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Analyze Contingencies Present in the Transmission Systems Case of North–West Grid of Tanzania

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Abstract: ***The northwest grid network of TANESCO (Tanzania state power company) suffers the stressful condition caused by factors such as worst climate condition affecting hydropower source (which is 75% of the total generated units), an over exploitation of the existing transmission system and less or no number of new power system projects, together caused lack of reactive power sources into the system resulting in voltage instability. Research carried in this work observe and record some indication of the severe condition existence, aiming to find methods to relieve this system from voltage instability. The Contingencies present in the Transmission System in the North –West Grid of Tanzania were analyzed. And it was found that power faults contribute a lot to the grid outages and therefore the losses. The study proposes that there be Power Generation Capacity Reinforcement and Transmission Line Reinforcement. However the study was limited to hydropower sources only in the country (northern and southern). The research recommends that proper selection, location and economic analysis are needed further to provide the most efficient performances of power system***

Keywords: Transmission system; power system; contingence

1. Introduction

TANESCO is the only power utility company in Tanzania since independence which is responsible for supplying electricity to Tanzanian consumers. The TANESCO mission is to generate, transmit, distribute and supply electricity in the most safe, reliable, cost effective and environmentally friendly manner [1].

The overall reliability of the electrical transmission network in Tanzania has become a national concern. Over the past few years the country has experienced electrical power crisis due to unreliable availability of power. These problems have risen from a heavy dependence on one kind of energy source i.e. hydropower which is 74% of total installed generation which has persisted and ended in bringing a challenge of improving power delivery environment among the energy experts.

One of the common measures, which have been taken, is the interconnection of different generating power stations, which are available in Tanzania. This approach is good in that it improves power flow in the grid network. However, its weakness is the inherited problems from one area to another during interconnections. For this reason it requires improved techniques that will minimize such weaknesses and improve the power reliability.

Moreover, there has been inefficient and lack of control of the existing electrical power system infrastructure over the years. This situation has led to greater power loss and unreliable power supply. Table 1 indicates utility general information in the Southern Africa Development Cooperation (SADC) countries in which Tanzania reveals that it has the largest transmission losses [2].

Table 1: Utility general information of energy in SADC countries for the period April 2005 to March 2006

Country	*Utility*	*Installed Capacity*	*Maximum Demand*	*Sales GWH*	*Sales Growth %*	*Generation Sent Out GWh*	*Net imports Gwh*	*Net Exports GWh*	*Transmission system losses %*
Angola	ENE	745	397	1,843	12.7	2,649	0	0	2.5
Botswana	BPC	132	434	2583.7	7.5	977	2,006.50	0	10.96
DRC	SNEL	2,442	1012	4,656	13	6,904	0	1,800.00	6.3
Lesotho	LEC	72	90	354	12	446	8	11	20
Malawi	ESCOM	285	242	970	4	1,177	0	0	19.0
South Africa	ESKOM	42,011	33,461	207,921	0.8	221,985	8,730	13,107	8.9
Swaziland	SEB	51	172	853	2.5	103.5	916.3	0	16
Tanzania	TANESCO	839	531	2,549	10.3	3,674	43	0	24
Zimbabwe	ZESA	1,975	2,066	10,480	3.5	9,391	2.66	255.5	12.6

SOURCE: [2]

Today's challenge of providing quality power has forced TANESCO to have interconnections of its power generating plants. This has resulted from the much dependency on only one kind of energy source (Hydro power), although it has proved not reliable during dry seasons as a worst weather condition. Also, the efficiency of the transmission infrastructure needs to be improved to reduce losses to have maximum power delivery. Such unsatisfactory power delivery and the high demand from consumers have necessitated running the transmission system near or above its operating limits and thus stressing the system and consequently causing frequent grid outages such as major load rejection (load shedding) causing rise of voltage hence frequent tripping of the grid, Overloaded transmission system especially during peak load hours. This situation calls for a study that will investigate available contingencies and proper methods to be used to minimize/mitigate the problems; also analyze the contingencies so as to predict and/or forecast the future situation; and improve the capacity of the transmission systems. Therefore the overall objective of this research is to Analyze contingencies present in the transmission systems.

2. Methodology

The research adopted method was based on measuring of power quantity in surveyed area in Tanzania North –West Grid (TNWG) and reviewing secondary data from TANESCO

2.1. Load Shedding and Grid Outage

The power system grid outage and load shedding is a problem to consider for efficient economic operation of the system. This occurs due to several problems; Transmission line overload during peak loads, insufficient supply of water to hydropower generators during dry weather, Voltage rise at a sudden load rejection during load shedding, etc. Table 2 gives the record of the power losses in the interruption due to the listed problems for year 2007. The highlighted line covers the highest amount. Solution for maintaining voltage at a required value when tested using Power System Simulators for Engineers (PSSE) software, indicates the need for line compensation, which needs an efficient switching system.

Table 2: Grid Substation Feeder Power interruptions

	JAN	FEB	MAR	Total
Load Shedding	1,194,375	17,272	27,824	1,239,471
Faults	2,060,786	1,952,298	2,656,677	6,669,760
Maintenance	942,865	1,148,872	2,740,763	4,832,500
TOTAL	4,198,025	3,118,442	5,425,264	12,741,731

Source: [2] Three months losses –watt-hour (Wh)

From Table 2, power interruption reveals that faults contribute a lot to the grid outages and therefore the losses calculated per hour.

2.2. Load flow in the Tanzania

Table 3 is the substation recorded load demand and averaged each year existed, which were used to calculate the load flow growth for the region (research area).

Table 3: Actual load demand for years 1997, 2000, 2003 and 2006.

Year	1997	2000	2003	2006
Substation	Load MW			
Shinyanga	13.7	13.9	13.9	14.73
Arusha	29.7	29.95	29.95	30.55
Mwanza	18.0	19.2	19.2	20.31
Dodoma	9.2	9.3	9.3	9.67
Musoma	8.1	8.5	8.5	8.86
Singida	2.5	2.6	2.6	2.68

Source: [2]

2.3. Overloaded High Voltage Transmission Line

The main backbone of TANESCO power transmission system is 220 kV power line. This line is constructed using Bison conductors. As regards power quality and reliability issues found in this work, the power line from Iringa - Mtera –Dodoma – Singida – Shinyanga is one which suffer most in voltage depressions, surges and total outages. The situation is now pulling an effort for upgrading and reinforcement of the power transmission system in addition to improving the lines power transferring capabilities.

TANESCO objectives for reinforcement of transmission lines include: Enhance overloaded High Voltage (HV) transmission lines, Improve voltage condition, improve power line capabilities for smooth power transfer to the lake zone mining loads and possible power export to Kenya and Uganda, and finally reduce Technical power system losses in the Extra High Voltage (EHV) transmission lines.

2.4. Voltage Violation of System (Dodoma – Mtera - Singida)

The number and time for grid outage is high, therefore causing a big loss to TANESCO and the Nation economy. This is listed in table 4, showing grid outages, time of black out, recorded maximum demand, minimum demand and number of outages over four months cases as example having a severe case increasing.

Table 4: Power outages for the 1st four months of year 2007

Month	*Outages*	*Time (Min)*	*Maximum Demand (MW)*	*Minimum Demand MW)*	*Load thermal Limit (KW)*
Jan.	2	49 2	11.0	4.6	88,000 148,000
Feb.	6	31 4 3 18 5 35	11.59	4.5	131,000 141,000 36,000 36,000 152,000 146,000
March	2	4 52	11.55	4.2	140,000 140,000
April	5	40 9 1 30 80	11.82	4.8	80,000 88,000 106,000 106,000 106,000

Source [2]

The power outage of Dodoma - Mtera line is the one severely affected as a result of its circuit being at its 220-MVA thermal limit. However the northern system voltage profile needs to be improved so as to deliver quality power to the northern (lake zone) consumers and to meet the required power transfer, expected to be 360MW in few years to come [3]

2.5 Proposed Solutions

2.5.1 Power Generation Capacity Reinforcement

Previous work from TANESCO has been shown how to improve power sent out, the capacity and additions to be made to assist the hydropower source. The following are the possible proposed solutions;

1) Have the grid interconnected to other nation's grid i.e. Tanzania – Zambia, Tanzania – Kenya, Tanzania – Uganda and Tanzania – Rwanda
2) Introduce new generating plants of sources other than hydro power, i.e. Coal - Kiwira, Gas - Songas, Wind – Singida and Makambako, Thermal - IPTL and other small generation stations to be interconnected in the National grid.

2.5.2 Transmission Line Reinforcement

Construction of new transmission line parallel to an existing line as indicated in another option, which can be used. As an example the line supplying the Lake zone could have a parallel line in additions to the one from Iringa to Shinyanga. The 220-kV transmission line between Mtera and Dodoma has a thermal rating of about 220 MVA, (equivalent to 178 MW) but the transfer capability is much below this, because of the technical difficulty of loading this line higher than about 125 MW. Beyond this level of power flow, additional 220-kV lines are proposed between Mtera, Dodoma, Singida and Shinyanga. These new lines will be required before the year 2008 under this scenario. Mchuchuma is expected to add into grid 200 MW by the year 2010, the power flow patterns will change and therefore an additional 220KV transmission line between Iringa and Mtera will be necessary.

3. Discussions of Results

The results obtained shows that, generally the north west zone suffers voltage variation, power losses due to rise in current during variation of voltage, ac transmission systems working below its thermal limit capacity and unequal load flow.

3.1 Transmission Line Losses

Power losses are associated with the series resistance R and shunt conductance G. When the current (I) flows along the line, I^2R losses occur, and when a voltage (V) appears across the conductors, (V^2G) losses occur. The data collected from TANESCO reveals very high losses in the transmission grid system of Tanzania as tabulated in table 5 for three months of year 2007. The grid under study is severely affected and it covers about 50%of the total losses of the national grid.

Table 5: Transmission losses – (Wh) for grid system- 2007

Route Name	JAN	FEB	MAR	**TOTAL**
HALE-TANGA-MOS-ARS	2,451,149	1,742,981	1,740,694	5,934,824
KID-MOR- UB-HALE	3,947,488	2,810,478	5,929,932	12,687,898
KID-IRA-MUF-MBY-KIH	2,153,568	771,031	1,537,541	4,462,141
IRA-KIHANSI-KIDATU	1, 344,159	1, 035,590	891,106	3,270,855
IRA-MTE-MWZ-MUS-TBR	5, 019,821	7, 747,575	7,951,382	20,718,777
SI-NJ	493,450	561,530	755,000	1,809,980
TOTAL	**15,409,635**	**14, 669,185**	**18,805,655**	**48,884,475**

Source [2]

The names of the grid section appearing in the table are:
HALE-TANGA-MOS-ARA = Hale – Tanga – Moshi – Arusha grid (132 kV)
KID-MOR-UB-HALE = Kidatu – Morogoro – Ubungo – Hale (220 kV/132 kV)
KID-IRA-MUF-MBY-KIH = Kidatu-Iringa-Mufindi-Mbeya-Kihansi (220 kV)
IRA-KIDATU-KIHANSI = Iringa – Kidatu – Kihansi (220 kV)
IRA-MTE-MWZ-MUS-TBR = Iringa–Mtera –Mwanza – Musoma –Tabora (220/132kV)
SI-NJ = Singida – Njiro (220 kV),

4. Conclusion

The results obtained in this study shows that, generally the north west zone suffers voltage variation, power losses due to rise in current during variation of voltage, ac transmission systems working below its thermal limit capacity and unequal load flow.

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Janeth Tesha worked as an Electrical Engineer in the Production Industries 1987-2000. I graduated MSc in Electrical Power Engineering 2008 and I work as Assistant Lecturer in the Electronics and Telecommunication Engineering Department of Mbeya University of Science and Technology. As academician, I am now involved in research and consultancy for society and National issues.