HYDRO AFRICA 2003

REHABILITATION OF KIDATU POWER PLANT IN TANZANIA
THE SALIENT FEATURES

By
Lewanga Tesha –Plant Manager
Steven Mahenda-Senior Mechanical Engineer
Antony Mbushi-Electrical Engineer
Kidatu Hydropower Plant, Tanzania
Tel:+255 23 2626130
Fax: +255 23 2626270
E-mail : kidatu @raha.com

HYDRO AFRICA 2003

CONTENTS

REHABILITATION OF KIDATU HYDRO POWER PLANT IN TANZANIA
THE SALIENT FEATURES

Abstract

Kidatu Hydropower Plant is the major hydro Power Plant in Tanzania. Built in two phases in 1975 and 1980 respectively, the Plant has continued to be the main stay of hydropower generation in Tanzania. The Plant has however deteriorated steadily with age, and by mid 1990, it was already due for rehabilitation.

Based on a technical study by Norconsult International A/S, of Norway, rehabilitation measures were recommended out covering the most deteriorated areas of the plant with the aim restoring it to its optimal performance.

Multilateral Donors (SIDA and Norad) jointly with the Government of Tanzania agreed to finance the Rehabilitation Project and signed a memorandum on implementation in 1998. Several contractors like Alstom Norway, Voith Siemens Hydropower Generation, GE Norway and the host Tanzania Electric Power Supply Company (TANESCO) participated in the implementation of the project

The scope of work ranged from general equipment service to complete replacement of some major parts. The Project has run since late 1999 and is now almost completed
The plant control system has been completely modernized and a new plant output optimization software introduced .The rehabilitation measures have completely reversed a deteriorating plant to fully-fledged "new" plant and a dependant one in the National Grid of Tanzania
Several technical personnel participated in the Rehabilitation works including the authors of this article.

The paper is intended to dwell into main technical aspects of the projects and discuss problems and solutions encountered including benefits accrued there upon. A hydropower generation is foreseen to dominate the power generation resources sources in Tanzania for some years to come, and the experience gained from operation, maintenance and rehabilitation of Kidatu Plant can be shared through this presentation.

1.INTRODUCTION

The 200 MW Kidatu Power Plant operated by TANESCO is located on the Great Ruaha River in Morogoro Region, about 280 km west of Dar es Salaam.

The construction of Kidatu Power scheme was started in the early seventies with the commissioning of the two first units as at 50 MW each in 1975. The last two 50MW units were commissioned in 1980, making a total installation of 200 MW.

Since its initial inauguration in 1975, Kidatu Power Plant has played a very important role in Tanzania` electric power supply. When the first phase of the Kidatu rehabilitation project started in 1991, Kidatu` installation represented more than 50% of the installed capacity in Tanzania. Today, Tanzania has a total installation of about 800 MW of which Kidatu generates about 50% of the total energy consumption in Tanzania. The station generated about 0.83GWh in 2000 and 1.13GWh and 1.19Gwh in the years 2001 and 2002 respectively.

2.DESCRIPTION OF THE PLANT

2.1 Layout

Kidatu is an underground power station with four vertical Francis units of 50 MW each and designed for a total discharge of about 140m^3 per second. The power plant utilizes a maximum head of 175 m between the intake and the tailrace. The intake reservoir has a live storage of 125 million m^3 contained by a 40 m high earth and rock fill dam with a crest length of 350 m. Three spillway sector gates have a total capacity of 6,000 m^3/s. The headrace tunnel is unlined with a length of 9.6 km. The tailrace tunnel has a length of 1.0 km. Fig. 3 displays the layout

A vertical steel-lined penstock feeds each of the Francis stainless steel turbines. Litostroy Lubjana made the two first units while Voith made the two last units designed for about 35m^3/ second each. Rade Koncar in Zagreb, - Yugoslavia manufactured the generators. Each unit has a total rotating mass of about 180 tones. Rotating at a speed of 375 revolutions per minute.

Power from the generators is fed to the single-phase transformers located in the powerhouse cavern via 10.5 kV polyethylene insulated cables. From the main 220 kV transformers the power is led through an 85 m vertical cable shaft to the pothead yard via 220kV oil immersed power cables. There are four 220 kV overhead lines connecting to the 220 kV switchyard. Fig 1 displays the layout

2.2 Kidatu key data

- Catchment's area	80,000 km^2
- River run-off (mean value)	191m^3/s
- Discharge capacity	140 m/^{3}/s
- Turbine capacity	4x52.5 MW
- Generator capacity	4x80 MVA
- Annual generation	1.2 TWh
- Annual asset creation	11 billion SEK
	(At average consumer sales tariff

3.STATUS BEFORE REHABILITATION

The Kidatu Plant had been in operation for about 25 years without major upgrading since it was commissioned in 1975.
The plant had deteriorated considerately with age in due course and its output availability had dropped to about 175MW from the installed capacity of 200MW.

The rotary excitations system for all the units had to be replaced between 1991-1993 by new static excitation system as part of urgent repairs that were conceived as Phase I of Kidatu Rehabilitation. A failure on excitation system of unit 1 during that period had triggered the need for replacement of the old rotary excitation system for all the four units.

A detailed feasibility study carried out by Norconsult International A/S in 1996 recommended major areas of improvement in order to increase overall reliability of power in Tanzania and summed up the actions under Rehabilitation of Kidatu Phase II. The feasibility study distinguished the following main scope of works:

Turbine works

Runners
Cavitations damages on runners for unit 1 and 2 were found to be severe and considerable repairs were recommended.

Fig.1 Outlet Cavitations Damage on one of the runner blades

Waterways
The steel lined waterways were also found to be in poor conditions and reconditioning of the steel with new protective layer of paint was necessary. Corrosion had developed considerably and further corrosion could lead to complete failure collapse and the steel lining.
It was recommended to carry out sandblasting and painting all the waterways (mainly 185m high vertical shafts) with area approximated to 8,000m^2

Turbine leakages
Leakage through guide vane clearances in turbine 1 to 2 was found to be high due to worn out sealing strips/on both bottom and top turbine covers. Similar observations were later noted on turbines 3 and 4.

Replacement of all the sealing strips with stainless facing plates was recommended on both covers (top and bottom) for all four turbines.

Governors:
The governors for unit 1 and 2 were found to have deteriorated considerably. They were no longer reliable in governing the units. Oil leakages on the governor pressure system were severe and complete replacement of the governors was recommended for units 1 and 2.

Generators

Cooling
The capacity of all the four generators at Kidatu was found to be limited due to heating problems in the bearings. Oil temperatures ranged between 55-60^oC whereas winding temperatures rose up to above 80^oC.

Oil leakages and carbon particles
Oil leakages on the bearings were also found to be severe. (The leakage was approximately 2 litres/day). The old slip ring house also served as ventilation from the generator pit. Carbon dust soaked in oil from the generator pit went out via the slip ring. The combination of oil vapor/carbon dust negatively influenced the insulation of the winding in the excitation system as well as the generator windings.

It was recommended to replace the bearings coolers (combined bearings) modify and replace the slip ring house with completely new construction and the generator also needed thorough cleaning of both the stator and rotor to remove sticky carbon dust/oil layers.

Oil pumping efficiency
The pumping efficiency on the bearings oil system was studied further, and it was found necessary to modify the pump holes for increased cooling efficiency. Preliminary studies found the pumping holes on the bearing oil pumping systems to have been rather oversized and recommended for reduction of the same to improve oil-pumping efficiency.

Control and Protection Systems

Many defects were noted on the plant control system. Some of the electromechanical relays were malfunctioning, presenting an operation risk on the reliability of the system. Lack of spare parts for the components that had been in operation of over 25 years was also distinguished as a major risk
Consequently, it was concluded to carry out a complete replacement of the conventional technology based control and protection system to an almost 100% Computerized Control System.

Other areas

The feasibility study also looked at other areas of the plant and recommended improvement actions.

Plant Output
The need to optimize plant out put was dwelt into details. However, with several dynamic factors that influence total efficiency factor, it was found to be very difficult for operators to select optimum setting for individual units and the plant as a whole. It was proposed as an alternative to introduce RANAID software alongside the computerized control system as a means to optimize out put from the units.

Maintenance Management System
General ageing of the plant through deterioration of equipment and components require improved maintenance through the years to sustain reliability. Introduction of computerized Maintenance Management System (MMS) was recommended and implemented.

Environmental Improvement
- The general outlook of the power plant needed to be face lifted. The ambient temperature in the cavern was not comfortable (about 30^{o}C). Noise level was found to relatively high while insufficient illumination and dirtiness were also sighted as problems. The working environment required considerable improvement

4.PROJECT BRIEF AND BENEFITS

4.1 Contracts and Financing

Based on the outcome of the feasibility studies, the scope of the works was categorized accordingly and tender documents prepared on the same.
Through government request, funding support from SIDA and NORAD was obtained for the project to the tune of about 10 million US $ (SEK 103 million). The government also raised an equivalent of about 3 million US $ to meet local costs via TANESCO. The various contracts were signed on 10th June 1988 as summarized below:

I. Rehabilitation of Turbine works by Kvaerner Energy AS (now GE Hydro)
II. Rehabilitation of Generators by ABB Kraft (now Alstom Power)
III. Delivery, Installation and commissioning of Control and Protection Equipment by Siemens A/S (now Voith Siemens).
IV Improvement of the Maintenance Management system (MMS) by Norconsult AS

V   Consultant Services also by Norconsult AS

The utility company (TANESCO) provided both skilled and semi-skilled staff for all the contracts above. Intensive training of the local staff was also covered by the various contracts.
The site works commenced in August 1999 and has progressed well despite works. The works are scheduled for completion during 2003.

4.2 Results and Benefits

There are several factors that contributed to an improved total economy for Kidatu and Tanzania as a whole as benefits of the rehabilitation project. Below are some of the main results:

Available Capacity
The available power generation capacity was increased from 175 MW to 200 MW, which represents an additional generation capacity of 25 MW. This additional generation capacity is deeply needed both for peaking power and as base-load during the rainy seasons. Since commissioning, the rehabilitated units have been operated continuously on almost full load at 50 MW, representing an increase on annual production of up 15%. In monetary terms the increase in energy earns about 12,6 million US$ making it unnecessary to purchase power from thermal sources like IPTL at about 10 million US$ annually.

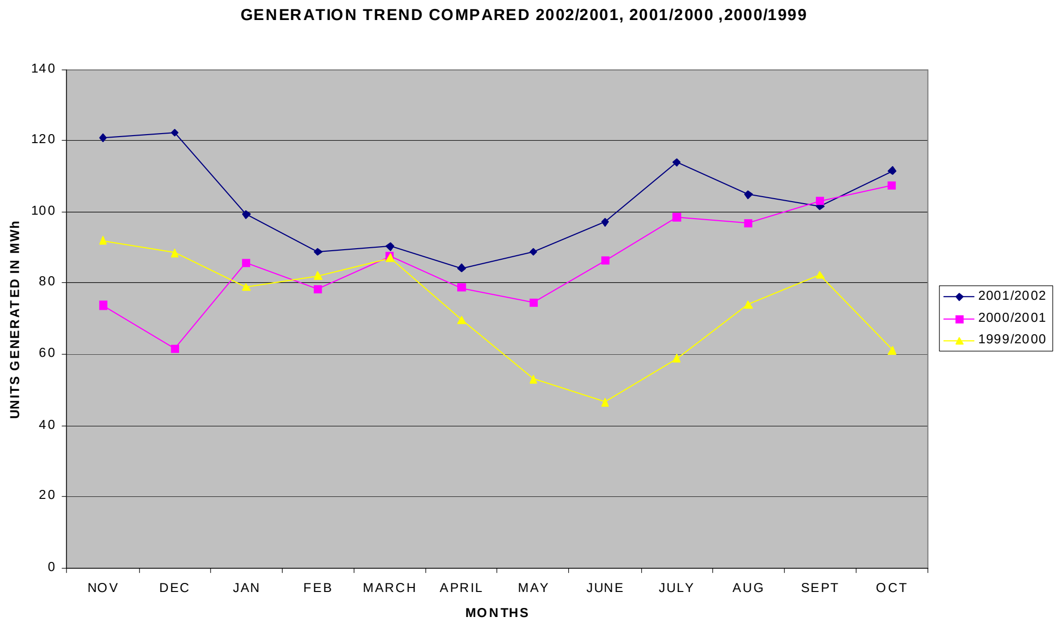

Fig.1 Output improvement trend in recent years during rehabilitation

Efficiency
Through improved efficiency, an average total increase of 2% represents an additional production of about 24 GWh. This increased power sales to consumers, amounts to about 2 million US$ on an annual basis with the current consumer sales tariff.

Reliability
Through implementation of a new control and protection system, reduced outages of the plant resulted to plant improved reliability. Disturbance records on the network due to internal faults on the units have reduced to the very minimum.

6. CONCLUSION

Improved generation capacity, reduced losses and increased overall reliability of Kidatu Power Plant are the main positive achievements of the rehabilitation project.
The condition of the plant that was gradually deteriorating has been restored to optimum performance. Deteriorating has been arrested; the plant is almost "New".
The recovery of the investment cost on rehabilitation is expected shortly, while the improved condition, the assets is geared for more profit within decades.
The improved working condition in the power cavern was also a strong motivator for the power station staff and an increased individual productivity has definitely been enhanced.
Based on the environmental, reliability and other benefit achievements, we may conclude that the project has been very successful, fulfilling most of the required development objectives.

REFERENCES

I. Norconsult 2003, " Rehabilitation of Kidatu Power Plant" *Project presentation*

II. Norconsult 1995 "Feasibility Studies on Kidatu"

III Norconsult 1998 "Kidatu Rehabilitation –Phase II", *Tender documents on turbines. generators and control System.*

IV Norconsult 1998. "Kidatu Rehabilitation Phase II", *Contract Documents on- Turbine (M1), Generators and Transformers (E1), Controls and Protection System (E2 and E3).*

APPENDICES

Fig.3 Layout of Kidatu Power Plant
Fig.4 New computerized control room
Fig 5.Condition of runner blades after repairs

About the authors
Lewanga Tesha a hydropower engineer majoring in mechanical engineering with TANESCO, a power utility in Tanzania. He is presently a plant manager for Kidatu Hydropower plant
Steven Mahenda a senior mechanical engineer and Antony Mbushi an electrical engineer are both placed at Kidatu power plant. All the three among others have participated in the implementation of the rehabilitation of the plant as employees of TANESCO.

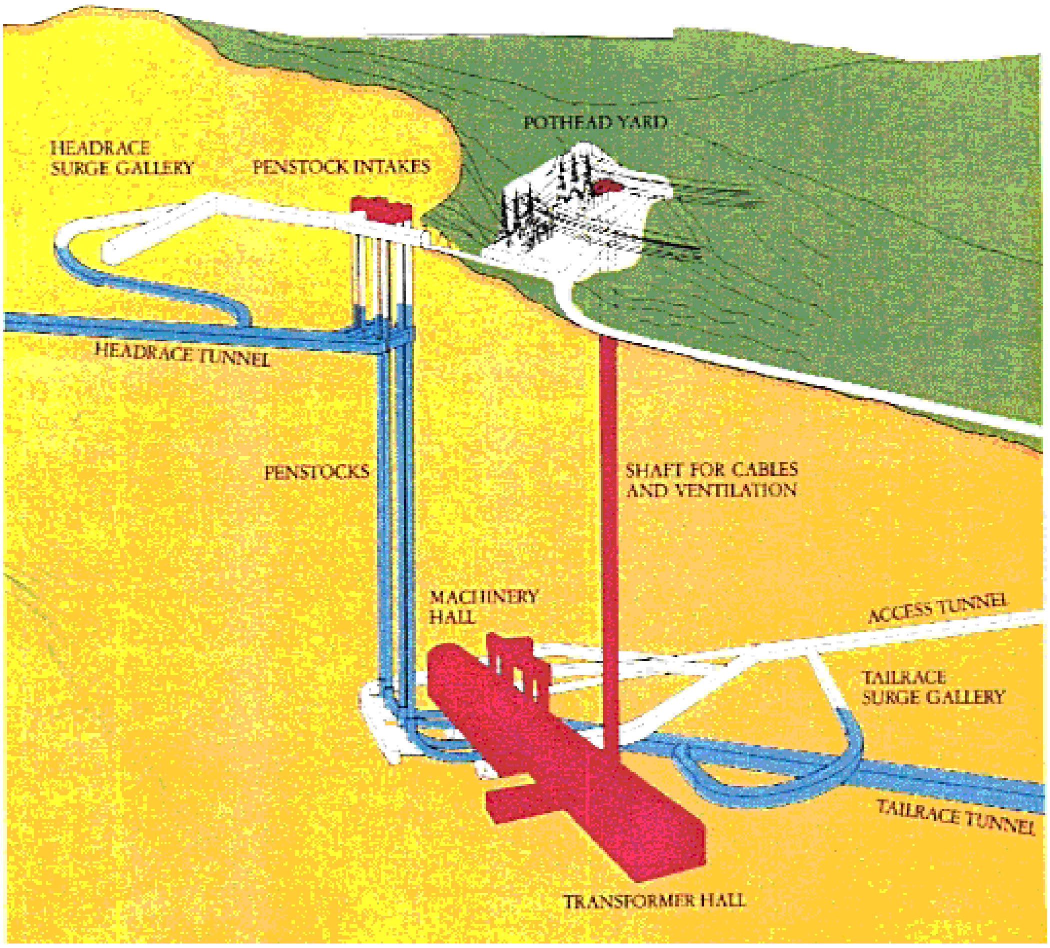

Fig3.Layout of Kidatu Power Plant

Fig 4.New Computerized Control Room

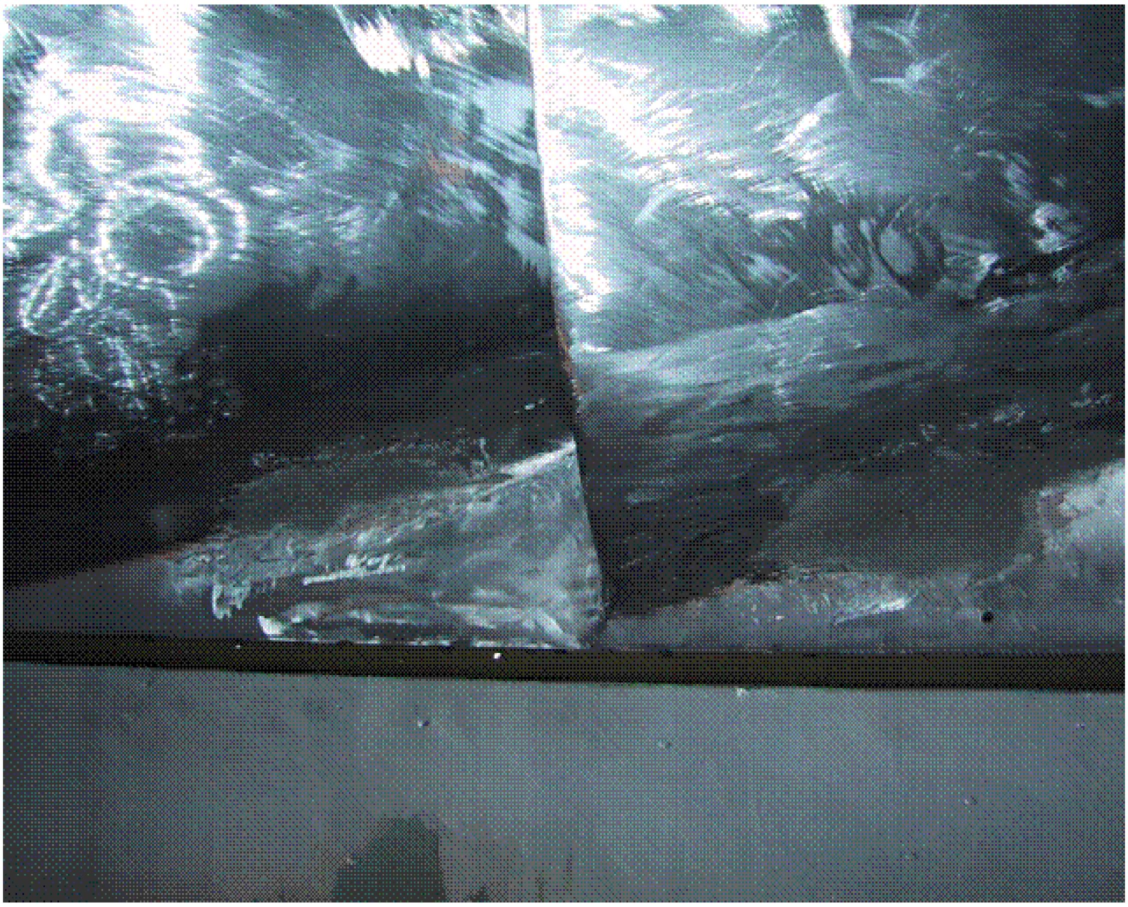

Fig 5.Runner 2 outlet after repair