The United Republic of Tanzania

THE EXECUTIVE SUMMARY OF POWER SYSTEM MASTER PLAN 2012 UPDATE

Ministry of Energy and Minerals **May 2013**

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ACKNOWLEDGEMENT

The 2012 update to the PSMP was carried out by a Technical Team composed of members from Ministry of Energy and Minerals (MEM), President's Office, Planning Commission (POPC), Ministry of Finance (MoF), National Bureau of Statistics (NBS), Rural Energy Agency (REA), Tanzania Electric Supply Company (TANESCO), Tanzania Petroleum Development Corporation (TPDC) and Energy and Water Utilities Regulatory Authority (EWURA). The work was carried out during the months of September to November 2012.

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CHAPTER 1

INTRODUCTION

Purpose and Scope

The 2012 Power System Master Plan (PSMP) update accommodates recent development in the economy and 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 attain low cost energy service that will allow more inflow of foreign direct investment (FDIs). It also targets to increase per capita electricity consumption from 81kWh in 2011/12 to 200kWh by 2015/16 through increased generation capacity alongside accelerated electrification program.

The overall objective of the 2012 Update is to re-assess short-term (2013 – 2017), mid-term (2018 - 2023) and long term (2024 - 2035), generation; transmission plans requirements and the need for connecting presently off-grid regions, options for power exchanges with neighbouring countries and increased supply of reliable power. While the short-term plan requires immediate decision and actions, the mid – to longer terms plan require coordinated planning, project development studies which ensures that future supply utilises the least cost projects, consistent with sound planning criteria and addresses national interests.

The report draws inference on specific data items or detailed procedures in the previous 2008 PSMP and the subsequent updates. In 2008, the Government of Tanzania developed a Power System Master Plan (PSMP) 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.

The Electricity Act, 2008 requires the Plan to be updated annually. The 2009 and subsequent updates were carried out by MEM and TANESCO to review the progress and challenges encountered during its implementation. In order to come up with more inclusive plan that echoes sectoral linkages, the 2012 update broaden up participation to include more actors namely POPC, MoF, TPDC, EWURA, REA and NBS. The 2012 Update covers a review of the following components:

a) Electricity demand forecast;
b) Assessment of the short-term, mid-term and long-term generation plan;
c) The transmission plan that reflect the update in plans for connecting presently isolated regions and increased generation capacities; and
d) Economic and financial analysis

CHAPTER 2

POWER DEMAND FORECAST

Forecast Approach and Methodology

The 2012 Update of load forecast uses the following methodologies:-

a) Trend line analysis for regional forecasts to arrive at total country forecasts; and

b) Econometric analysis as an overall check on the reasonableness of the results obtained using trend-line approach.

Assumptions

There are two groups of assumptions used in this forecast; general and specific assumptions. The general assumptions are summarised in the table below. The demand forecast assesses only the domestic demand although the future regional power trade has been considered under the generation plan section.

Table 2-1: General Assumptions

High Case - Assumptions	**Base Case - Assumptions**	**Low Case - Assumptions**
Base Year Data - 2010	Base Year Data - 2010	Base Year Data - 2010
Target – Achieve 100% of the 250,000 new customers per annum for 5years.	Target – Achieve 85% of the High Case target (212,500)	Target – Achieve 75% of the High Case target (187,500)
Household size – 8 people	Household size – 8 people	Household size – 8 people
Emerging of high demands of electricity (industrial survey, open up of economy – Mtwara corridor and mining activities)	Emerging of high demands of electricity (industrial survey, open up of economy – Mtwara corridor and mining activities): Assuming structural breaks – delays and shift of projects	Historical growth rates
By 2025 Tanzania is assumed to be a middle income Country according to the TDV 2025 • FYDP-I requires 2780 MW by 2015/16 • Requires >6700 MW by 2035	By 2025 Tanzania is assumed to be a middle income Country according to the TDV 2025 • FYDP-I requires 2780 MW by 2015/16 • Requires >6700 MW by 2035	Business as usual, following historical trends

Specific assumptions

a) **Additional electrification:** In implementing a five-year program to connect 250,000 new customers per year, two approaches are considered to allocate customers: (1) to allocate new customers on a pro-rata basis across all regions and (2) a similar basis but assuming that more weight would be given to the regions other than Dar es Salaam. Given the already relatively high level of electrification of Dar es Salaam, the second approach is used. After end of the five-year program, historical growth rates are used to project forward up to 2035. The new targets of electrification will be achieved through concerted efforts from many stakeholders like REA, TANESCO, private developers, and the recent government strategy to reduce connection fees as an incentive to attract many electricity customers.

b) **Loads from Extraction of Natural Resources and others:** It is estimated that Tanzania has some 140.2 million tons of gold reserves, 535.8MT of coal, 33.04TCF of gas and abundant reserves of other minerals. In the wake of the liberalization of the economy, the government has been heavily promoting private investment in the natural resource extraction sector. Considerable development are expected in the growth of mining/extraction activities and the position of natural resources in the economy, and it is likely the trend to intensify over the forecast period.

The development of mining activities in a specific region impacts directly on the future power needs in the region, and finally future power needs for the country. The new identified mining loads, their expected power needs, and respective locations are shown in the tabulation below. These are treated explicitly and included as a set of specific assumptions in addition to other identified loads for each regional forecast as indicated in the table below.

Table 2-2: Selection of Anticipated Major loads in Tanzania

Mine	Capacity (MW)	Location	Expected Online
Kabanga - Nickel	32	Kagera	2016
Mibongo - Gold	20	Kigoma	2016
Ntaka Hill - Nickel	30	Lindi	2018
Dangote Cement plant	40	Mtwara	2015
Panda Hill - Gold	5	Mbeya	2016
Buckreef - Gold	8	Geita	2015
Geita - Gold	30	Geita	2015
Mchuchuma – Iron Smelter	100	Iringa	2018
Golden Ridge - Gold	7	Shinyanga	2015
Dutwa - Nickel	10	Shinyanga	2015
Bulyanhulu - Gold	20	Shinyanga	2013
Textile Mill	30	Shinyanga	2014
Williamson Diamond	10	Shinyanga	2013
Williamson Diamond	12	Shinyanga	2014
Williamson Diamond	3	Shinyanga	2015
Liquidified Natural Gas Power plant(LNG)	100	Mtwara	2018
Expansion of Makonde Plateau Water Supply and Sanitation Authority	6	Mtwara	2017
Ikwiriri Sugar factory	4	Lindi	2014
Mtwara Fertilizer Factory	30	Mtwara	2017
Dawasa- Ruvu pumping Expansion	12	Coast	2015
Hong Yu Steel (T) Ltd - Expansion	34	Coast	2015
Eagle Cement Co. Ltd	20	Coast	2015

c) **Losses:** The estimate of losses for the forecast period is based on the losses in 2010 and is amounted to 25.0 percent including transmission loss of 5.3 and distribution losses of 19.7 percent as per the Cost of Service Study (COSS - 2010). For the update forecast, the COSS projects reduction of losses up to 21.6 percent by 2015. Thereafter, the projection is assumed a rate of 0.2 percent deduction up to the end of plan. A reasonable and achievable target for reduction of losses would be to achieve a level of about 15.8 percent by 2035. A number of projects are ongoing like grid reinforcement projects which include TEDAP, Dar–Tanga-Arusha distribution grid upgrade and reinforcement, selected MCC distribution reinforcement and installation of smart meters to curb electricity theft and ensure revenue protection with the TANESCO grid system.

d) **Load factor:** The data available indicates a load factor of 55.31 percent for 2010. If the amount of load shed in 2010 is added to the energy generated and the peak is kept the same, the load factor would increase to 62.43 percent with a gradual increase to 71.78 percent in 2035. The level of electricity not delivered to customers (load shedding) was taken to represent the supply system constraints. An alternative scenario is to project demand without adding back the amount of load shed which will give unrealistic forecast of electricity.

e) Other specific assumptions for each region are as follows:

i. Population growth
ii. Number of people per household
iii. Rate of increase in customers under the electrification program (applied to T1 customers)
iv. Rate of increase in customers in T2 and T3 as well as in T1 beyond the electrification program
v. Unit consumption for all three categories
vi. Amount and timing of new industrial loads
vii. Amount and timing of major expansions of existing T3 customers.

The Table 2-3 on the next page summarizes the results. It should be noted that there is a strong increase of annual demand growth starting 2013 to 2015 largely due to identified additional power demands from existing, new customers (see **Table 2-2)** and a special electrification program which tallies with government's policy statement of connecting 30% of population by 2015. The **Table 2-3** on the next page summarizes the results, and **Table 2-4** provides the corresponding peaks and evolution of the interconnected grid system - to include all the isolated regions, while **Table 2-5** presents generation requirements. **Figures 2-1 to 2-5** visualizes the sales, demand and generation forecasts for the three cases considered.

Table 2-3: Detailed Forecast Results

Sales, Generation and Peak Forecast - Total Country		Actual	Unconstrained		Base Case							
Region	**Unit**	**2010**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Arusha	GWh	305.3	305.3	322.7	343.5	488.2	685.2	853.7	1,608.8	2,472.8	3,179.9	4,091.6
Dar es Salaam	GWh	2,202.3	2,202.3	2,261.5	2,349.0	2,713.0	3,360.3	3,936.6	5,792.4	6,936.6	8,332.3	10,070.5
Dodoma	GWh	92.0	92.0	96.5	102.2	186.9	301.7	373.9	572.6	818.5	1,179.6	1,492.3
Iringa	GWh	94.7	94.7	98.1	101.6	118.8	149.4	201.3	325.5	522.5	795.1	949.8
Kagera	GWh	46.0	46.0	51.1	56.6	83.5	111.1	176.6	479.2	734.2	1,191.8	2,036.7
Kigoma	GWh	12.4	12.4	14.3	15.0	18.6	33.6	55.5	459.8	583.1	749.0	980.8
Kilimanjaro	GWh	137.9	137.9	141.7	146.9	172.0	196.8	223.2	375.8	440.4	505.4	571.0
Lindi	GWh	14.9	14.9	15.8	16.8	28.2	40.5	76.9	432.4	568.5	739.5	953.7
Manyara (*Included in Arusha*)				-	-	-	-	-				
Mara	GWh	58.8	58.8	67.3	77.5	87.7	98.6	109.6	181.8	304.9	521.3	916.5
Mbeya	GWh	144.0	144.0	151.8	160.6	179.8	207.2	232.2	463.3	746.3	1,159.2	1,697.7
Morogoro	GWh	182.2	182.2	188.8	196.5	216.0	241.4	268.3	476.3	792.0	1,203.2	1,577.6
Mtwara	GWh	29.1	29.1	33.3	36.0	73.4	167.4	289.5	731.1	954.9	1,226.8	1,554.2
Mwanza	GWh	217.3	217.3	223.9	231.6	358.0	465.9	543.9	933.7	1,489.8	2,065.2	2,376.1
Rukwa	GWh	17.5	17.5	18.4	19.5	30.7	41.4	61.6	174.6	282.9	450.0	710.9
Ruvuma	GWh	21.3	21.3	20.4	19.8	26.8	33.3	39.1	125.3	186.1	278.9	400.5
Shinyanga	GWh	286.9	286.9	322.2	359.3	391.7	538.3	730.5	1,368.1	2,390.6	3,776.4	5,622.8
Singida	GWh	30.3	30.3	32.3	34.6	48.4	56.6	65.4	112.3	183.4	298.5	485.1
Tabora	GWh	84.9	84.9	98.1	111.6	152.7	163.5	174.4	305.1	572.8	940.5	1,439.8
Tanga	GWh	197.1	197.1	206.8	218.0	276.6	341.3	461.5	903.3	1,263.0	1,732.6	2,155.4
Total Sales	GWh	***4,175.0***	***4,175.1***	***4,364.9***	***4,596.7***	***5,651.1***	***7,233.4***	***8,873.8***	***15,821.4***	***22,243.5***	***30,324.9***	***40,083.0***
Annual Growth Rate	*%*		*0.0%*	*4.5%*	*5.3%*	*22.9%*	*28.0%*	*22.7%*	*7.4%*	*6.6%*	*6.0%*	*5.5%*
T1	GWh	2,024.1	2,024.1	2,126.2	2,258.4	2,661.1	3,094.3	3,548.7	6,016.5	9,318.0	13,642.0	18,827.5
T2	GWh	592.5	592.5	598.1	606.6	896.3	1,234.0	1,576.0	2,713.1	3,600.5	4,763.2	6,313.8
T3	GWh	1,558.5	1,558.5	1,640.6	1,731.7	2,093.7	2,905.1	3,749.1	7,091.7	9,325.0	11,919.7	14,941.8
LESS *New loads*	*GWh*	-	-	-	-	*(459.0)*	*(1,412.4)*	*(2,400.3)*	*(5,445.1)*	*(6,599.3)*	*(8,000.9)*	*(9,703.3)*
Total Sales	GWh	***4,175.0***	***4,175.1***	***4,364.9***	***4,596.7***	***5,651.1***	***7,233.4***	***8,873.8***	***15,821.4***	***22,243.5***	***30,324.9***	***40,083.0***
Distribution Losses			*1,027.3*	*1,074.0*	*992.7*	*1,111.0*	*1,286.5*	*1,575.8*	*2,588.8*	*3,338.5*	*4,147.7*	*4,960.9*
Distribution Loss rate	*%*		*19.7%*	*19.7%*	*17.8%*	*16.4%*	*15.1%*	*15.1%*	*14.1%*	*13.1%*	*12.0%*	*11.0%*
Generation required at S/S	GWh	***4,175.0***	***5,202.3***	***5,439.0***	***5,589.4***	***6,762.2***	***8,520.0***	***10,449.6***	***18,410.1***	***25,582.0***	***34,472.6***	***45,044.0***
Recovered Loadshedding	GWh		*98.0*	*98.0*	*98.0*	*98.0*	*98.0*	*98.0*	*98.0*	*98.0*	*98.0*	*98.0*
Transmission Losses	GWh		*290.8*	*305.9*	*331.0*	*391.1*	*480.8*	*574.6*	*882.7*	*1,160.3*	*1,570.7*	*2,056.7*
Transmission Loss rate	*%*			*5.2%*	*5.4%*	*5.3%*	*5.2%*	*5.1%*	*4.5%*	*4.3%*	*4.3%*	*4.3%*
Net Generation	GWh	***4,175.0***	***5,591.2***	***5,842.9***	***6,018.5***	***7,251.3***	***9,098.8***	***11,122.2***	***19,390.9***	***26,840.3***	***36,141.3***	***47,198.7***
Station Use	*GWh*		*62.19*	*64.99*	*66.94*	*80.65*	*101.20*	*123.71*	*215.67*	*298.53*	*401.98*	*524.96*
Fraction of Station Use	*%*		*1.1%*	*1.1%*	*1.1%*	*1.1%*	*1.1%*	*1.1%*	*1.1%*	*1.1%*	*1.1%*	*1.1%*
Gross Generation	GWh	***4,175.0***	***5,653.4***	***5,907.9***	***6,085.4***	***7,331.9***	***9,200.0***	***11,245.9***	***19,606.6***	***27,138.8***	***36,543.3***	***47,723.6***
Annual Growth Rate				*4.5%*	*3.0%*	*20.5%*	*25.5%*	*22.2%*	*7.0%*	*6.4%*	*5.7%*	*5.2%*
Sum of Peak Demands (MW)	MW		***1,061.9***	***1,117.0***	***1,138.9***	***1,364.6***	***1,704.1***	***2,088.5***	***3,573.3***	***4,724.3***	***6,084.6***	***7,644.8***
Coincident Peak (MW)	MW	***832.6***	***1,054.2***	***1,108.9***	***1,130.7***	***1,354.7***	***1,691.8***	***2,073.3***	***3,547.3***	***4,690.0***	***6,040.5***	***7,589.4***
Annual Growth Rate	*%*			*33.2%*	*2.0%*	*19.8%*	*24.9%*	*22.6%*	*5.9%*	*5.4%*	*4.8%*	*4.9%*
Overal Electrification Levels	***%***		***14.0%***	***14.0%***	***15.0%***	***18.0%***	***21.0%***	***24.0%***	***37.0%***	***51.0%***	***66.0%***	***78.0%***

Table 2-4: Regional Peak Demand Forecast

Non-coincident Peak Demand Forecast - Interconnected Grid **Base Case**

MW	Actual 2010	Unconstrained 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2025	2030	2035
Arusha	53.83	68	72	74	103	142	176	204	231	259	289	322	481	603	751
Dar es Salaam	373	472.61	485.09	490.14	554.38	672.2	783.66	921.33	1023.86	1054.58	1086.46	1119.53	1304.8	1526.05	1801.61
Dodoma	18.07	23	24	25	44	69	85	97	104	111	118	125	173	240	295
Iringa	22.6	29	30	30	34	41	55	59	64	69	75	81	121	171	188
Kagera	12	15.95	16.91	17.86	25.09	32.03	49.55	78.05	99.34	108.98	114.27	121.37	170.47	255.08	402.64
Kigoma	5.69	7.65	8.70	8.92	10.04	16.42	25.25	78.11	140.36	165.09	158.77	158.6	162.83	175.06	193.79
K'Manjaro	35.76	45.31	46.52	46.15	52.01	57.37	63.72	69.85	75.8	82.45	89.24	96.46	102.74	107.88	114.98
Lindi	1.28	1.72	3.71	3.84	6.18	8.63	16.17	25.51	34.58	82.11	83.99	88.63	115.09	147.89	188.49
Manyara															
Mara	20.2	25.6	29.24	31.5	33.78	36.01	38.63	41.19	43.65	46.87	50.3	53.97	78.01	116.88	183.93
Mbeya	30	38.01	40.04	40.86	44.48	49.83	55.17	65.66	75.13	85.52	93.9	102.79	155.58	227.75	320.79
Morogoro	39.07	49.5	51.29	51.31	54.65	59.16	64.73	69.99	74.67	84.76	94.99	105.47	162.14	228.91	281.7
Mtwara	10.71	14.41	15.24	15.33	28.44	60.12	99.12	146.31	179.45	202.85	200.7	204.72	226.07	250.84	285.3
Mwanza	42	53	55	55	83	106	123	139	155	170	187	205	318	428	477
Rukwa	6.08	6.688	8.08	8.04	11.73	14.86	21.15	30.18	35.55	45.25	47.62	50.19	70.32	98.32	140.61
Ruvuma	5.77	7.77	7.87	8.58	10.86	12.71	14.41	16.66	27.33	36.42	37.09	38.66	50.17	66.6	79.41
Shinyanga	74.3	94.14	105.52	112.6	118.34	156.46	207.75	243.18	255.5	286.75	318.28	350.13	555.74	803.17	1128.12
Singida	7	9.37	9.98	10.17	13.74	15.62	17.8	19.92	22.02	23.97	26.09	28.39	43.29	66	97.35
Tabora	19.61	25	29	31	42	43	46	48	50	58	66	74	130	201	289
Tanga	59.3	75.14	78.79	78.61	94.92	111.72	146.38	169.5	206.48	231.17	236.98	247.34	304.02	371.18	426.12
System Peak Demand	**832.6**	**1,054.17**	**1,108.88**	**1,130.65**	**1,354.75**	**1,691.78**	**2,073.35**	**2,504.15**	**2,876.71**	**3,180.54**	**3,349.22**	**3,547.34**	**4,690.02**	**6,040.50**	**7,589.41**
Growth			*33.2%*	*2.0%*	*19.8%*	*24.9%*	*22.6%*	*20.8%*	*14.9%*	*10.6%*	*5.3%*	*5.9%*	*5.4%*	*4.8%*	*4.9%*
Overall Electrification Rate		**13.75%**	**14.46%**	**15.23%**	**18.31%**	**21.28%**	**24.14%**	**26.91%**	**29.59%**	**32.05%**	**34.63%**	**37.34%**	**50.75%**	**65.78%**	**78.17%**

Table 2-5: Demand, Generation Forecasts

Year	Sum of Peak MW	Coincidental Peak MW	Gross Generation GWh
2010-Unconstrained	1,061.9	1054.17	5,653
2011	1,117.0	1108.88	5,908
2012	1,138.9	1130.65	6,085
2013	1,364.6	1354.75	7,332
2014	1,704.1	1691.78	9,200
2015	2,088.5	2073.35	11,246
2016	2,522.4	2504.15	13,520
2017	2,897.7	2876.71	15,494
2018	3,203.8	3180.54	17,194
2019	3,373.7	3349.22	18,322
2020	3,573.3	3547.34	19,607
2021	3,780.7	3753.31	20,943
2022	4,008.7	3979.63	22,424
2023	4,252.9	4222.11	24,000
2024	4,482.8	4450.34	25,514
2025	4,724.3	4690.02	27,139
2026	4,979.2	4943.10	28,860
2027	5,247.6	5209.56	30,689
2028	5,531.0	5490.90	32,635
2029	5,806.0	5763.93	34,560
2030	6,084.6	6040.50	36,543
2031	6,377.5	6331.25	38,646
2032	6,678.8	6630.38	40,836
2033	6,978.6	6927.98	43,030
2034	7,290.2	7237.37	45,359
2035	7,644.8	7589.41	47,724

Figure 2- 1: Electricity Sales Forecast: 2011 - 2035

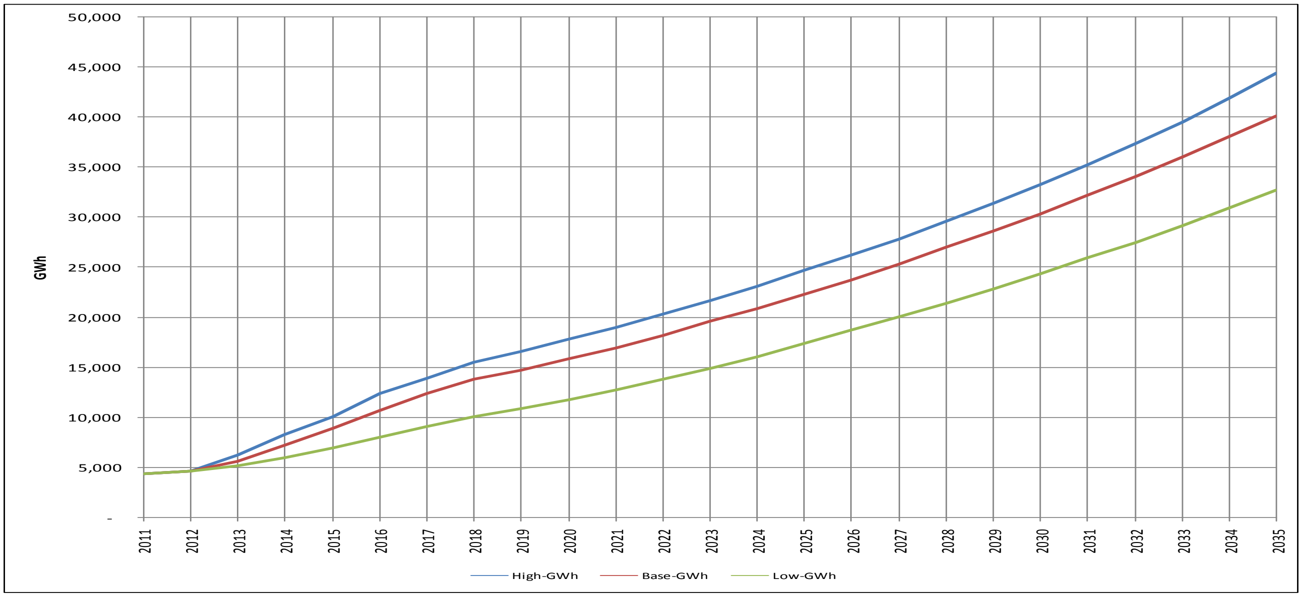


Figure 2- 2: Gross Generation Forecast: 2011 - 2035

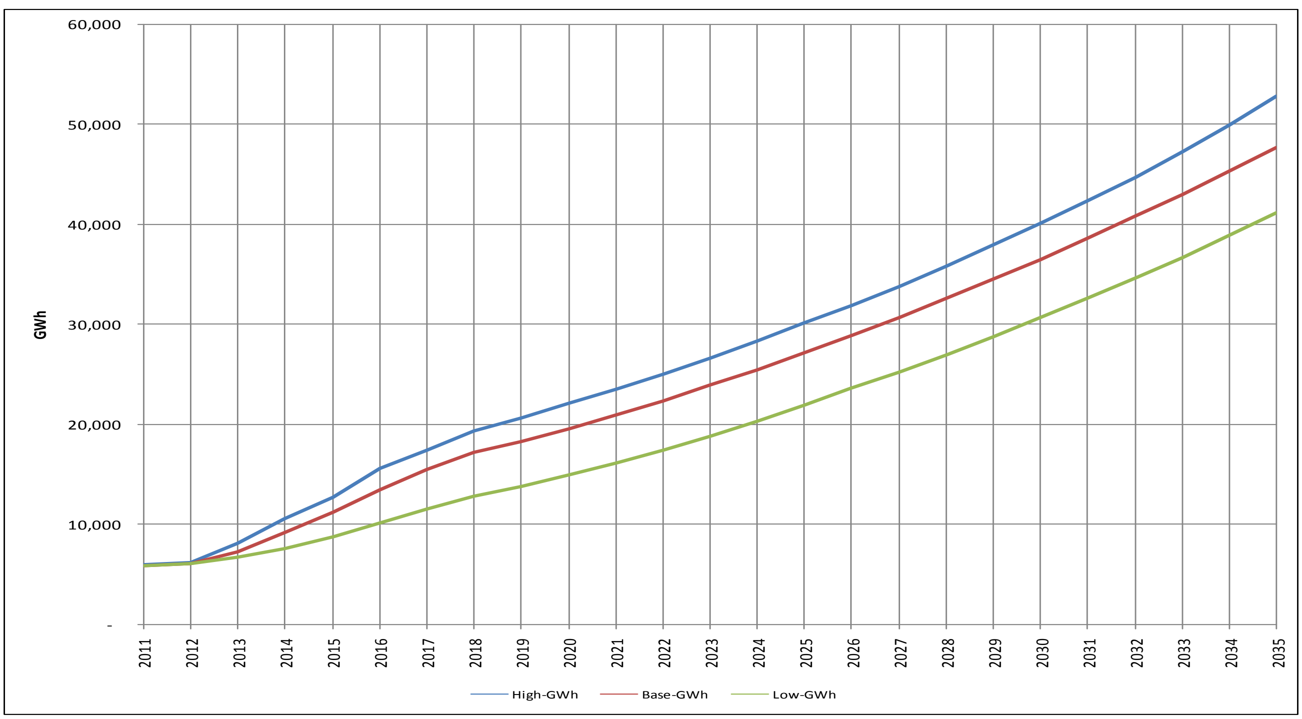
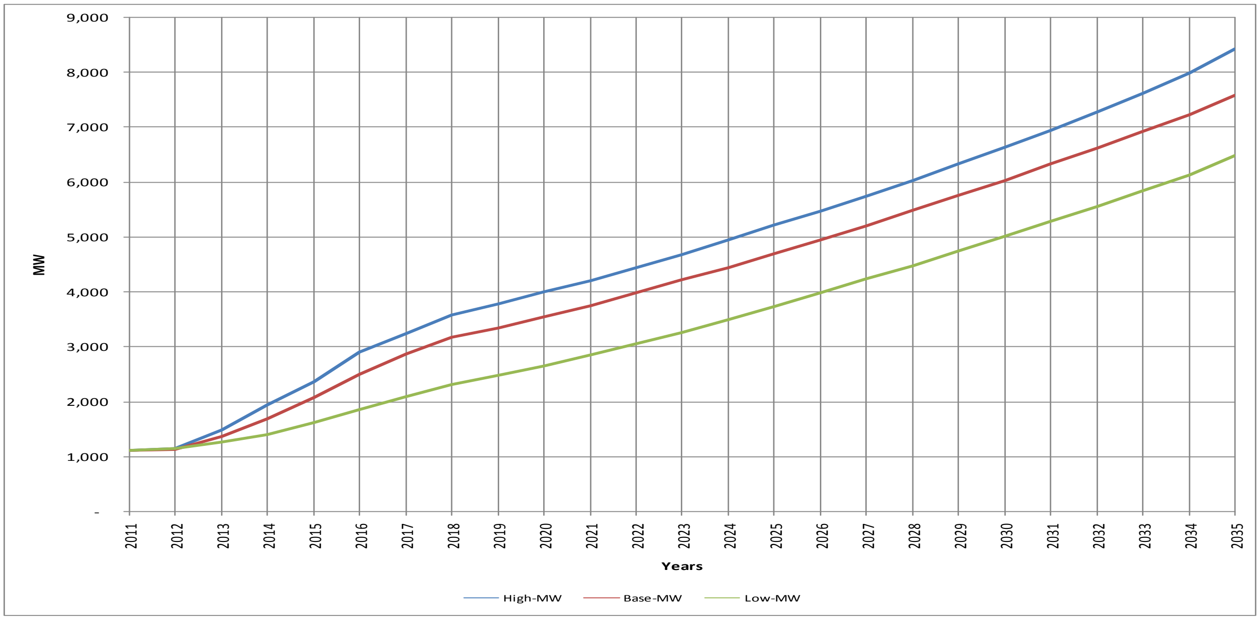


Figure 2- 3: Peak Demand Forecast: 2011 - 2035



Note: The forecast is based on actual data for 2010 base year and therefore peak demands for 2011 and 2012 were estimates. Furthermore, the estimates were based on unconstrained electricity demand consumption.

Econometric method

The econometric method consists of two steps which are detailed in the main report of this study. A snapshot of the methodology follows below:

.

Step 1: Plot the Sales vs. economic and/or demographic indicators, i.e. fit – via a regression analysis – an equation of the form:

Sales (t) = α + β • (demographic indicators, t) + γ • (economic indicators, t)

Where at time t:

Sale = Sales in GWh (Sales could be T1 Sales, T2 Sales, T3 Sales or Country Sales),

Demographic indicators = Population, housing, etc.

Economic indicators = GDP, or subset thereof, and α, β and γ are the (estimated) coefficients.

Forecast for Category T1

Category T1 is composed of residential, commercial, light industry and street lighting customers. A series of relationships between sales to T1 customers and a number of combinations of various economic and demographic parameters were examined. The regression equation is given by:

T1 Sales as function of Total GDP

The relationship is: **T1 = 16.9954 + 0.000118 x GDP**

Where T1 is expressed in GWh and the Total GDP is in TSh million (constant 2001 prices).

Forecast for Category T2

Category T2 includes low voltage commercial, service and industrial supply. A series of relationships between sales to T2 customers and a number of combinations of various economic and demographic parameters were examined. The equation is given by:

T2 Sales as a function of the sum of industry and services GDPs

The relationship is: **T2 Sales = 191.2547 + 0.0000271 x (Industry +Services GDPs)**
Where T2 is expressed in GWh and the Industry **Plus** Services GDP is in TSh million (constant 2001 prices).

Forecast for Category T3

Category T3 includes high voltage supply, agricultural and National Urban Water Authority (NUWA) and mining load customers. A series of relationships between sales to T3 customers and a number of combinations of various economic and demographic parameters were examined.

The best relationship found was:

Sales to T3 customers as a function of sum of Agriculture and Industry GDPs alone

The relationship is: **T3 Sales = -422.0447+0.000251 x (Agric + Industry GDPs)**
Where T3 is expressed in GWh and the Agriculture **plus** Industry GDP is in TSh million (constant 2001 prices).

Forecast of total sales using a global equation

Total sales as a function of total GDP

The relationship is: **Global Sales = -291.516 + 0.00026928 x GDP**
Where Total Sales is expressed in GWh and the Total GDP is in TSh million (constant 2001 prices).

Forecast Results: Figure 0d: Econometrics forecasts – as sum of the three categories and as global

Figure 2- 4: Econometric Forecast: 2011 - 2035

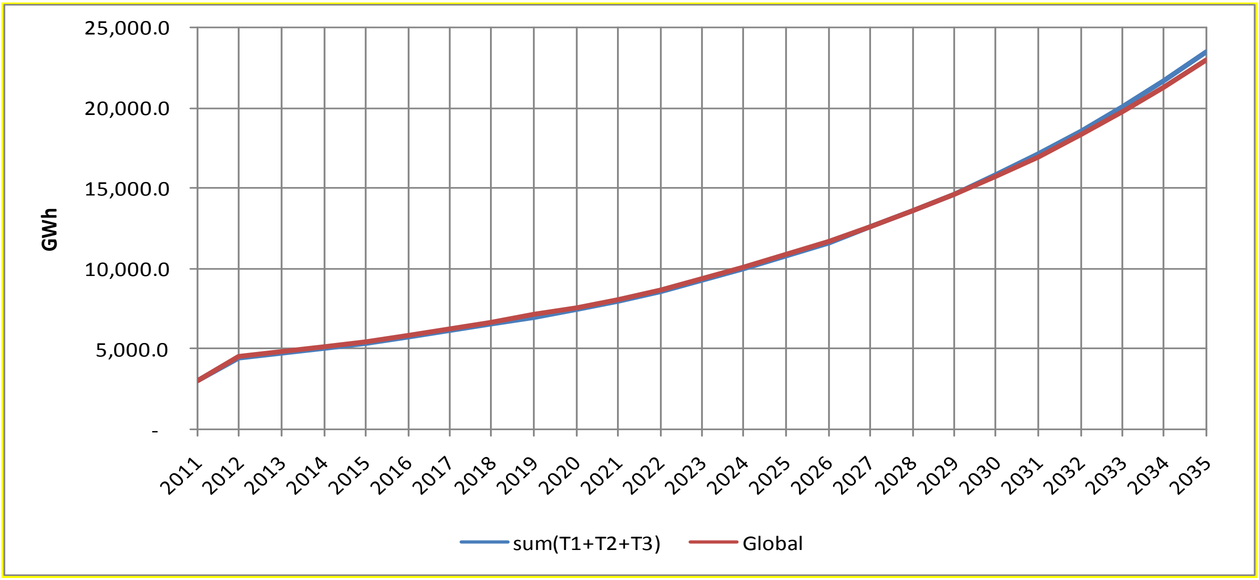


Table 2-6: Sales Forecast (GWh) by Econometric Method

YEAR	T1	T2	T3	T1+T2+T3	Global
2010	2,187.0	599.8	1,604.4	4,391.2	4,391.2
2011	1,444.4	413.7	1,192.7	3,050.8	3,050.8
2012	2,140.1	560.5	1,736.7	4,437.3	4,552.1
2013	2,272.2	586.1	1,876.1	4,734.5	4,853.4
2014	2,413.1	613.5	2,026.0	5,052.6	5,174.9
2015	2,563.6	643.0	2,187.0	5,393.5	5,518.1
2016	2,725.3	674.5	2,362.5	5,762.3	5,887.0
2017	2,896.8	708.4	2,548.9	6,154.1	6,278.4
2018	3,080.1	744.7	2,749.4	6,574.2	6,696.5
2019	3,276.0	783.7	2,965.4	7,025.0	7,143.3
2020	3,485.3	825.5	3,198.0	7,508.8	7,620.9
2021	3,709.1	870.4	3,448.7	8,028.2	8,131.5
2022	3,978.1	925.4	3,741.9	8,645.4	8,745.1
2023	4,268.2	985.0	4,060.8	9,314.0	9,407.0
2024	4,581.3	1,049.7	4,407.6	10,038.6	10,121.4
2025	4,919.3	1,119.7	4,785.1	10,824.1	10,892.5
2026	5,284.4	1,195.6	5,196.1	11,676.1	11,725.2
2027	5,678.7	1,278.0	5,643.8	12,600.4	12,624.8
2028	6,104.8	1,367.3	6,131.7	13,603.7	13,596.8
2029	6,565.3	1,464.2	6,663.6	14,693.1	14,647.5
2030	7,063.3	1,569.3	7,243.9	15,876.4	15,783.6
2031	7,601.9	1,683.4	7,877.0	17,162.2	17,012.3
2032	8,184.6	1,807.2	8,568.0	18,559.8	18,341.7
2033	8,815.2	1,941.7	9,322.6	20,079.6	19,780.4
2034	9,498.0	2,087.6	10,147.0	21,732.6	21,337.9
2035	10,237.3	2,246.2	11,047.7	23,531.2	23,024.6

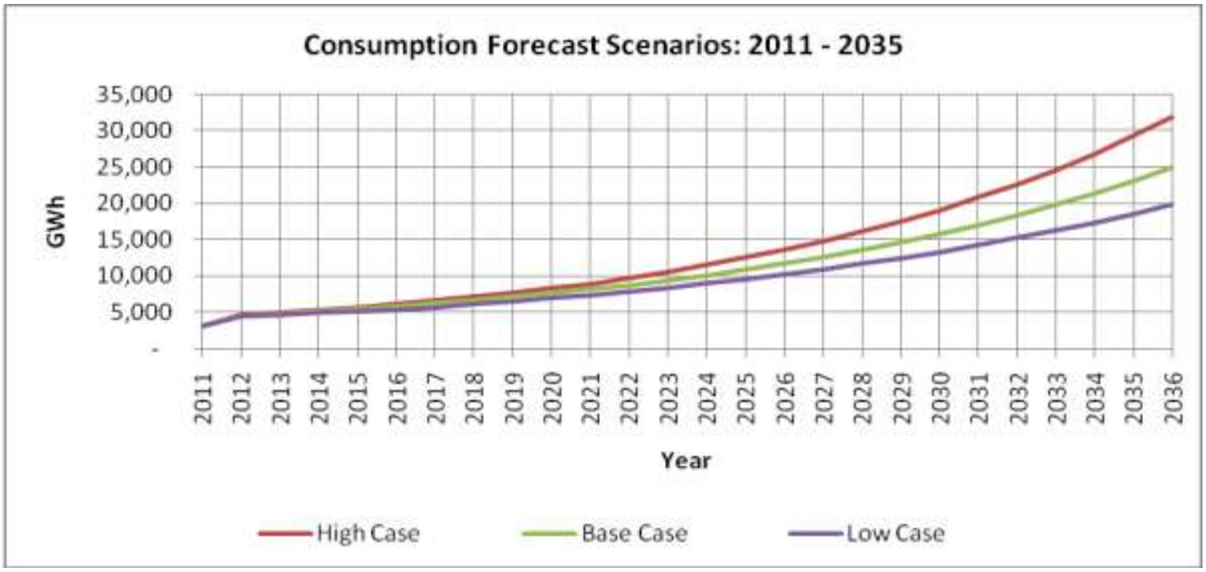
Trend of Energy Share per Customer Tariff Category

Looking at the trend of electricity share per customer categories as illustrated in **Table 2.7**, it is apparent that projections of tariff aimed at facilitating Tanzania to become a middle income country characterised by semi-industrial activities. Notwithstanding, a large contribution of T1 category in overall sales, its share is gradually declining reaching 43.5% in 2035 from a highest share observed in 2012. Similarly, T2 share is declining slowly reflecting graduation of T2 category into T3 category (agriculture and Industry). Comparably, T3 categories despite of their lower share in the early years of projections, their trend is increasing from 39.1% in 2011 to 46.9% surpassing T1 category mainly on account of expected increase and expansion of industrial and mining activities.

Table 2-7: Trend of Electricity Share per Customer Tariff Category

Year	T1	T2	T3
2011	47.3%	13.6%	39.1%
2012	48.2%	12.6%	39.1%
2013	48.0%	12.4%	39.6%
2014	47.8%	12.1%	40.1%
2015	47.5%	11.9%	40.5%
2016	47.3%	11.7%	41.0%
2017	47.1%	11.5%	41.4%
2018	46.9%	11.3%	41.8%
2019	46.6%	11.2%	42.2%
2020	46.4%	11.0%	42.6%
2021	46.2%	10.8%	43.0%
2022	46.0%	10.7%	43.3%
2023	45.8%	10.6%	43.6%
2024	45.6%	10.5%	43.9%
2025	45.4%	10.3%	44.2%
2026	45.3%	10.2%	44.5%
2027	45.1%	10.1%	44.8%
2028	44.9%	10.1%	45.1%
2029	44.7%	10.0%	45.4%
2030	44.5%	9.9%	45.6%
2031	44.3%	9.8%	45.9%
2032	44.1%	9.7%	46.2%
2033	43.9%	9.7%	46.4%
2034	43.7%	9.6%	46.7%
2035	43.5%	9.5%	46.9%

Figure 2- 5: Econometrics forecasts: Scenarios



Comparison of Trend Analysis and Econometric Analysis

Table 2-8 provides a comparison of the econometric results with the trend line results. The econometric relationship applied to Global Sales was used for this comparison as it was, by far, the strongest econometric relationship. For comparison and considering the impact of the identified new loads in the industrial surveys, and the five-year program to connect 1.25 million customers, the difference between the forecast using the two approaches reveal that trend analysis approach provide higher estimates (taking into account assumptions of programs etc) than econometric approach. In this context and in the absence of policy interventions[1], the two approaches to the forecast energy would essentially derive comparable forecast results.

Table 2-8: Forecast Comparison: Econometric–Global vs Trend-Total in GWh

Year	Global - Econometric	Trend Forecast_ Total	Difference: with Global	Difference: (percent)
2012	4,552.1	4,596.7	44.6	1.0%
2015	5,518.1	8,873.8	3,355.7	60.8%
2020	7,620.9	15,821.4	8,200.4	107.6%
2025	10,892.5	22,243.5	11,351.0	104.2%
2030	15,783.6	30,324.9	14,541.3	92.1%
2035	23,024.6	40,083.0	17,058.5	74.1%

The difference of the forecast in terms of average growth rate over the planning horizon remains large as the trend approach reveals more GWh compared to econometric methods. The reason is mainly attributable to the connection of 1.25million customers under electrification program in early years of the forecast. Thereafter, the growth rates of trend approach grow at a sustainable

[1] *The policy intervention means special program initiated by the government to be implemented such as special rural electrification program which results in strong demand growth in the early years of the forecast.*

rate necessary to achieve overall objective of electrifying 75% of population by 2035. As such the growth using the trend line averages 9.7 percent while the growth using the econometric approach averages 7.5 percent.

CHAPTER 3

GENERATION PLAN

Introduction

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

Table 3-1: Planning Criteria

Description	Criteria
Plan Horizon	2010 - 2035
Shadow Price	Not applicable, as foreign currencies are freely trading in Tanzania
Cost of Un-serve Energy	US$ 1.1 per kWh (taken from 2009 PSMP updates)
LOLE	5 days per Year
Plant Outage time	
Hydro	8%
Thermal	11% – 20%
Plant Service Life	
Hydro	50 Years
Thermal	20 – 25 Years
Lead Time	
Hydro	5 – 10 Years
Thermal	2 – 6 Years
Reserve Margin	15% – 20%

Hydropower Projects

The hydro system capabilities for the existing plants have been assessed for both average and firm energy deliveries. The probable on-power date depends on, at which stage of preparation the project has reached (lead time). Tables 3.1 below show the lead time and capacity for future hydropower projects.

Table 3-2: Lead-Times on Hydropower Projects

PROJECT	MW	Capital cost $M no IDC / 2010	Con-struction - months	Present status	Project preparation years	Contract and construction - years	Minimum lead time years	Source	Earliest on power (January)
Ruhudji *	358	1688.07	66	Committed	*2*	*6*	*8*	EAPMP	2020
Stieglers Phase 3 Addition	300	280.94	24	Feasibility	3	2	5	EAPMP	2024
Kihansi II	*120*	211.05	45	Prefeasibility	2	4	6	EAPMP	2018
Stieglers Phase 2 addition	600	342.71	36	Feasibility	3	3	6	EAPMP	2023
Kakono	53	99.29	36	Prefeasibility	2	4	6	SSEA	2018
Rusumo	90	423.60	36	Feasibility	2	4	6	SNCL	2018
Songwe Bipugu	34	92.67	36	Prefeasibility	2	4	6	Norconsult	2018
Masigira	118	229.53	54	Prefeasibility	3	4	7	EAPMP	2019
Malagarasi (Igamba III)	44.8	209.30	60	Feasibility	2	4	6	ESBI	2018
Mpanga	144	274.09	63	Prefeasibility	3	5	8	EAPMP	2020
Songwe Manolo	149	285.84	48	Prefeasibility	3	5	8	Planning criteria	2023
Taveta	145	257.40	60	Prefeasibility	3	5	8	Planning criteria	2022
Rumakali	520	994.05	84	Feasibility	3	5	8	EAPMP	2020
Songwe Sofre	157	281.13	60	Prefeasibility	3	6	9	***(must follow Sofre)*** Planning criteria	2021
Ikondo	340	682.49	72	Prefeasibility	3	6	9	Planning criteria	2021
Stieglers Phase 1	300	961.95	108	Prefeasibility	4	6	10	EAPMP	2022

* Implementation under negotiation with IPP
Stieglers earliest on power assumes construction of additions in parftially in parallel. Lag between stages is arbitrary

Thermal Power Projects

The following new thermal power proposals have been identified and reviewed with regard to likely lead-times for determining expected on-power dates.

Table 3-3: Lead-Times on Thermal Projects

Plant	Fuel	Installed Capacity MW	Nominal Service Life Years	Minimum lead time years	Earliest on power year (Jan)
COAL FIRED PLANT					
Coast Coal	Coal	500	25	6	2019
Kiwira I *	Coal	200	25	6	2017
Kiwira II *	Coal	200	25	6	2019
Local Coal I	Coal	100	25	6	2026
Local Coal II	Coal	200	25	6	2029
Local Coal III	Coal	400	25	6	2030
Local Coal IV	Coal	400	25	6	2031
Local Coal V	Coal	400	25	6	2033
Local Coal VI	Coal	300	25	6	2034
Mchuchuma I	Coal	300	25	5	2018
Mchuchuma II	Coal	300	25	6	2019
Mchuchuma III	Coal	300	25	6	2019
Ngaka I	Coal	200	25	6	2019
Ngaka II	Coal	400	25	6	2019
HFO/Gas/IDO FIRED PLANT					
Kinyerezi I	GTs - Gas	150	20	1	2014
Kinyerezi II	CCGT	240	20	3	2016
Kinyerezi III	CCGT	300	20	4	2017
Kinyerezi IV	GTs - Gas	300	20	4	2017
Mkuranga 250	CCGT	250	20	4	2015
Mtwara 400	CCGT	400	20	4	2016
Mwanza MS Diesel	MSD	60	20	1	2014
Somanga Fungu	CCGT	320	20	3	2016
Zinga 200	CCGT	200	20	4	2015
TOTAL		**6420**			

Renewable Projects

The following new renewable power projects have been identified to be developed in the short term. These are biomass, solar and wind as shown in the table below.

Table 3-4: Lead-Times on Renewable Projects

RENEWABLES					
Mufindi (Cogen)	Biomass	30	20	3	2016
Sao Hill (Cogen)	Biomass	10	20	3	2016
Solar I	Solar	60	20	3	2016
Solar II	Solar	60	20	3	2018
Wind I	Wind	50	20	3	2016
Wind II	Wind	50	20	3	2017
TOTAL		**260**			

Geothermal

Geothermal is another potential source of power in the country. Currently there are about 50 geothermal potential sites in the country, with an estimated geothermal potential of more than 650MW. There are three most promising sites proposed for more detailed investigations. The sites are:

a) Lake Natron in Arusha region

b) Songwe river basin in Mbeya region

c) Luhoi Spring site, with potential of 50 – 100MW located in Lower Rufiji Valley, Utete district.

There is insufficient information to consider geothermal option in the generation expansion plan under the current PSMP review. However given the importance of using Tanzanian resources, the coming comprehensive PSMP update could include up to 100MW geothermal plant as a candidate starting 2025 in anticipation that confirmatory studies will have been completed.

Gas Availability

It is assumed that 70 percent of the available gas will be used for power generation and the remaining 30 percent for other uses including industrial activities. The 70:30 assumptions is based on the expectation that number of gas based industries will increase as per Gas utilization Master Plan. The current gas consumption ratio in Dar es Salaam is at 85:15; therefore, it is a rule of thumb. Other assumptions on the timing, costs, infrastructure required on gas development is out of scope of this report.

The assumed gas resource for existing plants and future projects in the 2012 PSMP update is shown in **Table 3.4.** This table indicates gas supply to meet the present gas plants and the proposed future projects to cover their operational lives. It is assumed that a significant portion of the available gas resources is confined for use in power generation implying that other gas customer needs remain at current level.

Table 3-4: Natural Gas Utilization–Existing/committed Plants

Generation assumed at average plant factor for 70 %	Proven (BCF)	Reserve (BCF)		
PAE(T) contract 245 MW x 16 years =			3920 MWYEAR	70 %PF
SONGO SONGO	880	2000	15136 MWYEAR	70 %PF
MNAZI BAY	262	5000	4506.4 MWYEAR	70 %PF
MKURANGA		20	0 MWYEAR	70 %PF
KILWANI		7	0 MWYEAR	70 %PF
NTORYA		17	0 MWYEAR	70 %PF
DEEP SEA		28000	0 MWYEAR	70 %PF
1 bcf equivalent to	17.2 MW-years at 70 % CF			

YEAR	PLANT		GAS ADDED MW	HFO MW	GAS ON LINE MW	END YEAR	GAS YEARS (After Jun 2014)	MW-YEARS 70% PF COMMITTED
2002	Tegeta IPTL			100		2014		
2004	Songas 1	IPP	42		42	2024	11	462
2005	Songas 2	IPP	120		162	2025	12	1440
2006	Songas 3	IPP	40		202	2026	13	520
2007	Ubungo I		100		302	2026	13	1300
2008	Mtwara	IPP	18		320	2027	14	252
2009	Tegeta new		45		365	2029	16	720
2012	Ubungo II		105		470	2032	19	1995
2013	Kinyerezi I		150		620	2033	20	3000
2013	Symbion 205	IPP	100		720	2014	1	100
2014	Kinyerezi II		160		880	2034	20	3200
2014	Somanga	IPP	210		1090	2034	20	4200
2015	Kinyerezi III		300		1390	2035	20	6000
2015	Zinga-Bagamoyo	IPP	225		1615	2035	20	4500
2015	Mkuranga		250		1865	2035	20	5000
2014	Tegeta IPTL		100		1965	2022	9	900
2016	Mtwara	IPP	400		2365	2036	20	8000
TOTAL			2365					41589

Coal Resources

Tanzania is endowed with coal resources estimated at 496 million metric tonnes (MT) of proven reserves as indicated in table 3.4 below. As per the project lead time, the first coal power plant is expected to be on line by 2016. This plan has taken in to consideration the importance of coal in electricity generation, therefore, future generation will consider coal fired power plant as base load.

Table 3-5: Coal Resources Utilization for future generation

Coal Resources	Proven (MT)	Reserve (MT)
NGAKA	251.00	
MCHUCHUMA	125.30	454.10
KIWIRA	86.31	
KATEWAKA	33.50	81.70
Total	496.11	

YEAR	PLANT		INSTALLED CAPACITY [MW]	SPECIFIC CONSUMPTION [GJ/MWh]	CONSUMPTION PER YEAR [MT]	PLANT LIFE TIME [YEARS]	TOTAL COAL CONSUMPTION [MT]
2016	Kiwira I		200	9.24	0.72	25	18.00
2016	Coastal Coal		300	9.73	0.80	25	19.90
2017	Ngaka I	IPP	200	9.73	0.53	25	13.27
2018	Mchuchuma I	IPP	300	8.99	0.74	25	18.48
2018	Kiwira II	IPP	200	9.24	0.72	25	18.00
2022	Ngaka II	IPP	200	9.73	0.72	25	18.00
2020-2024	Mchuchuma II	IPP	400	8.99	1.13	25	28.29
2026-2028	Mchuchuma III	IPP	300	8.99	0.28	25	21.22
2029	Local Coal I		200	9.73	0.05	25	1.33
2030	Local Coal II		400	9.73	1.33	25	33.17
2031	Local Coal III		400	9.73	1.33	25	33.17
2033	Local Coal IV		400	9.73	1.06	25	26.53
2034	Local Coal V		300	9.73	0.80	25	19.90
TOTAL			3800				269.25

Plan Strategies

This update has retained some of the following strategies used in the preparation of the 2008 Master Plan, and subsequent 2009 Update study.

Overall Power Development Strategy:	
Element	**Why?**
Base case load forecast	To take account of all identified new industrial loads, including background load growth, and to target a 75% electrification rate by 2035.
Interconnect isolated regions	To the extent that it is economic and feasible to do so, in order to promote social and economic development
Install all new generation options that are feasible in the short term regardless of unit cost	To eliminate risk of load shedding in early years of the plan
Use judicious mix of hydro and non-hydro generation options	To avoid over-reliance on hydro with attendant risk of power shortages during dry periods
Accept limited amounts of firm imports/exports	To balance low cost of power and energy self-sufficiency
Schedule new generation so that sufficient reserve margin is provided to allow for future pool power trading	To improve the economics of system expansion by developing revenue potential, while also providing improved security of energy supply

Projects Considered in the Short-Term Plan

Power generation projects tabulated below have been included in the short-term plan (2013 – 2017). These are either under construction, committed stage, and/or they have short lead time and can be developed under accelerated arrangements. As per the study review and given the existing demand, the Plan has identified with reasons some projects that need to be considered in the short term.

Table 3-6: Power Generation Projects for Short – Term Expansion Plan

Project Description	Reasons	Date On-line
a) Mwanza 60MW, Diesel fired	i. They are committed plants, ii. Meet background growth in demand in Tanzania iii. These are the only resources identified as capable of being ready at this short time	Early 2013
a) Kinyerezi I, 150MW GTs plant	i. Meet background growth in demand ii. They are the only resources identified as capable of being ready at this time	Early 2014
a) Somanga Fungu (TANESCO) 8MW b) Somanga Fungu 210MW c) Kinyerezi II, 240MW GTs plant d) 200 ± 25MW Gas based Combined Cycle Power Project (Zinga - Bagamoyo) e) Mkuranga 250MW - Enka f) Renewable - Cogen (Mufindi) 30MW g) Renewable – Cogen (Sao Hill) 10MW	i. Meet background growth in demand ii. Generation mix, to include renewable wind power iii. They are the only resources identified as capable of being ready at this time	Early 2015
a) Kinyerezi III, 300MW GTs plant b) Mtwara (18), 400MW c) Kiwira I 200MW Coal fired, Mbeya d) Somanga Fungu, 110MW e) Wind I, 50MW f) Solar I, 60MW g) Import (Kenya/Ethiopia), 200MW	i. Meet background growth in demand ii. They are the only resources identified as capable of being ready in the short time iii. Generation mix, to include more renewable wind power iv. Build base for possible power trading	Early 2016
a) Wind II, 50MW, b) Ngaka-I 200MW, coal fired Ruvuma c) Hale, 11MW d) Interconnector	i. Meet background growth in demand ii. Import from Ethiopia through Tanzania – Kenya interconnector.	Early 2017

Mid to Long-term strategies	
Element	**Why?**
Work with IPPs/PPPs to Identify and study additional sites for renewable power generation	It is a renewable energy whose costs are being lowered through ongoing research world-wide
Implement the Demand Side Management Program as per energy efficiency study report.	Postpone investments of power generation projects that are expensive. It is cheaper to implement energy efficiency program than building a new plant
Work with the Ministry of Energy and Minerals, and the private sector to continue studies to prove up additional quantities of natural gas	It is a relatively low-cost indigenous fuel with relatively few negative environmental and social impacts
The government to harmonize the acceleration of coal usage for power generation	It is a relatively low-cost indigenous fuel although it has significant negative environmental and social impacts. With new technology can be considered as base load resource.
Develop and implement a program of project preparation studies, including environmental and social assessments, for all hydro sites included in this PSMP generation plan.	Hydro is of key importance as an indigenous resource, and indicative costs are lower than thermal power. Adequate basic information is required to encourage private investors to submit proposals for project implementation
Work with the Ministry of Energy and Minerals to develop a long term policy on possible use of nuclear power, and support studies to prove the availability and capacity of uranium resources and study the opportunities for the development of nuclear generation	It may be a relatively low-cost indigenous fuel that has few immediate environmental and social impacts.
Complete studies on Stiegler's Gorge hydro development to the point where a decision can be made on whether or not it can be implemented	On the one hand, it is a relatively low cost power development with few negative environmental and social impacts. On the other hand, it is located in a Game Reserve which makes it difficult to obtain international financing

Interconnection strategies The country should move immediately towards interconnection with neighbouring power system interconnection.			
Countries	**Generation**	**Why?**	**When?**
Ethiopia via Kenya		To improve energy security with power purchases	
Zambia and Kenya,		- do –	From 2016
Tanzania and Mozambique	Interconnector	- do –	
The rest of EAC countries.		- do –	mid – term
Comments: Interconnection would facilitate integrated power resource planning that have environmental and social risks and would strengthen the transmission networks of each country.			

Generation Plan Results

Development of Comparative Expansion Plans (High, Base and Low Case)

The development of alternative expansion generation plans covered the three scenarios following three cases of load forecast. The scheduling of projects in each plan (high, base and low case) observes a reserve margin on firm capacity in the order of 15 - 20 percent, hydro thermal mix of 40:60 and export/import of not more than 25 percent of total available capacity. The purpose of these relatively high reserve margins is to allow sufficient generation capability to meet local demand and the possibility for power trading with the neighbouring countries during average hydro supply.

The 2012 Update generation expansion plan retains the base case scenario as a recommended power generation expansion plan for the country. The plan reflects the most likely evolution of power demand, sector and economic growth. Overall and as shown in **Table 3.7,** the “Base Case Plan” has a total 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. This plan fulfills all assumptions and results which were assumed and obtained in the load forecast respectively.

Table 3-7: Base Case Plan

EXPANSION PLAN
LOAD FORECAST CASE BASE

Retirements January 1
On power January
Thermal additions are net MW

YEAR	PLANT	FUEL	TYPE	ADDITION MW	ADDITION GWH FIRM	TOTAL SUPPLY MW	TOTAL SUPPLY GWH FIRM	DEMAND MW	DEMAND GWH	SURPLUS (DEFICIT) MW	SURPLUS (DEFICIT) GWH	Reserve Margin Capacity %	Reserve Margin Energy %	Generation Mix % HYDRO Capacity	Generation Mix % HYDRO Energy	Power Pool Trading MW	Power Pool Trading GWH
2011	All existing plants			1103	5310	1103	5310	833	4485	270	825	32	18	33	55	(145)	(152)
				-	-	1103	5310										
2012	Aggreko (Ubungo)	FUEL	GO	50	242	1153	5551										
	Aggreko (Ubungo)	FUEL	GO	(50)	-81	1103	5471										
	Symbion 112	GAS	GT	(75)	-161	1028	5310										
	Symbion 112	GAS	GT	75	484	1103	5793										
	Symbion 112	FUEL	Jet- A1	(37)	-80	1066	5714										
	Symbion 112	FUEL	Jet- A1	37	239	1103	5952										
	Ubungo II	Gas	GT	105	338	1208	6291										
	Aggreko (Tegeta)	FUEL	GO	50	242	1258	6532										
	Aggreko (Tegeta)	FUEL	GO	(50)	-81	1208	6452										
	Mwenga Hydro	Hydro	Hydro	4	2	1212	6453										
	Symbion 205 DODOMA	FUEL	GO	55	355	1267	6808										
	Symbion 205 ARUSHA	FUEL	GO	50	215	1317	7023	1139	6085	178	937	16	15	28	42	(7)	(25)
2013	Mwanza MS diesel	FUEL	Diesel	60	290	1377	7313										
	Ubungo II	Gas	GT	105	677	1482	7990										
	Ubungo II	Gas	GT	(105)	(338)	1377	7651										
	Aggreko (Ubungo)	FUEL	GO	(50)	(242)	1327	7410										
	Aggreko (Tegeta)	FUEL	GO	(50)	(242)	1277	7168										
	Symbion 205 DSM	FUEL	GO	100	645	1377	7813										
	Mwenga Hydro	Hydro	Hydro	4	6	1381	7819										
	Mwenga Hydro	Hydro	Hydro	(4)	-2	1377	7817										
	Symbion 112	FUEL	Jet- A1	75	242	1452	8059										
	Symbion 112	FUEL	Jet- A1	37	119	1489	8178										
	Symbion 112	FUEL	Jet- A1	(112)	(722)	1377	7456										
				-	-	1377	7456	1365	7332	12	124	1	2	27	40	192	976
2014						1377	7456										
	Somanga Tanesco	Gas	GE	8	48	1385	7504										
	Symbion 205 ARUSHA	FUEL	GT	50	215	1435	7719										
	Symbion 205 ARUSHA	FUEL	GT	(50)	(355)	1385	7365										
	Retire Symbion 205 DODOMA	FUEL	GT	(55)	(355)	1330	7010										
	Kinyerezi I	Gas	GT	150	967	1480	7977										
	Somanga Fungu (320)	Gas	GT	210	677	1690	8654										
	Mwanza MS diesel	Fuel	Diesel	(60)	(315)	1630	8339										
	Mwanza MS diesel	FUEL	Diesel	60	387	1690	8726										
	Retire Symbion 112	FUEL	Jet- A1	(112)	(361)	1578	8365	1704	9200	(127)	(835)	(7)	-9	23	35	382	2,215
2015	Kinyerezi II	Gas	CCGT	240	1682	1818	10047										
	Retire Symbion 205 ARUSHA	FUEL	GO	(50)	(215)	1768	9832										
	Retire Symbion 205 DSM	FUEL	GO	(100)	(645)	1668	9187										
	Somanga Fungu (320)	Gas	GT	(210)	(677)	1458	8510										
	Zinga 200MW	Gas	CCGT	200	1,289	1658	9799										
	Somanga Fungu (320)	Gas	GT	210	1,354	1868	11153										
	Mkuranga 250MW	Gas	CCGT	250	1,612	2118	12765										
	Renewable - Cogen (Sao Hill)	Biomass	Cogen	10	84	2128	12849										
	Renewable - Cogen (Mfindi)	Biomass	Cogen	30	210	2158	13059	2088	11246	69	1813	3	16	22	23	244	(126)
2016	Kinyerezi III	Gas	GT	300	1934	2458	14993										-
	Somanga Fungu (320)	Gas	CC	110	709	2568	15703										
	Interconnector (Ethiopia/Kenya)	Import	Import	200	1,402	2768	17104										
	Kiwira I	Coal	Steam	200	1,402	2968	18506										
	Mtwara 400MW	Gas	CCGT	400	2,579	3368	21085										
					-	3368	21085										
	Solar I	Solar	Solar	60	210	3428	21295										
	Renewable - Wind I	Wind	Wind	50	201	3478	21496	2522	13520	955	7976	38	59	12	14	(577)	(5,948)
				-	-	3478	21496									-	-
2017	Renewable - Wind II	Wind	Wind	50	175	3528	21672										
	Ngaka I	Coal	Steam	200	1,289	3728	22961										
					-	3728	22961										
	Hale	Hydro	Hydro	11	28	3738	22989										
	Coastal Coal	Coal	Steam	300	1,934	4038	24923										
					-	4038	24923	2898	15494	1140	9429	39	61	11	12	(706)	(7,105)
2018	Rusumo Falls	Hydro	Hydro	27	148	4065	25071									-	-
	Mchuchuma I	Coal	Steam	300	1,934	4365	27005										
	Kiwira II	Coal	Steam	200	1,289	4565	28295										
	Solar II	Solar	Solar	60	210	4625	28505										
	Interconnector - Rwanda/Burundi	export	export	(50)	(350)	4575	28154										
	Interconnector - Mozambique	export	export	(100)	-645	4475	27510										
	Interconnector - I (Zambia)	export	export	(100)	(701)	4375	26809	3204	17194	1171	9614	37	56	10	11	(690)	(7,035)
2019						4375	26809									-	-
	Kakono	Hydro	Hydro	53	335	4428	27144										
	Ngaka II	Coal	Steam	200	1,402	4628	28545										
					-	4628	28545	3374	18322	1254	10223	37	56	11	10	(748)	(7,475)
2020						4628	28545									-	-
	Mchuchuma II-1	Coal	Steam	100	701	4728	29246										
	Malagarasi	Hydro	Hydro	45	187	4773	29433	3573	19607	1199	9827	34	50	11	11	(663)	(6,886)
2021	Ruhudji	Hydro	Hydro	358	1,333	5131	30766									-	-
					-	5131	30766										
						5131	30766	3781	20943	1350	9823	36	47	18	10	(783)	(6,682)
2022	Mpanga	Hydro	Hydro	144	646	5275	31412									-	-
						5275	31412										
	Mchuchuma II-2	Coal	Steam	100	701	5375	32113										
				-	-	5375	32113	4009	22424	1366	9689	34	43	20	9	(765)	(6,325)
2023	Retire Tegeta IPTL	Fuel	HFO	(100)	(701)	5275	31412									-	-
	Stieglers Gorge I	Hydro	Hydro	300	1908	5575	33320										
	Songwe Bupigu	Hydro	Hydro	34	101	5609	33421										
					-	5609	33421										
						5609	33421	4253	24000	1356	9422	32	39	26	9	(718)	(5,822)
2024	Masigira	Hydro	Hydro	118	492	5727	33913									-	-
	Mchuchuma II-3	Coal	Steam	200	1,402	5927	35315										
						5927	35315	4483	25514	1444	9801	32	38	27	8	(771)	(5,974)
2025	Rumakali	Hydro	Hydro	520	2,520	6447	37835									-	-
						6447	37835										
					-	6447	37835										
	Retire Songas 1+2+3	Gas	GT	(187)	(1,310)	6260	36524										
					-	6260	36524										
					-	6260	36524	4724	27139	1535	9386	33	35	34	8	(827)	(5,315)
2026						6260	36524									-	-
	Songwe Sofre	Hydro	Hydro	157	456	6417	36980										
						6417	36980										
	Mchuchuma III-1	Coal	Steam	100	701	6517	37681	4979	28860	1537	8821	31	31	35	8	(791)	(4,492)
2027						6517	37681									-	-
					-	6517	37681										
	Ikondo - Mnyera	Hydro	Hydro	340	1,316	6857	38997	5248	30689	1609	8308	31	27	33	11	(822)	(3,705)
2028						6857	38997									-	-
	Mchuchuma III-2	Coal	Steam	200	1402	7057	40399										
	Songwe Manolo	Hydro	Hydro	149	488	7206	40887	5531	32635	1675	8252	30	25	37	8	(845)	(3,357)
2029	Taveta - Mnyera	Hydro	Hydro	145	622	7351	41509									-	-
	Local Coal I	Coal	Steam	200	1402	7551	42910	5806	34560	1745	8351	30	24	39	7	(874)	(3,167)
2030	Retire Ubungo GT	Gas	GT	(100)	(701)	7451	42210									-	-
					-	7451	42210										
	Local Coal II	Coal	Steam	400	2803	7851	45013										
					0	7851	45013	6085	36543	1766	8469	29	23	37	7	(853)	(2,988)
2031	Retire Tegeta GT	Gas	GT	(41)	(287)	7810	44725									-	-
				-	-	7810	44725										
	Local Coal III	Coal	Steam	400	2803	8210	47529										
						8210	47529										
					-	8210	47529	6377	38646	1832	8883	29	23	36	6	(876)	(3,086)
2032	Retire Mwanza Ms Diesel	Fuel	Diesel	(60)	(420)	8150	47108									-	-
	Retire Ubungo EPP	Gas	GT	(100)	(701)	8050	46407										
	Retire Cogen	Biomass	Steam	(40)	(280)	8010	46127										
				-	-	8010	46127										
				-	-	8010	46127										
	Stieglers Gorge II	Hydro	Hydro	600	855	8610	46982										
					0	8610	46982	6679	40836	1931	6146	29	15	41	6	(929)	(21)
2033	Local Coal IV	Coal	Steam	400	2,579	9010	49561									-	-
					-	9010	49561										
				-	-	9010	49561										
					-	9010	49561										
					-	9010	49561										
					-	9010	49561	6979	43030	2031	6531	29	15	39	6	(984)	(77)
2034				-	-	9010	49561									-	-
				-		9010	49561										
	Local Coal V	Coal	Steam	300	1,934	9310	51495										
						9310	51495										
					-	9310	51495	7290	45359	2019	6136	28	14	38	6	(926)	668
2035	Stieglers Gorge III	Hydro	Hydro	300	464	9610	51959	7645	47724	1965	4236	26	9	37	7	(818)	2,923
						9610	51959										
	TOTAL ADDITIONS 2011-2035			9610	51959	19219	103918										

CHAPTER 4

TRANSMISSION PLAN

In year 2012, the government launched the development plan for the next generation main grid, a plan to upgrade and invest in new grid capacity to meet the future energy requirements from society including extending the grid to isolated centers and delivering reliable and high quality energy to end-users. The plan represents our ambitions for the coming decade and is committed to, through on time implementation of the recommended projects in years leading up to 2035, strengthen Tanzania's grid infrastructure, and thus safeguard the "backbone" of the power system. With this in mind, the 2012 Grid Development Plan is a realizable and sound one. The existing transmission network to date is as shown on the map below:

Figure 4- 1: Existing Transmission Network

Source: **TANESCO**

Drivers for grid development

a) Security of supply is our top priority

The Western, Northern and Lake Zones need new transmission capacity to secure a satisfactory supply, the South-West and Dar es Salaam areas also need transmission capacity to evacuate excess generated power to other load centers. In 2010, the government initiated preparations for the 400kV transmission projects namely the backbone project, South-West transmission project, Dar es Salaam – Tanga – Arusha and Dar es Salaam – Morogoro - Dodoma transmission projects and the 220kV transmission projects namely the North-West Grid, Makambaku – Songea, Dar es Salaam – Somanga – Mtwara and Songea - Mtwara.
Lengthy preparation procedures have forced the government to increase focus on preparedness in recent years, and in some cases have found it necessary to implement special short-term preparedness measures in certain areas.

b) Renewable energy requires more grid capacity,

The government is determined to achieve its goals regarding new renewable generation in the most social economic efficient way. The government aims to contribute to at least 260MW of new renewable power generation being connected to the Tanzanian grid by 2016. Since the potential for renewable in the country is great, it is important that all these developments are balanced, so that new generation is harmonized and adjusted to the implemented grid development plans as well as changes in consumption patterns. This applies both nationally and regionally and that is why the plans for a reinforced main grid include both domestic implementation measures and interconnector capacity to other countries. An increase in the generation of renewable energy will further increase variations in the grid power system between years with low precipitation and years with high precipitation; this requires an increase in the exchange capacity between Tanzania and other countries, both to secure access to energy in dry years, and ability to export surplus power during wet years.

c) Reliable grid creates value,

The government will facilitate value creation by securing the necessary transmission capacity domestically, delivering power to the growing number of newly established enterprises, as well as facilitating increased power exchange internationally. Generally, in the entire country, the load forecast show that there will be high growth of power demand mainly due to increase of industrial activities and in addition to that, the gas and coal discoveries made in recent years, will lead to higher levels of energy consumption, for example, the Mtwara EPZ alone will require not less than 200MW by 2016. It is anticipated that the next generation main grid will comprise stronger connections between all regions, and contribute to more uniform electricity prices across the country during normal situations. This will provide producers and consumers alike with improved predictability, and facilitate value creation all over Tanzania.

d) The future of Tanzania is electric,

The government's policy is to attain electrification rate of 78% of its people by year 2035. In addition to that, the expectation in the long term is that the transport sector will be extensively electrified and industrial sector will grow up, in order to be able to facilitate these objectives; sufficient grid capacity must be developed.

Transmission planning criteria

The planning of the transmission grid considers the operation of a power system under two possible situations, that is:

Normal operating conditions (N-0). The transmission infrastructure is entirely available (no equipment has been forced out of service).

Contingency operating conditions (N-1). The main principal is that the main grid will be operated and scheduled based on the so called **N-1 criterion.** This means that under normal system conditions a fault in one single component (say line, transformer or VAr compensator) will have no influence on the general power supply. This criterion establishes security of supply as a stronger driving force in grid development. In this chapter, the study has set as target to rectify all known breaches of the planning criteria by 2035. The deadline has been predetermined to ensure that we also have the capacity to carry out investment projects related to additional priorities, therefore only outages of equipment rated at 220 kV or above will be considered under the N-1 criteria.

System operations challenges

The following challenges have, from our experience, proved to be one of the causes for the delay in implementing various investment projects. Hence while we prepare ourselves to implement the transmission plan, we should also prepare ourselves to solve or avoid them.

a) Accumulated reinvestment requirements,

Large sections of the existing grid face significant reinvestment requirements, both due to age and to ensure sufficient preparedness. This Transmission plan has prepared a long-term reinvestment schedule, which significantly increases the amount of reinvestments in the coming decade leading up to 2035. Unless specials efforts are made to secure sufficient financing, this will have consequences for the implementation of investment projects than it is assumed today.

b) Prolonged project preparation procedures

Experience from the implementation of projects that were proposed in previous Master Plans has proved to be particularly resource demanding and long-lasting. The time spent to clarify various issues has increased significantly and includes approval of environment and securing project funds. This has led to an increased use of resources and delays in the construction phase, and ties up resources that were, in a greater extent, planned for other projects and have caused delays in these.

Development of new interconnectors

Transmission capacity to other countries is an integrated and important part of a main grid that facilitates new renewable power generation and ensures security of supply domestically. It is necessary to increase the exchange capacity with other countries, both to ensure access to power in dry years and to ensure trade of surplus power in years with high precipitation. The results from the operational experience in recent years lead to necessary adjustments of the plans for establishing new interconnectors in the coming ten-year period. The countries project portfolio for interconnectors comprises six potential projects:

The new 400kV interconnector to Kenya, currently undergoing preparation phase, is scheduled for entering into operation in 2016. The connection point in the Grid is Singida. Tanzania is planning another connection to Zambia with a line voltage of 400kV, currently undergoing preparation phase is on schedule for entering operation in 2016 and the connection point in the Grid is Mbeya. Uganda and Tanzania are planning for the 220kV Masaka (Uganda) - Mwanza (Tanzania) interconnector, it is scheduled for operation by 2015.

Tanzania is also planning a new connection to Mozambique with a capacity of 220kV; currently efforts to initiate discussions with the Mozambican counterparts are underway. Tanzania, Rwanda and Burundi are planning a 90MW hydro power plant project at Rusumo border with Rwanda and Burundi, the project will enable the National grids of the three countries be interconnected through 220kV transmission line by 2016. The last one involves Tanzania and Malawi, a total of 340MW hydro power plant project at Songwe border is planned, the project will enable the National grids of the two countries be interconnected through 220kV transmission line by 2021.

Costs

The government expects that investments in the coming ten year period will amount to 3.708 billion United States dollars (US$). These costs will be covered by the customers through an increase in cost reflective grid tariffs.

Short and Medium term Prioritized transmission projects

Priotised Projects

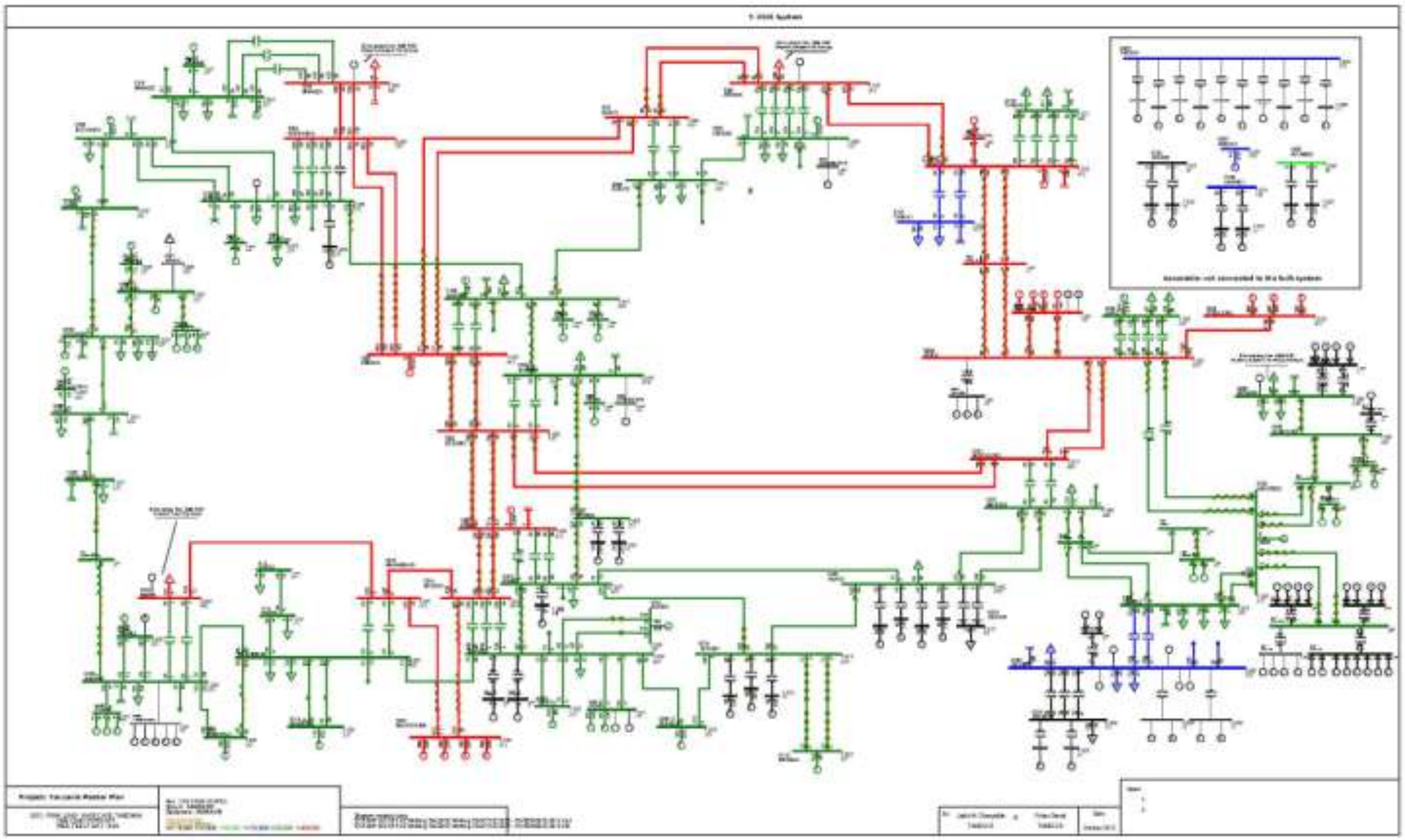
Measure	Description	Timing
132KV Ubungo -Mtoni Interconnector	New Overhead line that strengthens security of supply and connection of Marine cable to Tanzania Island	Under procurement of Contractor. Expected to be commissioned in 2013
220KV Somangafungu to Kinyerezi	198 km new Overhead line that strengthens security of supply of power to the South Eastern tanzania and connection of 8MW tanesco power Plant and planned 320 MW Somanga Fungu power planed	Planned to be commissioned on 2014
220KV Ubungo - Kinyerezi	15 km new over head line that strengthens security of supply and connecting planned power plants at Kinyerezi	Planned to be commissioned on 2014
220KV Mlandizi - Zinga	15 km new over head line that strengthens security of supply and connecting planned power plants at Zinga	Planned to be commissioned on 2015
400KV Iringa – Shinyanga	647 km new Overhead line that strengthens security of supply of power to the central and west and norhern Tanzania	Under procurement of Contractor. Expected to be commissioned in 2015
220KV Makambako – Songea	250 km new Overhead line that strengthens security of supplyto the Southern Tanzania	Under procurement. Expected to be commissioned on 2015
220KV Bulyanhulu – Geita	150 km new Overhead line that strengthens security of supply and connect offgrid part in North west Tanzania	Planned to be commissioned on 2015
220KV Geita - Nyakanazi	133 km new Overhead line that strengthens security of supply and connect offgrid part in North west Tanzania	Planned to be commissioned on 2015
220KV Nyakanazi – Kigoma	280 km new Overhead line that strengthens security of supply and connect off grid part in North west Tanzania	Planned to be commissioned on 2015
220KV Masaka-Mwanza	250 km new Overhead line that strengthens security of supply and connect off grid part in North west Tanzania	Planned to be commissioned on 2015
220KV Wind Project to Singida	10 km new Overhead line that strengthens security of supply and that will be linked with great volumes of wind power in Singida Region	Planned to be commissioned on 2016
400KV Tanzania -Kenya Interconnection (Tanzania Part)	414.4 km new Overhead line that strengthens security of supply that will facilitate interconnection and facilitate trade among EAPP	The project is under securing the fund and planned to be commissioned in 2016
400KV Kiwira – Mbeya	100 km new Overhead line that strengthens security of supply and that will be linked with great volumes of coal power plant in Kiwira	Planned to be commissioned on 2016
400KV Mbeya – Iringa	350 km new Overhead line that strengthens security of supply that will facilitate interconnection and facilitate trade among SAPP	Planned to be commissioned on 2016
220KV Solar I Project to Dodoma	10 km new Overhead line that strengthens security of supply and that will be linked with great volumes of Solar power in Dodoma Region	Planned to be commissioned on 2016
400KV Coastal Coal to Tanga	10 km new Overhead line that strengthens security of supply and that will be linked with great volumes of coal power plant in Tanga	Planned to be commissioned on 2016
400KV Dar es Salaam-Chalinze-Same - Tanga-Arusha	682 km new Overhead line that strengthens security of supply of power to the North East of Tanzania	Planned to be commissioned on 2016
132KV Factory Zone III to Factory Zone II	The existing connection to the factory Zone will be upgraded to increase the security of supply and to facilitate the security supply to the industrial area in Dar es salaam	Planned to be commissioned on 2016
132KV Factory Zone II to Mbagala	The existing connection to the Mbagala will be upgraded to increase the security of supply and to facilitate the security supply to the supply to Mbagala	Planned to be commissioned on 2016
132KV Mbagala to Kurasini	The existing connection to the Kurasini will be upgradedand linked to Mbagala to increase the security of supply and to facilitate the security supply to the supply to kurasini	Planned to be commissioned on 2016
132KV Kurasini to Ubungo	The existing connection to the Kurasini will be upgradedand linked to Mbagala to increase the security of supply and to facilitate the security supply to the supply to kurasini	Planned to be commissioned on 2016
220KV Nyakanazi to Mbeya	The existing connection to the Kurasini will be upgradedand linked to Mbagala to increase the security of supply and to facilitate the security supply to the supply to kurasini	Planned to be commissioned on 2017
400KV Dar es Salaam-Morogoro-Dodoma	451 km new Overhead line that strengthens security of supply and connect off grid part in North west Tanzania and linking with the South West Tanzania	Planned to be commissioned on 2017
400 KV Ngaka to Makambako	200 km new Overhead line that strengthens security of supply and that will be linked with great volumes of Ngaka power plant to Makambako	Planned to be commissioned on 2017
220KV Somanga -Lindi_Mtwara	154 km new Overhead line that strengthens security of supply of power to the South Eastern Tanzania and linking the Off grid part in South Eastern Tanzania.	Planned to be commissioned on 2017
220KV Nyakanazi – Rusumo	95 km new Overhead line that strengthens security of supply and connecting power plant at Rusumo	Planned to be commissioned on 2018
220KV Solar II Project to Shinyanga	10 km new Overhead line that strengthens security of supply and that will be linked with great volumes of Solar power in Shinyanga Region	Planned to be commissioned on 2018
220KV Kigoma to Sumbawanga	485 km new Overhead line that strengthens security of supply and connect off grid part in Kigoma nad Sumbawanga	Planned to be commissioned on 2018

Priotised Projects Continue

Measure	Description	Timing
330KV Pensulo – Mbeya	100 km new Overhead line that strengthens security of supply that will facilitate interconnection and facilitate trade among SAPP	Planned to be commissioned on 2018
400KV Mchuchuma – Mufindi	200 km new Overhead line that strengthens security of supply and that will be linked with great volumes of power plant to Mufindi	Planned to be commissioned on 2018
132KV Musoma – Nyamongo	100 km new Overhead line that strengthens security of supply	Planned to be commissioned on 2018
220KV Masigira – Makambako	180 km new Overhead line that strengthens security of supply and that will be linked with great volumes of 118 MW Masigira power plant to Makambako	Planned to be commissioned on 2019
400KV Rumakali – Mbeya	150 km new Overhead line that strengthens security of supply and that will be linked with great volumes of Mchuchuma power planst to Mbeya	Planned to be commissioned on 2020
400KV Rumakali – Makambako	200 km new Overhead line that strengthens security of supply and that will be linked with great volumes of Mchuchuma power planst to Makambako	Planned to be commissioned on 2020
220KV Mtwara to Songea	656 km new Overhead line that strengthens security of supply and that will be linking the southern part to the national grid	Planned to be commissioned on 2021

A successful 2012 Grid Development Plan , through on time implementation of the recommended projects in years leading up to 2035, will strengthen Tanzania's grid infrastructure, and thus safeguard the "backbone" of the power system. With this in mind, the Grid network will appear as shown on the single line diagram below:

Figure 4- 2: Load Flow



DISTRIBUTION SYSTEM PLANNING

a) Purpose and aim of electricity distribution network planning and expansion

The Power System Master Plan objective seeks to promote efficient operation and investment in the electricity sector for the long term interest of consumers from the perspective of reliability, price, safety and quality of electricity services. The electricity network infrastructure plays a critical role in delivering services to consumers and driving efficient and competitive outcomes in the wholesale (Zanzibar) and retail segments of the market. Unreliable infrastructure which does not meet the needs of the community will have significant adverse effects on the public and the economy as a whole. An appropriate planning process is essential to ensure ongoing efficient and reliable supply of electricity.

b) Existing Distribution System

The distribution system network voltages are 33kV and 11kV which serve as the distribution back-bone stepped-down by distribution transformers to 400/230 volts for residential, light commercial and light industrial supply. Heavy industries are supplied at 11 kV and 33 kV. By December 2012, there are 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). The total length of the 33kV lines is 12,602 km, an 11kV line is 6,392 km and a 400/230 Volts lines is 26,565km. Total number of transformers in distribution system is more than 12,000. All of these facilities were critically in poor condition, to date, distribution networks (including 33 & 11kV, LV lines and distribution substations) in Dar es Salaam, Kilimanjaro and Arusha are being rehabilitated and reinforced under the TEDAP project. In other regions, rehabilitation initiatives by Finland and AFDB's Electricity V project are also playing a great role in restoring the distribution system 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.

c) System Losses

Despite the above efforts, there are still high energy losses in transmission and distribution system. This alarming situation called for a need to have a study to identify the problem areas and their causes so as to take the necessary actions to minimize the losses. A study was commissioned in 2010 by Millennium Challenge Account – Tanzania to carry out a technical and commercial loss-reduction study of the transmission and distribution of electrical power system. The loss rates derived are summarized in table below:

System Level	Losses
Transmission	5.3%
Distribution	8.1%
Total Technical	13.4%
Commercial	11.6%
Total	**25.0%**

NB: By 2012, the loss level was 20.65% and the target by 2015 is 18%

d) Specific Remedial Measures

The most efficient way to improve technical loss performance on both the transmission and distribution networks is to amend the processes for network development to build efficiency into the networks through normal network development. This takes time to produce results.

(4.1) Transmission Network

There are four transmission reinforcement projects proposed to be commissioned by year 2015 that will definitely improve the transmission technical losses to the allowable loss level. These projects include the 400 kV Grid Backbone (Iringa to Shinyanga), 400 Kv Dar es Salaam – Chalinze – Tanga – Arusha, 400 kV Iringa – Mbeya, and 400 kV Dar es Salaam – Morogoro – Dodoma. The higher voltage level of 400 kV will transfer more power with less losses compared to the existing 220kV network.

(4.2) Distribution Network

To achieve significant technical loss reduction in the short term additionally requires a specific program of remedial measures targeting the most problematic networks. The program is proposed to start from year 2013 to 2015 with an objective to minimize energy losses from a level of 20.65% to the acceptable level of 18%. These measures including the respective associated costs and loss savings (for distribution network) are summarized as follows:

No.	Problematic Areas	Remedies	Associated costs (US$ Million)	Loss Savings (US$ Million)
1	**11kV Networks**	➢ Power factor correction with capacitor installation. ➢ 11to 33kV voltage conversion for heavily loaded 11kV lines ➢ Install fixed capacitors ➢ Construction of new feeders ➢ Construction of new substation	39.7	163.4
2	**LV Networks**	➢ New MV/LV transformers to relieve heavily loaded LV networks. ➢ Reconductoring the heavier loaded sections of the feeder.	28.8	120.8
3	**Commercial losses (K'Njaro, Arusha, Tanga, Dar & Mbeya)**	➢ Sensitize the community on electricity theft ➢ Give incentives to whistle blowers ➢ Enforce legal measures	3.6	32.05
4	**Losses caused by Vandalism (K'Njaro, Arusha, Tanga, Dar & Mbeya)**	➢ Sensitize the community on the effect that will be caused by demaging infrastructures and equipments ➢ Give incentives to whistle blowers ➢ Enforce legal measures	3.6	32.05
		Total Costs for years 2013, 2014 and 2015	**75.7**	
		Total Savings for years 2013, 2014 and 2015		**348.3**

CHAPTER 5

ECONOMIC AND FINANCIAL ANALYSIS

Introduction

This chapter spells out the required cost to implement the proposed power expansion plan in the 2012 PSMP Update. The modality of implementing the identified projects in this Plan can either be public, private or public private partnership (PPP). The role of the Government in this respect will be to mobilise financial resources to implement some of the earmarked projects and to create conducive environment of attracting investors in the power sector. In additional, it also analyse economics of interconnecting the isolated load centres as well as estimating long run marginal cost.

The main assumptions used in this analysis include; discount rate of 10 percent based on the World Bank SSEA study for the East Africa region of 2006; debt equity ratio of 70:30 which is a standard ratio preferred by most financiers/banks; interest rate of 7 percent was used to represent average cost of debt in Tanzania. Since most of the costs in electricity projects are based in US dollar, inflation rate of 2.5 percent per year has been assumed, which is in line with USA CPI index. Interest during construction was also considered to add cost to the overall capital expenditure.

Financial Analysis

The financing requirement to implement the PSMP in the short run (2013 – 2017) is about US$ 11.4 billion, the breakdown of which is indicated in **Table 5.1 and 5.2** below.

Table 5-1: Short Term Financing Requirement (2013 – 2017)[2]

Investments	Installed Capacity MW	Planned On-Line Year	2012	2013	2014	2015	2016	2017	Project Total
Mwanza MSD	60	2013	80						**80**
Kinyerezi I	150	2014		188					**188**
Somanga Fungu II (CC 320)	210&110	2014 &16		135	91	84	55		**365**
Mufindi Cogen	30	2015	21	14	6				**41**
Sao Hill Cogen	10	2015	2	8	6				**16**
Kinyerezi II	240	2015		259	173				**432**
ZINGA BAGAMOYO	225	2015		138	138				**276**
MKURANGA	250	2015		100	100				**200**
Kiwira - 1	200	2017		62	123	123	103		**410**
Coastal Coal - I	300	2017		215	431	431	359		**1,435**
Wind I	50	2016		19	62	44			**125**
Ngaka Coal - Phase I	200	2017		71	143	143	119		**476**
SOLAR- 1	60	2016		43	144	101			**289**
Stiegler's Phase-1	300	2023		38	66	38	66	66	**272**
Kinyerezi III	300	2016			214	143			**357**
Wind II	50	2017			19	62	44		**125**
Mchuchuma - I	300	2018			115	231	231	192	**769**
Kiwira II	200	2018			62	123	123	103	**410**
Rusumo Hydro	27	2018			6	28	45	34	**113**
Ruhuji Hydro	358	2021			49	85	98	244	**476**
Mtwara 400	400	2017				289	192		**481**
Mchuchuma II	400	2018				32	95	32	**159**
Mchuchuma III	400	2018				32	95	32	**159**
SOLAR- II	60	2018				43	144	101	**289**
Kakono Hydro	53	2019				5	24	39	**68**
Mpanga Hydro	144	2022				11	22	25	**58**
Ngaka Coal - Phase II	200	2019					71	143	**214**
Malagarasi	45	2020					8	38	**46**
Rumakali Hydro	520	2025					30	52	**81**
Generation Investments			**103**	**1,290**	**1,947**	**2,046**	**1,923**	**1,099**	**8,409**
Transmission Investments				**161**	**161**	**161**	**161**	**161**	**806**
Total Investments			**103**	**1,452**	**2,108**	**2,208**	**2,084**	**1,260**	**9,215**
Cum. Investments			**103**	**1,555**	**3,663**	**5,871**	**7,955**	**9,215**	**9,215**
Financing									
Debt		**70%**	**72**	**1,016**	**1,476**	**1,545**	**1,459**	**882**	**6,451**
Equity		**30%**	**31**	**435**	**633**	**662**	**625**	**378**	**2,765**

Source: Team Compilation

Table 5-2: Summary of short term financing requirement (2013 -2017)

Investments	Installed Capacity MW	Planned On-Line Year	2012	2013	2014	2015	2016	2017	Total
Generation Investments			**103**	**1,290**	**1,947**	**2,046**	**1,923**	**1,099**	**8,409**
Transmission Investments				**161**	**161**	**161**	**161**	**161**	**806**
Distribution Investments			**25**	**348**	**506**	**530**	**500**	**302**	**2,212**
Total Investments			**128**	**1,800**	**2,615**	**2,737**	**2,584**	**1,563**	**11,427**
Cum. Investments			**128**	**1,928**	**4,542**	**7,280**	**9,864**	**11,427**	**11,427**
Financing									
Debt		**70%**	**89**	**1,260**	**1,830**	**1,916**	**1,809**	**1,094**	**7,999**
Equity		**30%**	**38**	**540**	**784**	**821**	**775**	**469**	**3,428**

[2] Project cost marked with red color are partial cost since construction of these projects goes beyond 2017

The breakdown of the total capital expenditures, inflation and interest during construction for generation and transmission plan over the period 2011 to 2035 is given in the table below.

Table 5-3: Breakdown of Capital Costs

Cost Item	(Mill. USD)	(Mill. USD)	(%)	(%)
1 Capital Costs without Inflation and IDC				
Generation	17,518		63.3	42.8
Transmission	3,708		13.4	9.1
Distribution	6,460		23.3	15.8
Total Capital Cost (excl. Inflation & IDC)	**27,687**		100.0	67.7
	(Mill. USD)	**(Mill. USD)**	**(Mill. USD)**	
2 Capital Costs with Inflation		*(Inflation)*		
Generation	17,518	*8,221*	25,740	
Transmission	3,708	*1,414*	5,122	
Distribution	6,460	*1,693*	8,153	
Inflation		***11,329***		27.7
Total Capital Cost (incl. Inflation)			***39,015***	
3) Capital Costs with Interest During Construction				
Interest During Construction			1,903	4.9
Total Capital Costs (incl Infl & IDC)			***40,919***	100.2

Based on annual inflation of 2.5%, the overall capital costs will increase by 11,329 million dollars, an increase of 40.9%. Similarly, the Interest During Construction (IDC) for the generation, transmission and distribution over the period 2011 to 2035 amounts to 1,903 million USD, which increases the overall cost of the capital expenditures by 6.9%.

Impact of financing of capital expenditures

The financing of capital expenditures is given in **Table 5.4** and is based on the 70% debt and 30% equity financing of the draw-downs for capital expenditures. The IDC is based on the interest rate of 7% for new loans and the assumptions made on capitalizing the capital works in progress.

Table 5-4: Breakdown of overall financing requirements for capital costs

Capital Costs and Financing Items	(Mill. USD)	(%)
Total Capital Cost without IDC	39,015	
1 Drawdowns for Financing Capital Expenditures		
Debt financed	27,311	70.0
Equity financed	11,705	30.0
Total Financing without IDC	**39,015**	100.0
2) Overall Financing including IDC		
IDC	**1,903**	71.4
Total Debt (Drawdown +IDC)	29,214	28.6
Equity	11,705	100.0
Total Financing including IDC	**40,919**	

Source: Team Compilation

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

Long run marginal cost

The long run marginal cost of power in Tanzania was calculated on a year-by-year basis by examining the incremental cost over the base year. This approach is closer to the strict definition of long run marginal cost. The development of the capital and operating costs, average annual energy generated by the new plan additions and the energy transmitted is based on same approach as the original 2008 PSMP study and its subsequent 2009 Update study. From the analyses, the unit cost of generation, transmission and distribution are calculated for each year. These are presented in **Table 5-5**:

Table 5-4: Marginal cost ($ per kWh)

	Marginal cost Production	Marginal cost Transmission	Marginal cost Distribution	Marginal cost of supply
Period	**(US Cents/kWh)**	**(US Cents/kWh)**	**(US Cents/kWh)**	**(US Cents/kWh)**
2013 to 2020	14.6	1.3	2.8	18.1
2021 to2036	5.9	0.6	2.8	8.7
2013 to 2036	9.1	0.8	2.8	12.1

Source: Team Computation

It should be noted that the marginal costs of production, transmission and distribution cannot simply be added to result in the overall cost of supply since there are transmission losses of 5 % as well as distribution losses of about 20%. The marginal cost of supply is higher than other marginal costs because the marginal costs of generation and transmission are applied across a much smaller amount of energy at the distribution level.

Economics of interconnecting the isolated regions

The results from the economic analysis for varying loads and with distances of 200 to 500 km were analyzed via a model. The model was used to look at loads from 1MW to 35 MW. These show that to connect a 5MW load, the load should be within less than 100 km of the transmission system. This model was used for all isolated loads. The table below **Error! Reference source not found.** presents for the isolated load centres, the distance from the grid, the minimum economic load in MW and the load in 2010. The table also presents the year in which the load would be of sufficient size to make it feasible for connecting to the Tanzanian grid.

Table 5-5: Isolated Load Centers & Feasibility of Connection to the Tanzania Grid

Isolated Load Centre	Distance from grid (km)	Economic minimum load (MW)	Load in 2010 (MW)	Load in 2035 (MW)	Time for grid connection
Kagera	220	10	11.4	383	Now
Mtwara	353	15	10.2	271	2013
Rukwa	340	15	5.8	134	2015
Kigoma	280	10	5.4	184	2014
Lindi	353	15	1.2	179	2013

Source: Team Compilation

This analysis shows that the Government can initiate plans for the connection of all of these isolated load centres. In terms of priorities, the Kagera centres would provide the best economic return, followed by Mtwara. On economic point of view Lindi would be connected by 2015 but technically Mtwara and Lindi could be connected at the same time as early as 2013.

CHAPTER 6

CONCLUSION AND POLICY RECOMMENDATIONS

Conclusion

Discovery of new mineral deposits such as gold, nickel, natural gas, initial development of coal resources and uranium; and mushrooming of economic activities (construction, processing industries, and others) are changing the structure of Tanzania's economy. All these have effect on the electricity supply and demand in the country.

Despite the endowment of enormous resources for power generation, 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. Other general challenge especially in the preparations of this Plan is related to data issue. Some Most data and information was found to be inconsistency and outdated. Some of the identified projects have not been studied to feasibility level while others have outdated feasibility study reports, thus render it difficult to make meaningful decision on the project implementation. Furthermore, most genearation resources are located in the south-west part of the country while huge loads are located in the north-west of the country, implying the need for long transmission lines.

This Plan suggests countermeasures to address power shortage in the short, medium and long term. While the short-term plan requires immediate decision and actions, the mid – to longer terms plan require coordinated planning, project development studies to ensure that future electricity supply utilises the least cost projects, consistent with sound planning criteria and addresses national interests. In view of the above, the country will need a total of 3,400MW in the medium term (2013-2017) and 8,990MW by 2035 that will require financing to the tune of USD 11.4 billion and USD 27.7 billion in those two periods respectively. When inflation and interest during construction are added total investment required rises to USD 40.9 in the long run. Of this amount, about two third of it is for generation.

The following are recommendations for successful implementation of the PSMP 2012 updates.

General Recommendations

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

b) There is a need to ensure that strategic power projects are studied to full feasibility level to reduce project implementation lead time and cost;

c) To speed up feasibility studies for coal and geothermal power projects, there is need to enhance capacity of Geological Survey of Tanzania (GST) to carry out detailed geological exploration to identify location of all coal and geothermal resources;

d) There is a need to create conducive environment for development of renewable power projects (Wind, geothermal, Solar, and Biomass) to supplement exhaustible resources;

e) Coal, Geothermal and Nuclear Policies should be prepared to guide the utilization of these resources for power generation;

f) To ensure effective implementation of PSMP 2012 updates, the Government may need to establish a monitoring and evaluation unit; and

g) Capacity building: In order to internalise and broaden up experts of formulating plan of this nature and improve local expertise, the government needs to maintain and retain the core team that involved in the preparation of this plan. More capacity is required to enhance the process of formulate/ review/update of PSMP. There is a need to have modern software, tools to improve the level of projections. This will include training of the core team, procuring of the modelling packages (Stata, etc) and sharing leaf of experience with institutions involved in related planning works.

Specific Recommendations

A. Load Forecast

i. The current level of energy losses is high; more efforts are needed to scale down energy loss from 25% to 15.8% as forecasted. The projected loss level by 2035 is synonymous to semi-industrialised countries.

ii. Implement Demand Side Management programmes to defer investment in additional generation.

B. Generation

i. In order to avoid power shortages, projects earmarked for implementation in the short term (2013 – 2017) should be strictly adhered to as there is no room to manoeuvre.

ii. Two hydro options will require removal on significant obstacles before becoming firm candidates for implementation:

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

- **The Stiegler's Gorge** option is located within the Selous Game Reserve; its development is constrained by the Algiers Conventions which defines the developments possibilities within national parks and game reserves. It is therefore important to redefine the game reserve borders.

C. Transmission requirements

i. Continue implementation of earmarked Transmission lines projects parallel with generation projects to ensure power evacuation.

ii. Reinforce distribution network to meet electrification targets.

D. Financial and Economic Perspective

a) Implementation of this plan requires huge financial resources. Concerted efforts to be exercised in mobilizing required financing for both power generation, transmission and distribution;

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

c) The isolated centres should be connected to the main grid as soon as it is feasible.