Power Sector in Tanzania: *Performance, Trends and Reforms*

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***Abstract*— The United Republic of Tanzania is currently facing energy problems that have seriously affected its socio-economic development and environment. To solve these problems, the country is striving to exploit its renewable energy potential, among other efforts. This paper highlights the prevailing energy situation in Tanzania and provides a short review of potential energy resources. It then discusses current institutional efforts and capabilities in development, and commercialization of renewable energy technologies. The paper also identifies some barriers to promotion of renewable energy technologies as well as actions taken by the government of Tanzania to promote renewable energy technologies.**

***Keywords* –Power generation, Power systems, Power transmission lines, Renewable energy**

I. INTRODUCTION

Electricity supply in Tanzania consists of both interconnected and isolated systems. The electricity sub-sector is largely dominated by the state-owned enterprise, Tanzania Electric Supply Company Limited (TANESCO), which is responsible for about 98 percent of the electricity supply. TANESCO is a vertically integrated utility responsible for the generation, transmission, distribution and marketing of electricity in mainland Tanzania.

The Tanzanian national grid network is characterized by long distances between generation and load areas, with the long high voltage lines presenting low fault levels in the northern regions of Tanzania. The change in system voltages in many cases is between 2%-12% when switching of installed devices like reactors and capacitors take place.

A new policy paper outlining the new industry structure has been adopted since 2003 replacing the previous one of 1992. The policy from 2003 takes into account the structural changes that occurred over the last decade in terms of changes in the economy and political transformations at national and international levels [2].

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This paper first starts with an introduction followed by highlights on power supply trends in part 2. In part three, Tanzania's Grid connections are summarized. The energy policy, problems, performance, challenges faced, and response to challenges are covered on sections 4,5,6,7, and 8 respectively. In Section 9 Untapped energy resources are outlined. Discussions and recommendations are in section 10. Section 11 concludes the paper.

II. CURRENT TRENDS

The generation sources in the national grid are comprised of hydropower, gas turbines, and diesel generating plants. Currently, TANESCO has an installed capacity of 1189 MW in its grid network, of which 561 MW is hydro and 628 MW is thermal (table 1). The company has a power purchase agreement with Independent Power Tanzania Limited (IPTL), Kiwira Coal Power Limited (KCP), Songo-Songo Gas to Power (SONGAS), Aggreco, Warstila and Richmond Development Corporation (RDC). The maximum system demand is 650 MW with annual production of 2491.1 GWh. Annual demand growth in the country varies from 6% to 9% per annum. Electricity consumption breakdown is; households 40%, industry and businesses 50% and the balance 10% are for public lighting and exports to Zanzibar Island.

Tanzania's power system has been increasingly unable to meet the rapidly expanding power demand of a growing economy and therefore Tanzania's future plans are aimed at increasing the access of the population to electricity and general improvements of power supply availability and quality. To achieve this goal an expansion of the national grid system and isolated systems and service connections is envisaged. For the interconnected power system, plans include harnessing more locally available resources of natural gas, hydroelectricity and coal for generation, and associated transmission and distribution improvements to increase power supply availability, diversity, reliability and affordability. A number of generation, transmission and distribution projects are being discussed to interconnect new mining areas and emerging load centres in many parts of the country. This includes possibilities for power interconnection with neighbouring countries. Other measures include promoting private sector entry based on competitive bidding and autonomous regulatory arrangements. The power system under TANESCO will be unbundled into generation, transmission, and distribution segments. The national grid expansion plan is summarized in Table 3.

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III. GRID CONNECTIONS

TANESCO operates a National power grid network of 220, 132, 66, 33 and 11 kV spanning a total of 12,934 km (Table 2). Tanzania has a total number of 55 isolated and mini hydroelectric generators having a capacity of 23 MW with total length of 135km not connected to the National grid. Currently, Tanzania doesn't have major interconnection with neighboring countries; only small cross-border interconnections for supplies to isolated townships exist in the northern part of the country at 132 kV from Uganda to Bukoba town, and to the southern part at 66KV and 33 kV from Zambia to Sumbawanga and Tunduma Townships respectively [1].

A new transmission line to interconnect the power systems of Zambia and Tanzania has been under consideration since 1995, when the technical teams of the national utilities of Zambia (ZESCO), Tanzania (TANESCO) and South Africa (ESKOM) undertook the first feasibility study. Although the study was firmed up in 1998, recent studies on another transmission line interconnecting the power systems of Tanzania and Kenya have given fresh impetus to the Zambia - Tanzania interconnector project. This development creates a real prospect that would allow Tanzania and Kenya to participate in the Southern African power market. The future connection to Kenya has prompted the need to update the Zambia-Tanzania interconnector study, including looking at necessary reinforcement of the Tanzanian high-voltage (HV) network to support power flows to Kenya. This latest study on the long-planned interconnection, which was started in June 2003, will add another milestone to the structure of the Southern African Power Pool (SAPP). The Tanzania-Zambia interconnector will be 670km long and of 330kV transmission line from Pensulo in Zambia to Mbeya in Tanzania [1] and is expected to be complete by the year 2010.

IV. PROBLEMS

Tanzanian power utility (TANESCO) suffers from the following shortcomings:

- Poor (financial/technical) performance, resulting in poor quality of supply and service, and an inability to meet growing electricity demand;
- Inability of the country's government to fund expansion or refurbishment, or to attract private sector investment into power sector;
- Lack of maintenance of existing facilities leading to reliability problems;
- Inappropriate tariffs, often resulting from political interference, with tariffs below marginal costs; and
- Inadequate revenue collection mechanisms, and therefore credit unworthy businesses.

V. PERFORMANCE

A. *Technical performance indicators*

Table 4 displays some technical and financial performance indicators for the sole utility, TANESCO. It shows that the access to electricity, which was about 14.8% of the population in 1995, declined to around 6.6% in 2003 before increasing up to 13.5% in 2005. Rural electrification levels are much lower, estimated at less than 2%. One major explanation for this decline is that after the 1995 election the government pursued a tight monetary discipline, which reduced disposable income, leading to low housing construction and thus fewer connections. On the other hand, the number of customers per employee ratio has improved from 35 in 1995 to 70.3 in 2005 [3]. The fact that TANESCO decided to freeze employment since 1995 and also the efficient management of the contracted private firm, NETGroup solutions of South Africa can explain the improvement in this ratio.

System losses are normally classified into technical or non-technical losses. Technical losses are caused by a number of factors including energy consumed by auxiliary equipment, system overload, poorly designed system, poor load management, lack of preventive maintenance and delays in system up-grade. The data shows that system losses which were as high as 14% in 1995, declined to around 9.2% in 1998. The improvement is due to the system rehabilitation undertaken between 1993 and 1997 and measures taken by the utility to fight against non-technical losses [4,5]. Non-technical losses arise from poor electricity billing, nonpayment by customers and power stealing. Although data on non-technical losses is not immediately available, it is believed that it constitutes a substantial part of the power losses.

B. *Financial performance indicators*

The financial performance of TANESCO has been poor with regards to debt collection and profitability for a number of years now (Table 4). The debt collection period, which was 256 days in 1995, increased (worsened) to 316 days in 2001 before improving to 160 days 2005. The worsening debt collection period is partly due to inefficient debt collection by the utility and slow payment by the government and parastatals. This has led to large bad debt provisions, resulting in company losses in the period 1992–2002. Another factor behind the poor profitability of the utility is reduced production due to shortage of water in the reservoirs leading to load shedding. Thus there is a powerful justification for reforming the electricity industry in Tanzania. The most telling fact is that about 39 years of ministerial regulation of an integrated utility and a parastatal dominated ownership pattern have not produced sufficient service benefits. Instead the utility recorded unsatisfactory technical and financial performance, turning into a loss-maker whose survival is in many ways dependent on bailout arrangements from the central government [6]

VI. CHALLENGES

1). Low level of electricity use: In 2005, the contribution of energy sector to GDP continued to be 1.4 percent, same as it was in 2004. Biomass continued to be the main source of energy in both rural and urban areas. More than 90 percent of the population use biomass energy, which comprises firewood and charcoal. This is because many people do not access electricity and wherever it is accessible is not affordable. High connection charges as well as long period of waiting before being connected are some of the factors that contribute to low level of electricity use. Low purchasing power of most of Tanzanians prevent them from being able to purchase electric goods like electric cookers, refrigerators, etc.

2). Low level of electricity access: In a country of almost 37 million people, barely 10 percent of the population is connected to the national power grid, and in rural areas only 1 percent of the population has access to grid electricity. The electrification responsibility has largely been viewed as that of the public sector, and has been mainly undertaken by government, a situation that is targeted for change under reform. The majority of the unserved population resides in dispersed rural and peri-urban settlements; their load demand and incomes are low, and connection costs are unaffordable. As such, electrifying them is not financially attractive to the private sector.

3). Setting affordable tariffs: Reform demands increased participation of the private sector, which requires making the sector profitable. So tariffs in reforming countries like Tanzania have been rising, the justification being that it is below cost of service provision. In addition, lifeline consumption targets have been lowered. This is happening in an environment where economic growth in Tanzania has deteriorated and the proportion of the poor has risen. Ability to pay for electricity does not seem to play a significant role in determining the after-reform tariffs [8]. Such findings underscore the need for public sector involvement in reform; to ensure the poor get some form of subsidy.

4). Planning for calamities: Recurrent droughts have resulted in high load shedding at high economic costs. Between 1994 and 2000, Tanzania suffered three major electricity shortages due to drought and sub optimal operations of the hydro/thermal system [8] and last year (2006), Tanzania experienced almost a total black out for almost six months. These experiences are triggering concerns about the reliability of hydropower at a time when environmental problems are rendering use of fossil fuels unfavorable. Small-scale hydropower and other renewable energy technologies score higher than fossil fuels on environmental friendliness. The private sector players under reform, however, prefer to use conventional fossil fuel technologies since they are cheaper.

VII. RESPONSE TO CHALLENGES

A. *Rural electrification*

Tanzania National energy policy recognizes the importance and contribution of indigenous energy resources in particular in providing modern energy services in rural areas. With respect to rural energy, the policy stipulates the following development areas:

- To support research and development into rural energy
- To promote the application of alternative energy sources, other than wood fuels, in order to reduce deforestation, indoor health hazards and time spent by rural women collecting firewood
- To promote entrepreneurship and private initiatives in the production and marketing of products and services for rural and renewable energy
- To ensure continued electrification of rural economic centers and make electricity accessible and affordable to low-income customers
- To facilitate an increased availability of energy services including grid and non-grid electricity in rural areas, and
- To establish norms, codes of practice, standards and guidelines for cost effective rural energy supplies [2].

To this end, for the electricity access among the poor to be realized, the Tanzanian government has done the following:

- Promotion of mini-grids based on local resources
- Provision of electricity at the district centers
- Creation of Rural Energy Agency (REA) mainly to extend subsidies to Electric Supply Companies (ESCOs) i.e. REA has the objective of fostering development of energy services in the rural areas.

B. *Reforms of the power sector*

1). Commercialisation: Two commercialization measures have been taken. Firstly, tariff rates, which were around 4US cents in 1988 have been raised gradually, from 1989 and had reached 9US cents in 2000. Now the new rates prevailing in Tanzania are one of the highest in eastern and southern African countries [9]. Secondly, in 1996, TANESCO, the national utility started to implement electricity pre-paid metering system. A total of 45,970 meters had been installed in Dar-es-Salaam by the end of financial year 1998 [6]. The system has benefited both the utility and customers in a number of ways. It is no longer necessary for TANESCO to read meters in these areas and the utility receives advance payment for the electricity. The customer no longer has to worry about the accuracy of the electric bill, has more control over electricity use, and can buy power in the desired quantities. The new pre-payment system, however, has a number of disadvantages. Customers can tamper with the meter and the utility is now looking for tamperproof meters before stepping up installation into other areas of the country. Pre-paid meters cost more than conventional meters, at about US$80 and US$45 respectively [10].

2). Introduction of IPPs: Tanzania's power sector has changed since the beginning of the decade. The energy policy developed by the government in the early 1990s has been revised recently [2]. The policy among other things has given way to private power producers (Independent Power Producers, IPPs) and also emphasizes increased access of electricity to the population. Power Producers (IPPs) that sale power to TANESCO includes, IPTL (100MW), SONGAS (200MW), KCP (6MW), Aggreco (40MW), Warstila (100MW), and RDC (100MW). The Current investment in the energy sector hopefully will soon make the country stop relying entirely on unreliable hydroelectricity. Energy supply has started exceeding the demand due to increased investments in the sector. The country is able to produce over 1000 MW while the consumption is only 650megawatts.

3). Contract management and privatisation of non-core assets: Other reforms by the utility include introduction of private sector management skills in running the utility and divestiture. A Swiss company known as Asea Brown Boverri (ABB) is running the gas turbines at Ubungo and Tanesco Wood Pole Treatment Plant has been sold to the private investor. Up to the end of last year (2006), TANESCO was managed by NETGroup Solutions (Pty), of South Africa under a management support Services Contract since May 2002.

4). Restructuring of Tanesco: There are plans to unbundled TANESCO into several privately owned generation companies; a single transmission company and several privately owned regional distribution companies.

5). Regulatory Mechanism: The electricity sub-sector is administered under the Electricity Ordinance Cap. 131 of 1957 and is regulated by the Energy and Water Regulatory Authority (EWURA) whose bill of establishment was passed by the parliament on April 2001 and became operational in 2005.

6). Rural Energy Agency: The Government has established a Rural Energy Agency (REA) with the responsibilities of facilitating increased availability of energy services, and supporting Research & Development (R&D) in rural areas; creating an institutional and legal framework to promote the application of renewable energy and to promote entrepreneurship and private involvement in the marketing of renewable energy in the rural sector.

C. Renewable energy technologies

About 80% of the population lives in the rural areas where energy requirements are mostly met by wood fuel, resulting in deforestation. In order to reduce the trend the following projects are being promoted:

- Biogas production for cooking, improved technologies (cook stoves and kilns)
- Solar thermal applications for water heating and cooking, Solar and Wind technologies are being promoted.

Tanzania is in the process of implementing a National Solar Programme under the World Solar Programme (WSP). The WSP is an open-ended attempt through broad partnerships and cooperation of Governments and Non Governmental Organizations (NGO) to promote the wider utilization of renewable energy resources. The government has declared village level solar electrification and small islands solar electrification as being of high national priority. Efforts have been made to seek donor support but no funds have been committed yet [4].

VIII. UNTAPPED ENERGY RESOURCES

Tanzania has a wide range of untapped energy resources as indicated bellow:

- Coal reserves which could be exploited for electricity generation is estimated at about 1200 million tons of which 304million tones are proven. Natural gas is estimated at 44.02 billion cubic meters of proven reserves. Hydroelectric energy has a potential of installed capacity of 4.7 GW of which only about 10% is developed.

- Solar, wind and geothermal sources, remain virtually untapped. Very little attempt has been made to utilize this source of energy, which could be a viable alternative source to reduce the use of wood and oil for heating purposes. These energy sources require low investment capital compared to hydroelectricity generation [11].

IX. DISCUSSION AND RECOMMENDATIONS

Rising electricity demand and unmet electricity needs have necessitated increased investments in generation at a time when donor and traditional financing agencies policy have shifted from pro-public sector to pro-private sector. Lack of financial autonomy has left Tanzania with little choice than to adopt conditionality advanced by the external agencies in order to get support for electrification and other macroeconomic issues. If developmental goals are to be met under reform, the Tanzanian government will have to play a more active role. To increase access, strategies to accommodate rural and peri-urban electrification are imperative. These areas remain financially unattractive to the private sector and hence direct government intervention is required.

Due to lack of major repair work over last ten years, Tanzania is experiencing intermittent power disruptions even during rainy seasons. The country's power system is characterized by power outages and deterioration of power quality, while technical and non-technical losses have also been increasing. For these reasons, Tanzania Electric Supply Company (TANESCO) has to undergo wide-ranging rehabilitation, which may, among other things, avoid compounding the already worrying intermittent power disruptions that the country is facing due to other factors such

as drought. Also, by undertaking major rehabilitation, TANESCO will be able to:

- Reduce the duration and frequency of disruptions
- Improve voltage conditions at consumer premises
- Reduce technical and non-technical power system losses

Several options to improve the voltage performance have to be identified and evaluated technically, using load flow, optimal power flow, contingency and dynamic simulations. Evaluation can be done using various transmission technologies, which may include:

- Transmission line series compensation,
- Bus and Line Shunt Reactors,
- Static Var Compensators (SVC), and
- Variable Reactors.

In general, for smooth operation of the power system, TANESCO is obliged to perform the following:

- Improve security, reliability and efficiency of power supply
- Rehabilitate the ageing hydro plants throughout the country
- Develop urgently the most cost-effective new source of power
- Hasten interconnection of National grid with those of neighboring countries in particular Zambia through southern African Power Pool initiative (SAPP).

X. CONCLUSIONS

In recent years, the Tanzanian economy has suffered from power shortages and blackouts, owing to load shedding by the Tanzania Electric Supply Company Ltd (TANESCO). These interruptions have a high cost in terms of forgone output and incomes. Any meaningful drive to address these problems will require further investments by TANESCO. To this end, concerted efforts have to be made to solve the problems of long lags in electricity billings, customer's nonpayment for services, and delays in adjusting tariffs by the government. Routine maintenance and repair of the network, further research on the best ways of solving National power grid problems and alternative means of power generation has to be encouraged.

APPENDICES

Table 1: Current grid generation

Plant	Installed Capacity [MW]	Effective Capacity [MW]
Hydro: Mtera	80	80
Kidatu	204	204
Nyumba ya Mungu	8	8
Hale	21	21
Pangani Falls	68	68
Lower Kihansi	180	180
Total hydro:	**561**	**561**
Thermal: Ubungo Diesels	26	0
KCP	6	3
IPTL	100	100
SONGAS	200	200
Aggreco	40	40
Warstila	100	0
RDC	100	20
Remote diesels	56	40
Total thermal:	**628**	**403**
Total System:	**1189**	**964**

Table 2: Existing grid length

Year	1980	1990	2000	2006
Voltage [kv]				
	Length [km]			
220	300	1,847	2,658	2,658
132	821	1,160	1,420	1,420
66	136	136	378	378
33	N/A	3,136	5,500	5,500
11	N/A	2,720	3,218	3,218
Total	**1,257**	**8,999**	**12,934**	**12,934**

Source: Tanesco [1]

Table 3: National Grid Expansion Plan

Generation additions	MW	Year	Trans. Line additions	KV	KM	Year
Kiwira Coal Power	200	2008	Kinyerezi-Factory Zone	132	7	2007
Zambia Interconnector	200	2010	Iringa-Singida	220	447	2007
Ruhudji hydropower	358	2016	Mbeya - Singida	330	797	2010
Mchuchuma Coal Plant-I	200	2018	Shinyanga-Mwanza	220	139	2010
Mchuchuma Coal Plant-II	200	2022	Mtera-Singida-Arusha	220	665	2010
Rumakali hydropower	222	2023	Kidatu-Morogoro-Ubungo	220	310	2012
Stierglier'Gorge (I, II, & III)	1400	2032	Ruhudji-Mufindi-Kihansi	220	200	2016
Artumas Gas Plant	300	N/A	Rumakali-Mbeya	220	85	2022
Total	**3080**		Mchuchuma-Mufindi	220	283	2026

Source: Tanesco [1]

Table 4: Performance of TANESCO (1995-2005)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Technical											
Electrification rates (%)	14.8	12.7	7.3	5.3	7	7.4	7.2	6	6.6	10.1	13.5
Number of customers/employee	35	37.1	55	53	43.8	46	58.5	67	68.1	68.1	70.3
System losses (%)/year	14	9.5	11.25	11.7	n/a	11.7	11.2	11.5	11.3	11	9.2
Financial											
Profit/loss (billion Tsh)	-26	-3.7	-3.1	n/a	n/a	-3.2	-2.8	-1.4	1	1.8	3.9
Debt collection period (days)	256	284	315	n/a	n/a	310	316	305	298	200	160

Source: [4], [5] and Tanesco
n/a = not available

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