20	2032
1	New Candidate Project	Rumakali	222	1,188.01	32.54	33.55	53.51	51.79	53.51	51.79	53.51	35.83	10.29	9.96	14.56	26.82	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0	214.0	2.60	2,521.9	6	2023	50	-
2		Ruhudji	358	1,799.73	101.48	123.52	173.76	176.30	182.19	176.30	122.36	85.15	67.19	53.17	41.78	64.59	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0	283.0	2.60	1,860.4	6	2023	50	-
3		Rusumo	30	152.11	10.36	10.26	10.69	11.83	14.19	12.28	10.45	8.59	7.84	8.02	8.97	9.74	15.5	17.0	16.0	18.3	21.2	19.0	15.6	12.8	12.1	12.0	13.8	14.6	2.60	1,670.2	3	2019	50	-
4		Malagarasi Stage III	44.7	168.12	5.23	5.45	6.93	8.00	8.13	7.21	5.45	3.34	2.08	1.58	1.73	3.72	7.8	9.0	10.4	12.4	12.1	11.1	8.2	5.1	5.1	5.1	5.1	5.6	2.60	3,695.7	3	2020	50	-
5		Steiglers Gorge Phase 1	1,048	4,102.80	131.96	124.46	218.25	325.97	336.84	325.97	171.03	67.25	61.66	59.42	57.73	88.82	197.1	205.8	325.9	503.0	503.0	503.0	255.4	100.4	95.1	88.8	89.1	132.6	2.60	2,343.5	9	2027	50	-
6		Songwe Manolo(Lower)	89.0	308.73	23.30	34.14	44.24	42.82	39.68	9.65	6.76	5.18	4.37	3.40	4.36	13.67	34.8	56.5	66.1	66.1	59.3	14.9	10.1	7.8	6.7	5.1	6.7	20.4	2.60	2,662.8	5	2022	50	-
7		Songwe Sofre (Middle)	79.5	264.19	19.94	29.22	39.90	38.62	29.93	8.26	5.78	4.43	3.74	2.91	3.74	11.69	29.8	48.3	59.6	59.6	44.7	12.8	8.7	6.6	5.8	4.4	5.8	17.5	2.60	2,947.0	5	2022	50	-
8		Songwe Bipugu (Upper)	14.7	47.28	3.56	5.23	7.37	7.15	4.90	1.48	1.04	0.80	0.67	0.53	0.67	2.09	5.4	8.7	11.0	11.1	7.3	2.3	1.6	1.2	1.1	0.8	1.1	3.1	2.60	6,822.1	3	2020	50	-
9		Mpanga	160	716.40	42.54	46.95	51.10	68.43	70.42	39.84	28.54	27.48	23.81	17.69	22.64	33.37	63.6	77.6	76.3	105.6	105.2	61.5	42.6	41.1	36.8	26.4	34.9	49.8	2.60	2,626.4	5	2023	50	-
10		Masigira	118	597.62	41.67	46.54	59.21	57.35	50.46	33.86	29.26	27.09	24.32	22.03	23.10	33.35	62.3	77.0	88.4	88.5	75.4	52.3	43.7	40.4	37.5	32.9	35.6	49.8	2.60	2,213.6	5	2023	50	-
11		Lower Kihansi Expansion	120	62.10	2.54	3.80	6.10	7.77	5.33	2.81	1.53	0.91	0.59	0.43	0.36	1.37	3.8	6.3	9.1	12.0	7.9	4.3	2.3	1.4	0.9	0.6	0.5	2.1	2.60	1,839.6	4	2022	50	-
12		Upper Kihansi (JICA Site)	47	213.35	11.69	11.50	11.42	10.54	10.75	9.27	9.40	8.55	7.92	7.88	7.46	8.82	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	36.9	2.60	11,061.4	5	2025	50	-
13		Kakono	87	515.71	31.37	30.35	31.54	34.80	37.70	38.98	44.49	39.16	35.68	33.85	33.42	31.55	46.8	50.2	47.1	53.7	56.3	60.2	66.4	58.5	55.0	50.6	51.6	47.2	2.60	4,412.4	5	2022	50	-
14		Kikonge	300	1,141.20	82.02	96.50	136.05	145.80	121.99	57.89	48.25	38.60	30.40	22.67	22.67	53.07	122.5	159.5	203.2	225.0	182.2	89.3	72.1	57.7	46.9	33.8	35.0	79.3	2.60	2,235.6	6	2025	50	-
15		Iringa - Ibosa	36	167.49	9.55	12.22	13.98	13.53	13.98	8.89	5.52	4.45	3.45	2.72	2.78	6.07	14.3	20.2	20.9	20.9	20.9	13.7	8.2	6.7	5.3	4.1	4.3	9.0	2.60	3,418.3	3	2020	50	-
16		Iringa - Nginayo	52	236.51	13.49	17.26	20.20	19.55	20.20	11.20	7.79	6.29	4.88	3.84	3.93	8.57	20.1	28.5	30.2	30.2	30.2	17.3	11.7	9.4	7.5	5.7	6.1	12.8	2.60	2,412.7	3	2020	50	-
17		Mnyera - Ruaha	60.3	204.17	13.05	14.40	18.33	20.23	24.06	21.36	19.62	18.88	17.33	14.62	10.00	12.29	19.5	23.8	27.4	31.2	36.0	33.0	29.3	28.2	26.8	21.8	15.4	18.3	2.60	4,230.2	3	2020	50	-
18		Mnyera - Mnyera	137.4	464.35	36.39	38.50	48.76	53.27	54.52	44.30	39.38	36.48	32.69	27.40	21.01	31.65	54.4	63.6	72.8	82.2	81.4	68.3	58.8	54.5	50.5	41.0	32.4	47.3	2.60	1,994.7	3	2021	50	-
19		Mnyera - Kwanini	143.9	486.47	38.34	40.51	51.32	56.06	57.12	46.29	41.10	38.00	34.01	28.52	21.94	33.26	57.3	67.0	76.7	86.5	85.3	71.4	61.4	56.8	52.5	42.6	33.9	49.7	2.60	1,140.5	3	2021	50	-
20		Mnyera - Pumbwe	122.9	415.47	33.32	35.05	44.43	48.50	48.73	39.21	34.65	31.84	28.40	23.99	18.60	28.75	49.8	58.0	66.4	74.9	72.8	60.5	51.7	47.6	43.8	35.8	28.7	43.0	2.60	1,783.2	3	2021	50	-
21		Mnyera - Taveta	83.9	283.52	23.77	24.80	31.47	34.32	33.33	26.18	22.89	20.69	18.21	15.40	12.37	20.09	35.5	41.0	47.0	53.0	49.8	40.4	34.2	30.9	28.1	23.0	19.1	30.0	2.60	2,452.3	3	2021	50	-
22		Mnyera - Kisingo	119.8	404.97	34.00	35.45	44.98	49.05	47.60	37.39	32.68	29.53	25.97	21.96	17.66	28.70	50.8	58.6	67.2	75.7	71.1	57.7	48.8	44.1	40.1	32.8	27.2	42.9	2.60	2,617.1	3	2021	50	-
1	Replacement of Electrical & Mechanical Equipment	Hale	21	52.96	4.22	3.81	3.76	4.03	5.38	5.55	4.80	4.62	4.00	3.73	4.32	4.21	5.7	5.7	5.1	5.7	7.3	7.8	6.5	6.3	5.6	5.1	6.1	5.7	2.60	1,509.8	3	2018	50	2068
2		Nyumba Ya Mungu	8	27.35	2.43	2.34	2.37	2.32	2.26	2.15	2.23	2.25	2.29	2.15	2.28	2.04	3.3	3.5	3.2	3.3	3.1	3.0	3.0	3.0	3.2	2.9	3.2	2.8	2.60	1,918.0	2	2018	50	2068
3		Kidatu	204	901.89	78.04	73.70	81.47	79.90	75.87	68.37	69.21	71.43	73.16	73.58	71.94	76.20	106.0	110.8	110.6	112.1	103.0	95.9	94.0	97.0	102.6	99.9	100.9	103.4	2.60	548.3	4	2025	50	2075
4		Mtera	80	348.69	27.63	26.62	28.52	22.51	25.56	25.15	27.30	32.41	34.04	34.85	32.44	28.17	37.5	40.0	38.7	31.6	34.7	35.3	37.1	44.0	47.8	47.3	45.5	38.2	2.60	944.2	2	2038	50	2088
5		Uwemba	0.843	2.60	0.29	0.23	0.30	0.30	0.30	0.21	0.20	0.18	0.14	0.14	0.11	0.20	0.4	0.3	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.3	2.60	2,869.7	3	2041	50	2091
6		New Pangani Falls	68	253.60	21.46	16.09	18.46	23.59	30.30	25.34	20.74	20.05	16.90	19.11	19.85	19.17	29.1	24.2	25.1	33.1	41.1	35.6	28.2	27.2	23.7	25.9	27.9	26.0	2.60	1,012.9	2	2045	50	2095
1	SPP	EA Power SPP	10	42.74	3.00	3.06	5.06	5.27	5.94	4.53	3.45	3.49	2.44	2.24	1.63	2.61	4	4.6	6.8	7.3	8	6.3	4.6	4.7	3.4	3	2.3	3.5	37.72	-	1	2015	20	2035
2		Darakuta SPP	0.24	1.03	0.07	0.07	0.12	0.13	0.14	0.11	0.08	0.08	0.06	0.05	0.04	0.06	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	37.72	-	1	2015	20	2035
3		Mapembasi SPP	10	42.74	3.00	3.06	5.06	5.27	5.94	4.53	3.45	3.49	2.44	2.24	1.63	2.61	4	4.6	6.8	7.3	8	6.3	4.6	4.7	3.4	3	2.3	3.5	37.72	-	1	2016	20	2036