End-review of Capacity Building and Emergency Repair of Hydropower Plants

LEN BÖRJESON, BO PETTERSSON, JENNIE MOLIN - SWECO

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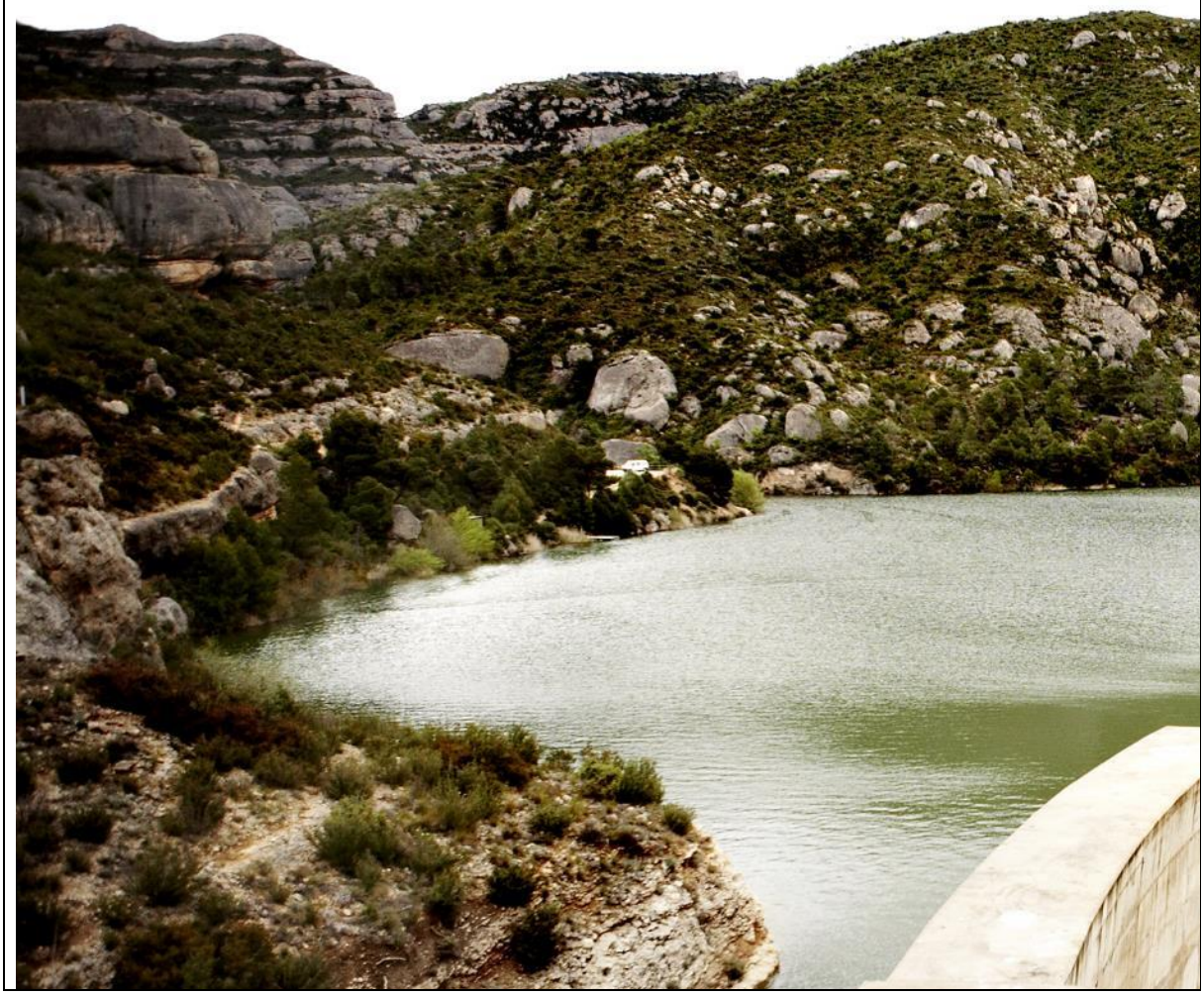

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Project manager	Len Börjeson
Authors and contributors	Len Börjeson, Bo Pettersson, Jennie Molin

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1 EXECUTIVE SUMMARY

This report presents the findings and recommendations for the End-review of Capacity Building and Emergency Repair of Hydropower Plants (ERP) in Tanzania. The ERP project is currently in its final stages and has been carried out with the support of the Royal Norwegian Embassy (RNE) through an institutional co-operation between TANESCO and the Norwegian Water Resources and Energy Directorate (NVE). TANESCO has been the implementing agency for the project and NVE has had the role of program administrator.

The ERP program has included the rehabilitation of five hydropower units in Tanzania as well as a Capacity Building component. A major share of the rehabilitation efforts have been successfully finalised. Several of the power plants have been restored to full functionality. Their availability is expected to be substantially improved and there will be less forced outages. The operational limitations of units 1 and 2 in the Kidatu Hydro Power Plant have for example been fully remedied and the units are now available for operation at full capacity. The specifically procured owner's engineer, Landsverkjun of Iceland, has closely monitored the rehabilitation efforts. This setup has contributed to a successful project.

Seven out of nine Capacity building courses have been conducted so far and they have been very beneficial for the organisation. A frequently mentioned example in this regard has been improved procurement and negotiation skills, which have facilitated the procurement of ERP Contractors. Another step forward was taken when the Computerized Maintenance Management System at the Kidatu and Kihansi hydro power plants was taken into operation. The capacity building program has been carried out by a small number of providers including the International Centre for Hydropower in Trondheim, Norway and TANESCO in cooperation with Kafue Gorge Regional Training Center in Zambia. The individual courses have responded to the original course requirements. For several of the involved courses, TANESCO should be able to proceed with future training without external assistance. Of particular importance has been training with regard to maintenance procedures. It is particularly important to recognise that neglected maintenance in the long term always tends to be more expensive than duly performed maintenance procedures. There are currently some quite important maintenance efforts that are being pushed forward since they would require a complete shutdown. In the worst of cases, this reluctance could lead to severe incidents that could result in a several month downtime. For these reasons, this topic has to be reinforced at all management levels of TANESCO.

A major concern through the duration of the project has been TANESCO's inability to perform timely payments. This inability has caused significant delays and added a quite significant burden to the project. Besides this key factor, cooperation between the involved stakeholders has worked quite seamlessly.

The report has identified several recommendations for the future. Through the course of the End-review engagement, the need to develop a hydropower training facility has been discussed at several occasions. The report presents several options in this regard. A second recommendation is to proceed with additional maintenance training and implementation of maintenance systems at all hydropower plants. A final recommendation is to develop and monitor program indicators for capacity building that also consider qualitative aspects. In summary, the program has been carried out in accordance with the original intentions, although with significant delay.

2 LIST OF ACRONYMS

AVR	Automatic Voltage regulator
CFO	Chief Financial Officer
CMMS	Computerized Maintenance Management System
DC	Direct Current
EHS	Health, safety and environment
ERP	Capacity Building and Emergency Repair of Hydropower Plants in Tanzania
ESI	Electricity Supply Industry
FAT	Factory Acceptance Test
HPP	Hydro Power Plant
ICH	International Center for Hydropower, Trondheim, Norway
KGRTC	Kafue Gorge Regional Training Center in Zambia
LOT	Work stream
MFA	The Norwegian Ministry of Foreign Affairs
NORAD	Norwegian Agency for Development Co-Operation
NVE	Norwegian Water Resources and Energy Directorate
PLC	Programmable Logic Controller
PSRS	Power Sector Reform Strategy
ROT	Rehabilitate Own Transfer (project/financing arrangement)
TANESCO	Tanzania Electric Supply Company Limited
TTS	TANESCO training school

3 BACKGROUND AND PURPOSE

This report presents the findings and recommendations for the End-review of Capacity Building and Emergency Repair of Hydropower Plants (ERP) in Tanzania. The ERP project is currently in its final stages and has been carried out through an institutional Co-operation between TANESCO and the Norwegian Water Resources and Energy Directorate (NVE).

Central steps towards program implementation included:

- Programme Document developed by TANESCO and NVE (November 2010)
  Identification of 6 main topics that will benefit the development of the Tanzanian power system and where Norwegian competence and know-how can be fully utilized.
- Emergency Repair Project 2011-2012 (April 2011)
  Further detailing of the first 3 tasks of the Programme Document including task scheduling and budget.
- Agreement between the Norwegian Ministry of Foreign Affairs and the Government of the United Republic of Tanzania regarding Development Co-operation on Capacity Building and Emergency Repair of Hydropower Plants owned by Tanzania Electric Supply Company Ltd. (October 19, 2011)
- Project Agreement between NVE and TANESCO for the capacity Building and Emergency Repair of the existing Hydropower Plants was signed on 30th November, 2011 by NVE and on 12 December 2011 by TANESCO.
- Assignment commenced in the first Quarter of 2012.

The intention of the ERP program has been to facilitate the Power Sector Reform Strategy defined by the Government of Tanzania. The strategy points out the tremendous expansion of the power sector of which hydropower is an essential and sustainable component. In order to secure the quality and longevity of existing hydropower units it has been considered essential to develop necessary maintenance and operation skills. The ERP-program has been tailored to facilitate the development of both of these aspects. This was accomplished through a three-pronged program emphasizing on the Emergency Repairs of Hydro Power Plants, a parallel Capacity building initiative at TANESCO and Coordination and backstopping support by NVE. The program was supported by the Norwegian Government to an amount of up to 67.5 million NOK. This amount was agreed through the Grant Agreement signed in October 2011 (25 MNOK) and Addendum No 1 signed in September 2013 (additional amount 42.5 MNOK).

The purpose of the end-review assignment as outlined by the Terms of reference has been “to assess the ongoing cooperation and provide Norway with input in the decision making process for entering into a new agreement.

Input sources for the report has been initial meetings with Norad and NVE in Oslo and a mission to Tanzania that took place over a two-week period in November, 2016. During the mission, field trips were made to two hydro power plants (Kidatu and Mtera) including site reviews and meetings with site management and staff. Follow-up meetings also took place at TANESCO’s head offices as well as the Norwegian Embassy in Dar-es-Salaam.

Additional information has been provided through complimentary contacts with TANESCO, NVE and Landsvirkjun (TANESCO’s Owners Engineer). Finally, a large number of documents including meetings notes, contracts and agreements have provided additional valuable information for the End-review.

3.1 Reference documents:

1. Gender Policy for NVE institutional programs (Annex 3)
2. Programme Document - November 2010 (Annex 4)
3. Emergency Repair Project 2011-2012 - April 2011 (Annex 5)
4. MTERA Inspection Report (Annex 6)
5. 2014-06 Tanzania Electricity Supply Industry Reform Strategy & Roadmap (Annex 7)
6. Agreement between the Norwegian Ministry of Foreign Affairs and the Government of the United Republic of Tanzania (signed October 19, 2011)
7. Evaluation of Norwegian support to capacity development (December 2015)
8. Tender Document of the “Procurement of Consultancy Services for End-Review of Capacity Building and Emergency Repair of Hydropower Plants”
9. Terms of Reference for “Procurement of Consultancy Services for End-Review of Capacity Building and Emergency Repair of Hydropower Plants”
10. Annual Reports
11. Quarterly Reports
12. Project Progress Reports

4 END REVIEW OF EMERGENCY REPAIR AND CAPACITY BUILDING

4.1 Programme responsibilities

4.1.1 TANESCO responsibilities

TANESCO has been the implementing agency for the project with responsibility to:

- Enter into contracts with the utilities being selected to undertake the different tasks.
- Approve the participation of TANESCO staff in training activities.
- Approve the purchase of equipment where applicable.
- Propose possible amendments of the project to GoT.
- Make requests for assignments to be carried out by the appointed short- or long-term advisers, consultants etc.

TANESCO has carried out accounting, control and procurements according to Tanzanian laws and procedures. TANESCO has had the responsibility to provide sufficient human resources to follow up the external inputs related to the implementation of the project. Particular emphasis should be given to an active participation in the activities aiming at transfer of competence to TANESCO staff.

TANESCO has also had the responsibility to prepare a detailed work plan including a corresponding budget for the first year of the project within reasonable time after commencement of the ERP. MFA/NORAD had the responsibility to approve the work plan. TANESCO has been responsible for the reporting.

4.1.2 NVE responsibilities

NVE has had the role of program administrator. Upon request from NVE, the Emergency initiative Management area (see below), was transferred to a specifically procured Owner's Engineer, Landsvirkjun from Iceland. This decision has had a beneficial influence on the programme. In practice, NVE's role was to oversee the successful implementation of the Capacity Building area at TANESCO. NVE has provided assistance in the following areas;

- Preparation of TOR and Tender process and contract follow up and management
- General Quality assurance
- Support within Capacity building in TANESCO to improve management
- Assist TANESCO in Project Monitoring

4.2 Programme Cooperation Areas

The programme (ref document 1) was originally designed with the following six cooperation areas;

1. Institutional arrangement TANESCO (Emergency initiative Management)
2. Capacity building in TANESCO (Before any arrangement)
3. Project management and organization
4. Twinning arrangement
5. Monitoring actual twinning arrangement
6. Assisting actual ROT arrangement

The original programme document lays out the contents of these six areas, how they should be implemented and evaluated. These cooperation areas where further detailed in the Emergency Repair Project 2011-2012 (April 2011). The focus of this second document is entirely on the first three areas. The twinning arrangement and the foreseen ROT arrangement where postponed and have been considered to be possible components of a future "phase 2"program. The three selected areas are further described below.

4.2.1 Cooperation area 1: Institutional Arrangement (Emergency initiative Management)

The objective of cooperation area 1 is to assist TANESCO for emergency upgrading (purchase of required equipments and installation) and immediately training of the personnel. Emergency initiative will include the most necessary actions to bring Power plants to sustainable standard. Based on the above, the following activities were included in the programme:

a) Develop priority list for emergency initiative for all hydropower plants.
b) Procurement of equipment and spares
c) Rehabilitate some hydropower plants according to priority list to sustainable standard.
d) Develop emergency training plan.
e) Carry out capacity building of staff through on-the-job training by consultants and suppliers.

The result chain for cooperation area 1 is presented in appendix 10.1.

4.2.2 Cooperation area 2: Capacity building in TANESCO

The objective of cooperation area 2 is to increase professional level and knowledge of the staff at TANESCO, and sufficient capacity to reach the goals set in the Power Sector Reform Strategy (PSRS). The following activities were included in the programme:

a) Develop a capacity building strategy within the O & M area, including appropriate measures to ensure a long-term gender balance in TANESCO.
b) Capacity building in TANESCO to improve management and performance
c) Capacity building to improve the area of negotiation with potential Twinning/ROT partners.
d) Planning and execution of seminars, workshops and training programme, included on-the-job training by Consultants/Suppliers.
e) Support for scholarships and other targeted actions to recruit qualified people to the sector.
f) Upgrading of training facilities and workshops, including procurement of necessary tools.

The result chain for cooperation area 2 is presented in appendix 10.2.

4.2.3 Cooperation area 3: Coordination and backstopping by NVE

The objective of cooperation area 3 is to secure an efficient execution and quality assurance of the project based upon a contract on institutional cooperation between TANESCO and NVE. Based on the above, the following activities were included in the programme:

a) Support in daily coordination with TANESCO
b) Assist and coordination for training of personnel at all levels
c) Assist in preparing reports to the Embassy/Norad
d) Review and comment upon reports and other documentation
e) Participate in meetings if considered necessary

5 COOPERATION AREA 1: EMERGENCY INITIATIVE MANAGEMENT

5.1 Original Work Plan

The works in the Emergency Repair Project has been executed during the years 2011 to 2016. As of November 2016, there are however still some pieces of work that have not yet been completed, especially in Nyamba ya Mungo HPP and New Pangani Falls HPP. For this reason, the End Review has been focused on Kidatu HPP and Mtera HPP and to some extent to Kihansi HPP. Assessment of the work included in the ERP for Nyamba ya Mungo and New Pangani Falls has not been possible as the End Review is performed prior to the execution of the site works for these two plants and no conclusions can be made on the result and outcome.

The Scope of Works for the Emergency Repair Programme is based on the findings resulting from the Feasibility Study performed by NVE in 2010. The scope for each plant is considered to be relevant and appropriate to restore the plants functionality to original conditions. In this context it should be underlined that the scope of repair works for each plant is highly individual and dependant on actual status. However, as a general rule, control and protection systems have a limited lifetime, about 20-25 years, so actions to refurbish this equipment should be expected. It can also be worth mentioning that the ERP is a relatively short-term action and should be followed by a more extensive rehabilitation project with the objective to secure the plants availability for another life cycle of 30 – 40 years. The need for this is not emergent but should be planned for within a 10-year perspective.

The detailed components of necessary emergency repairs are listed in Appendix 3, *Maintenance Requirement List* of the Final Programme Document (see Annex 4). This list is based on the operational experiences of the staff of TANESCO regarding flaws and failures on critical systems that have a substantial importance for the generating capacity and availability of the plants.

5.1.1 Kidatu HPP

Kidatu HPP comprise 4 vertical Francis units with a total installed capacity of 204 MW with an average annual generation of 1000 GWh. The plant was commissioned in 1975.

The Maintenance Requirement List encompasses the following components;

1. Penstock drainage system unit
2. Repair of tunnel drainage valves Audit 1&2
3. Air conditional and ventilation
4. Switchgears parts and repair
5. Turbine parts and repair
6. Control and Communication Equipment
7. Generator parts and repair
8. Tools and testing equipment
9. Standby generator parts and repair
10. Cylinder gate parts and repair
11. Transformer parts and repair

The Scope of Works above were included in Lot 1A and 1B in the procurement of Contractor, except for item 1, 2, 9, 10 and 11. The CMMS (Computerized Maintenance Management System) system Jobtech was upgraded for maintenance planning. This CMMS software facilitates the task of monitoring equipment status, maintenance scheduling and location of spares. The systems helps management to make informed decisions regarding preventive maintenance for each unit and improved allocation of resources.

In January 2014 Telenerg, Croatia was assigned as Contractor for the implementation of the Works included in Lot 1A and 1B.

5.1.2 Kihansi HPP

Kihansi HPP comprise 4 vertical Pelton units with a total installed capacity of 180 MW with an average annual generation of 694 GWh. The plant was commissioned in 2000.

The Maintenance Requirement List encompasses the following components;

1. Turbine equipment
2. Generator equipment
3. Runner and Main Injectors
4. Power House Ventilation System
5. Cooling Water System
6. Switch Yard Equipment

The Scope of Works to be implemented was divided in Lot 5A (item 4) and 5B (item 1 and 3). Lot 5A was awarded to Telenerg and Lot 5B to Jacobsen Electro. CMMS system Jobtech was also upgraded for maintenance planning. The work items 2, 5 and 6 were not performed due to prioritizing resulting from lack of necessary funding. These works should be reconsidered to be included in a possible second phase of the programme.

5.1.3 Mtera HPP

Mtera HPP comprise 2 vertical Francis units with a total installed capacity of 80 MW with an average annual generation of 429 GWh. The plant was commissioned in 1988.

Before the execution of the ERP, the Mtera HPP suffered from malfunctioning of a number of critical systems resulting especially in long restoration time in case of need of restart in case of faults closing down the unit.

The Maintenance Requirement List encompasses the following components;

1. Draft tube gate
2. Cooling water system
3. Auxiliary power supply
4. Chiller Plant
5. Cylinder gates
6. Passenger lift
7. Main transformers
8. Exciters
9. ST1 & ST2 tap changers
10. 11 kV Generator Isolator
11. Floating booms
12. Turbines and Governors

The Scope of Works above were included in Lot 2A and 2B in the procurement of Contractor, except for item 4, 6, 9 and 11.

In January 2014 Telenerg, Croatia were assigned as Contractor for the implementation of the Works included in Lot 2A and 2B.

Item 4, 9 and 11 has been performed separately by TANESCO. Item 6 is still pending but could be considered in a possible Phase 2 of the ERP. The reason for not performing item 6 was prioritizing due to constrains in funding.

All performed work has been successfully implemented and the plant is restored to normal, full functioning condition. The works has also been possible to execute within restrictions due to load demand as the works was planned during low reservoir level. As an outcome of the Contractors works, an inspection report was prepared by the Contractor (see Annex 6). The Sweco consultants have reviewed the report and consider it to be a vital document that will serve as a basis for specifying the scope of rehabilitation works to be performed at a later stage.

5.1.4 Nyamba ya Mungo HPP

Nyamba ya Mungo HPP comprise 4 vertical Francis units with a total installed capacity of 8 MW with an average annual generation of 36 GWh. The plant was commissioned in 1968.

Before the execution of the ERP the plant had problems with the draft tube gate hoist that is essential for dewatering the turbines. Repair of various auxiliary systems such as drainage is essential. The control system and auxiliary power supply system has to be repaired to restore full functionality.

The Maintenance Requirement List encompasses the following components;

1. Electronic governors
2. Dewatering systems
3. Drainage systems
4. Replacement of instrumentation
5. Replacement of protection relays
6. Repair of 400 V system
7. Generator circuit breaker and switchgears
8. Oil circuit breaker for 66 kV line
9. Air circuit breaker for 66 kV line

The Scope of Works above were included in Lot 4A (mechanical) and 4B (electrical) in the procurement of Contractor.

In January 2014 Telenerg, Croatia were assigned as Contractor for the implementation of the Works included in Lot 4A and 4B.

5.1.5 New Pangani Falls HPP

New Pangani Falls HPP comprise 2 vertical Francis units with a total installed capacity of 68 MW with an average annual generation of 341 GWh. The plant was commissioned in 1995.

In New Pangani Falls the main inlet valve had a leakage that needed urgent repairs. Further, the control system including excitation and governor systems needs to be repaired to restore full functionality and operational safety. AC and DC and diesel generator needs repair and replacement.

The Maintenance Requirement List encompasses the following components;

1. Upgrading control system
2. New chiller plant
3. PC model IPC-610
4. Repair of generator excitation and protection system
5. New battery system
6. New electronic governor

The Scope of Works above were included in Lot 3A (mechanical) and 3B (electrical) in the procurement of Contractor.

In January 2014 Telenerg, Croatia were assigned as Contractor for the implementation of the Works included in Lot 3A and Jakobsen Electro for the implementation of the Works included in 3B.

5.2 Implementation Output

5.2.1 Kidatu HPP

It can be concluded that all main Tasks under the Programme Work Plan as listed under section 5.1.1. above has been successfully implemented. The power plant is restored to full functionality and the availability of the units for generation is expected to be substantially improved also with less forced outages. The upgrading of the control system was essential for a possible trouble-free operation of the plant for years to come. The operational limitation of unit 1 and 2 is fully remedied and the units are now available for operation at full capacity.

The site visit and discussions with TANESCO staff has confirmed that the implemented repair work is sound. After finalization of the works, the Kidatu HPP is restored to original functionality and has an improved availability and increased generation, which is also confirmed by the resulting indicator values.

5.2.2 Kihansi HPP

The power plant was not visited. The scope and result of the ERP programme were verbally presented during the Kidatu HPP visit. The outcome presented by TANESCO staff was generally positive.

5.2.3 Mtera HPP

It can be concluded that all the main tasks of the Programme Work Plan listed under section 5.1.3. above have been successfully implemented. The power plant is restored to full functionality. The availability of the generating units is expected to be substantially improved and there will be fewer forced outages. Along with comprehensive discussions with TANESCO staff, the site visit has confirmed these results.

5.2.4 Nyamba ya Mungo

The implementation of the works has not been possible to evaluate, as these were not completed when the End Review was performed.

5.2.5 New Pangani Falls

The implementation of the works has not been possible to evaluate, as these were not completed when the End Review was performed.

5.3 Lessons Learned

Continuous capacity building is very important for TANESCO in order to maintain management and technical knowledge. This is particularly important considering the frequent changes in management positions. The capacity building courses that have been conducted so far have been very beneficial for the organisation. The improved procurement and negotiation skills have facilitated the procurement of ERP Contractors.

The scope of works in the technical specification for the Kidatu HPP would have benefitted from a significantly elaborated description. A better description regarding the division of supply and installation works between the suppliers and TANESCO would have led to superior results. An improved timing of the implementation works that require shutdown would have reduced necessary spilling of water.

Due to high load demands, there has also been some challenges to gain access to the plants in order to perform works that require partial or total shutdown.

5.4 Outcome and Indicators

As a general conclusion the ERP has been very beneficial for TANESCO in terms of restoration of the Kidatu and Mtera Hydro Power Plants to full operational status. All major systems with defects that has caused forced outage, long restart times and other operational limitations have been successfully remedied. In order to evaluate program objectives the outcome of the work tasks have been reviewed as well as corresponding indicators.

5.4.1 Outcome

The expected outcome of cooperation area 1 (ERP) is outlined in the following:

a) Hydropower plants rehabilitated to sustainable standard.

This outcome can be concluded as fulfilled for Kihansi, Kidatu and Mtera HPPs.

The ERP has resulted in updated plant equipment to a more modern standard with increased functionality. This has also resulted in improved support from suppliers as well as an improved availability of spare parts. Consequentially, the number of forced outages will be less and the stand-still periods due to lack of support and spare parts can be reduced. In monetary terms, this effect will result in more generation as further described below.

b) More electricity generated by hydropower plants

This outcome can in principle be concluded as fulfilled even though this is too early to evaluate in terms of more generated kWh for Mtera and Kihansi HPP. For the Kidatu HPP, where generation output has been restricted for units 1 and 2, the restoration to full capacity is expected to result in an increase of generation by 552 MWh per day. The availability of the plants will also be significantly improved and generation will increase through the reduction of forced outages.

5.4.2 Indicators

The indicators of cooperation area 1 (ERP) are as follows:

a) At least 20 % increase of electricity generated from hydropower

For Kidatu HPP the annual average power generation is 700 GWh during dry years and 1,000 GWh during wet years. The expected increase of generated electricity is 201 GWh annually, which corresponds to an annual revenue of about 80.4 MUSD based on a tariff of 0.40 USD/kWh (ref. Programme Document 2010). It can thus be concluded that the indicator is reached for Kidatu HPP.

For Kihansi HPP the increase of generated electricity is too early to evaluate. Plant availability for the period 2006 to 2013 was 95.7 %. From 2014 to date it has been 98.7 %. These figures indicate a significant improvement that will result in an increase of electricity generation. The number of outages due to faults has been reduced from a span of 7 to 32 occurrences per year for the period 2006 to 2013 to 2 to 5 occurrences per year for the period 2014 to 2016.

For the Mtera HPP, the increase of generated electricity is also too early to evaluate, as the operation is dependent on dam operation and availability of water that also relates to the operation of the Kidatu HPP. The reduction of forced outages due to the replacement and repair of the defect equipment will result in a positive impact on the electricity generation as e.g. the restoration time is significantly reduced from about 45 – 60 minutes before ERP to about 12 – 20 minutes after ERP. It can also be concluded that the availability of the plant has increased from an average of 98.0 % during the period 2006 to 2013 to an average of 99.7 % for the period 2014 to 2016.

Availability is defined as the number of hours when the unit is available for operation per year divided by total number of hours exclusive of time for planned maintenance. Of course, an availability of plants of 100 % would be the ultimate goal. However, in reality this is never the case.

As a world benchmark in developed countries, a plant availability of 99 % can be considered as realistic for a plant in good working condition.

The corresponding performance indicators for Nyumba ya Mungu and New Pangani Falls HPPs should be evaluated at a point in time when the planned rehabilitation efforts have been completed.

5.5 Remarks and recommendations

5.5.1 Kidatu HPP

The ERP work has been implemented successfully even though some work remains, especially regarding replacements of the main cooling water pipe that requires a fully shut down of the plant. Due to load demand, it is uncertain when this work can be done. The installation works is to be done by the Contractor later (material is already in the plant). The work is expected to be performed in less than a week as all preparatory works are finished.

5.5.2 Kihansi HPP

The ERP work has been implemented successfully and the plant is restored to fully functionality. There are however, a number of items on the initial list of prioritized works that are still not performed due to budget restrictions and these should be considered for a possible Phase 2.

5.5.3 Mtera HPP

The power plant does not have any CMMS system for maintenance planning and all planning and recording is performed manually. It is highly advised that operation & maintenance procedures at Mtera HPP are integrated in the planned implementation of the centralized CMMS system for all TANESCO hydro power plants.

The findings and recommendations included in the Contractor's report (see Annex 6) should be carefully considered by TANESCO as they provide valuable input for the long-term operations of the Hydro Power units.

The control system and electronic governors are currently fully functional. It should however be underlined that support, service and spare parts may soon be difficult to acquire. As the control system is from the original supply, i.e. close to 30 years old, it is recommended to plan for a complete replacement in the near future to a modern digitalized control system (within 5 years). The scope should also preferable include the replacement of the hydraulic governor system to a modern, high-pressure system and a new electronic governor. It is also recommended to replace the excitation system as well as this is close to the end of the lifetime.

6 COOPERATION AREA 2: CAPACITY BUILDING IN TANESCO

6.1 Original Work Plan

The Capacity Building activities has been performed in parallel with the ERP works. Training activities have included both management as well as operations and maintenance staff. Training has been conducted in workshop settings and as theory lectures. Additional training has been achieved through factory acceptance testing procedures (FAT) at some of the supplier's premises as well as through on-the-job training. Training sessions has also been conducted on control and protection systems at training centres in Tanzania.

The Capacity development program has included the following nine courses. These have been defined in Annex 2 – Training package.

1. General Equipment – switchgears, DC systems, PLC and excitation system
2. Dam equipment- Dam safety inspection
3. Management Course- Hydropower management, negotiation and contract management
4. Main control system
5. Modern maintenance techniques e.g. computerized maintenance management system
6. Plant operation and maintenance computer skills – Basic computer knowledge; MS-excel, word, power point, access and internet
7. Environment, Health & Safety (EHS) of plant and personnel and safety gears
8. Procurement procedures- methods, selection, store management, stores house keeping
9. Electro Hydraulic governing system – Electronic governor system, hydraulic governing system, hydraulic diagrams interpretation, fault diagnosis, documentation and reporting

Seven of these courses have already been implemented. The remaining two are the main control system and EHS. With the exception of the two courses related to dam equipment and electro hydraulic governing system which were performed in Norway, the courses were carried out locally

The course for Health, safety and environment will be performed internally under the supervision of TANESCO training school (TTS). The main control system cannot be done effectively in house because of lack of training facilities. It has been proposed to be done at Kafue Gorge regional training centre (KGRTC) in Zambia where there are all necessary teaching facilities. There is however some uncertainty if the costs for such training can be covered within the remaining available budget. TANESCO is currently in communication with KGRTC in order to know the actual cost for sending 12 engineers and technicians for training.

All courses have had significant importance and have been relevant for the specific situation i.e. ongoing refurbishment as well as more general needs. The course that has had the most significant attention by TANESCO's management was "Modern maintenance techniques". This topic is discussed in more detail in chapter 6.5.

6.2 Outputs and Indicators

As a general conclusion, the capacity building activities has been very beneficial for TANESCO. The number of staff trained in plant operations and fault remedies for a number of critical system has been significantly increased (see section 10.3 for course attendance). In addition, the restoration of the CMMS system at the Kidatu and Kihansi HPPs has enabled TANESCO to use more efficient maintenance planning procedures. Through discussions at site visits the importance of attending the courses has been underlined by a number of plant staff. There has also been a commitment in taking active part in the various course elements. This commitment has been highly visible when reviewing the actual tidiness of the refurbished hydropower units. There is usually a strong correlation between tidiness and efficient maintenance. The hydro power staff on site were also proud of their units and the fact of having the required skills. For their operations.

6.2.1 Output

The expected output of Cooperation Area 2 are as follows:

a) Staff trained according to capacity building and recruitment

This outcome can be concluded as largely fulfilled. Through the capacity building programme the overall knowledge and capacity strength in the TANESCO organization has been improved, The training program has had planned attendance (see sections 10.3 and 10.4 below) and the employees of TANESCO have confirmed through meetings and inquires that they have achieved useful knowledge in contract management, operation and maintenance of the hydro power plants.. In addition, through site interviews with hydropower staff the procedure of passing on acquired knowledge to colleagues on site was deep-rooted, most often in the form of on-the-job training, but also in more organised workshop settings. There is also an awareness among staff that relevant skills will ensure correct operations as well as improved plant maintenance. This in turn will lead to fewer mistakes and “try-and-fail” cases.

b) Training facilities upgraded to appropriate level

Training facilities have not yet been upgraded. This is primarily due to a lack of funds as well as a broad focus on immediate needs. Among the managers of TANESCO there is however a strong sense of the importance to develop this capacity.

c) Operation and Maintenance procedures prepared and implemented

This outcome can be concluded as fulfilled. Through the capacity building activities and especially through the O&M initiatives, plant staff has a sufficient understanding of O&M fundamentals. It should however be underlined that these issues require a thorough understanding at all levels of the organisation in order to have a lasting impact. This is further discussed in following chapters.

6.2.2 Indicators

a) At least 6 TANESCO personnel trained according to capacity building plan

This indicator has been met in that many more than 6 personnel have had the opportunity to take part in one or several capacity building courses.

b) At least 60% of capacity building activities planned and executed

Seven of the nine planned courses have successfully taken place.

c) Well functioning O&M procedures

As pointed out above, the CMMS system at the Kidatu and Kihansi HPPs have had a positive impact on current operations. This is due to not only the fact that the system is up and running. Staff on site show an increasing interest when modern computer tools are implemented.

6.3 Capacity Building Results

When it comes to CMMS the Jobtech system is back in operation and used in everyday planning in Kidatu and Kihansi HPP. This will enable a more effective planning of the maintenance work with more proactive measures instead of corrective thus less forced outages. In Mtera HPP the maintenance planning work is still done manually which reduces the possibility to have an effective preventive and planned maintenance. The importance of maintenance planning cannot be overemphasized. This topic is further outlined in the Conclusions section.

The training in contract management and procurement was very useful in the contracting process of the suppliers for the ERP and will enable for TANESCO managers to more efficiently procure similar contracts in the future. The general feedback from operation and maintenance staff is that the lecturing schedules were very tight and too short. Another opinion is that the courses should have included some study visits and practical exercises.

6.4 Current Capacity Status

An essential objective for the capacity training initiative has been to reach a capacity level to secure sustained operations in the hydro power plants. Based on the consultant's observations, primarily through meetings and interviews, TANESCO has the necessary capacity to maintain and develop the necessary skills in the following areas-

- General Equipment - DC system and Excitation system,
- Plant operation and maintenance computer skills,
- Health, safety and environment and
- Procurement procedures.

As for the remaining five areas, the two that were covered in Norway are particularly complex and seldom handled entirely by utilities themselves. It can be assumed that these two areas also in the future will require external training:

- Electro Hydraulic governing system – Electronic governor system, hydraulic governing system, hydraulic diagrams interpretation, fault diagnosis, documentation and reporting
- Dam equipment- Dam safety inspection

One course has not yet been performed and is currently under discussion as described above:

- Main control system

One course is special in the sense that it is not a technical course. The course has been well received although TANESCO might require support in this area also in the future:

- Management Course- Hydropower management, negotiation and contract management

The last course is considered to be extremely vital and is discussed in the Maintenance section below:

- Modern maintenance techniques e.g. computerized maintenance management system

6.5 Maintenance

A central theme for the engagement has been to develop maintenance procedures in order to avoid a situation with deteriorating hydro power plants. This training component has been considered to be of vital importance by staff and management. It should however be noted that the local staff is often quite knowledgeable with regard to the awareness of the status of "their" units. There are mainly two reasons that necessary maintenance is neglected despite local awareness. One is a shortage of necessary maintenance capital. One is an aversion towards shutting down a unit for necessary maintenance due to the constant supply shortage. The unfortunate outcome of this situation is that neglected maintenance in the long term always tends to be more expensive than duly performed maintenance procedures.

In summary, successful maintenance does not only require a skilled local work force with relevant and well-implemented maintenance systems. It is equally important to address the financial impact of these issues at corporate management levels. In order to achieve a lasting impact with regard to maintenance procedures it is necessary to gain a solid support for such procedures from corporate management.

6.6 Training material

The training material that has been made accessible for review has largely had presentation format. This is sufficient when the training is conducted as lectures and especially the case with highly skilled lecturers. The issue however is that the presentation material has to be supplemented with additional and significantly more detailed information if the documentation is to be used as reference material after the actual training has taken place. This is particularly important when the objective is to train the trainers. This approach requires more preparations leading to higher costs. It is also an often-neglected factor when drafting the ToR for the training engagement.

In the absence of such supplementary documentation, additional notes have been made for some of the courses. Course documentation has been stored at TANESCO training school for reference and is made accessible for all hydro power staff. In this context it should be noted that purely technical documentation quickly grows out of date. Training courses very often require an update before they can be reused.

6.7 Lessons Learnt

Regarding on-the-job training during installation works, there has been some criticism since the contractor's staff had a tight time schedule without sufficient time to present to TANESCO staff what was actually done and why.

In retrospect, through discussions with TANESCO it has been concluded that some of the topics to be addressed through on-the-job-training are in reality quite difficult to perform. An example is PLC-(Programmable Logic Controller) programming. In order for such on the job training to be effective, requires very experienced staff to start with. The knowledge gap between the suppliers who primarily were responsible for installing the equipment and the on-site technicians was just too significant to bridge through on-the-job-training. In general terms, it is very difficult to sufficiently perform on-the-job training as a spinoff of installation work. In many cases, the main task is to get the equipment up and running and there is simply not sufficient time, nor proper preparations to perform the task of on-the –job training.

Capacity Building is a matter of persistence. This is especially the case when softer aspects such as organization, management involvement and structural changes need to be taken into account. In this particular engagement, maintenance procedures have been specifically mentioned. A successful

training program requires a balanced amount of repetition, not only at the individual level but also targeting the needs of the organization. It is only when the training has had an impact on the whole organization that lasting effects can be achieved. Capacity building should therefore be considered as a continuous process and a long-term program to maintain current skill levels is vital. The capacity building activities within the Capacity Building and Emergency Repair programme have been very beneficial.

Given this description, it is an advantage that a number of the courses which were performed in the ERP project also are included in TANESCO's training plan. TANESCO uses internal trainers to perform the following five courses:

- Plant operation and maintenance
- Basic hydro plant main control system
- Excitation systems
- DC System
- Health, safety and environment.

Finally, the End-review engagement has revealed several training facilities in southern Africa. The following three training facilities have been mentioned:

- TANESCO Training School (TTS)
- Kikuletwa Hydropower Training Centre in Arusha, Tanzania
- Kafue Gorge Regional Training Center in Zambia (KGRTC)

From a longevity and effectiveness perspective, it could be an advantage to determine if and how the courses that are provided through these facilities could be coordinated.

6.8 Course Value

The overall impression of the capacity building initiative is that the courses have been relevant, well appreciated and have had reasonably high attendance. The question is if more value can be created by other means. It is possible that this could be achieved through a stronger and more centralized course implementation. In this particular engagement, courses were delivered through a number of channels. The advantage with such an approach is that cherry picking can be performed. The disadvantage however is that there is a lack of an engaged, empowered provider of the course packages. Through a more centralized approach it is more likely to achieve a more structured handling of documents. Documents would be more conform and would have a more formalized and authorized appearance. Course material would include both presentations and add-on material. Finally, all documents would comply to an overall theme. This approach would likely be more expensive using a cost/course evaluation factor. The overall impact would however be more lasting.

From a strict efficiency perspective, it should be underlined that the Capacity Building share of the full assignment was quite limited (approximately 3 million NOK). From this perspective, the sheer number of delivered courses is respectable. However, the full potential is only reached when the courses are repeated. Fortunately, as previously mentioned, there is a base at TANESCO to continue this work.

7 FINANCIAL MANAGEMENT

7.1 Disbursement of Funds

The financial management of the assignment has been governed by the split between the two main cooperation areas Emergency Repair Project (ERP) and Capacity Building (see table below for detailed description). The main share of the total funds (55 MNOK) has been distributed through TANESCO for the ERP areas. In addition to the 55 MNOK being transferred to the ERP area from MFA/Embassy, TANESCO has contributed to the program with approximately 1 000 000 EUR (approximately 9,5 million NOK) and it is expected that this amount will sum up to a total of 1,5 MEUR (approximately 14 million NOK) by the time the project has been completed.

An additional 13,5 MNOK has been distributed through NVE. These 13,5 MSEK will largely be used to support the ERP project, primarily by contracting an Owner's engineer for the ERP works and for Capacity Building area. Although the capacity building area has been considered to be of vital importance for the entire program it should be underlined that a total of only 2,2 MNOK were actually used for the training courses. Even considering on-the-job training within the ERP area, the capacity building area only represents a small fraction of the total project.

Through the course of the project the funding and distribution of funds, primarily to the contractors has been a concern. From TANESCO's perspective, the funds have not been sufficient to cover the project costs. The main reason for the lack of funds is primarily due to the decreasing exchange rate between the Norwegian Crown and the EURO. This is because the disbursements have been made on a semi-annual basis. Therefore, from the start of the project (March 2014) the exchange rate was approximately 8,3 NOK to the EURO. Two years afterwards (March 2016) the exchange rate was 9,4 NOK to the EURO. The reduced exchange rate has been further boosted by the significantly increased duration of the project. These two factors sum up to the quite significant lack of funds that has been covered by TANESCO. The following figure present an overview of the funding and distribution of funds described above.

	Managed by TANESCO		Managed by NVE	
	EURO	NOK	EURO	NOK
from MFA/Embassy		54 000 000		11 555 000
from MFA/Embassy (contingency)				2 000 000
from TANESCO (estimate)	1 500 000	14 343 968		
Total funds		68 343 968		
Jakobsen Eektro	875 739	8 374 381		
Telenergo	6 271 234	59 969 582		
Owners Engineer				7 000 000
Owners Engineer (contingency)				2 000 000
Capacity Building				3 000 000
Backstopping				1 500 000
Total expenditures	7 146 973	68 343 968		13 500 000
Comment: Underlined figures are calculated based on average exchange rate				

7.2 Payments

Payments within the project are made according to the Agreement between TANESCO and NVE Article VIII and country Agreement Article V, clause 4 which states that:

"Payment for the services performed by NVE will be made by MFA to a bank account designated by NVE but such disbursements will be made against requests accompanied by;

1. Original and specified invoice, and

2. A written approval of the invoices and a certification of the request by Chief Financial Officer of TANESCO"

For payment to Contractors; the process involves submission of the invoices by the contractor, the owner's engineer certifies the payments, and then the invoices are certified by the project coordinator and the Senior Manager Generation. Lastly, the invoices are approved by the Chief Financial Officer of TANESCO. The signed voucher is then sent to CRDB bank where the project account is for payment to the contractor's account.

For payment to NVE, the invoice is submitted by NVE signed by the project director, a written approval of the invoices is presented to Chief Financial Officer for certification. CFO writes a letter to the Norwegian Embassy to request payment to NVE. MFA then reports to TANESCO on payments made to NVE.

The chief Financial Officer (CFO) and other selected TANESCO staff have signatory power for the project account. Two signatures one for the CFO and any other eligible signatory are necessary requirement on the voucher in order to release money from the project account to the contractors account.

8 CROSSCUTTING ISSUES

There is an important similarity between Crosscutting Issues and the Maintenance aspects that have been addressed in section 6.5. This is the importance to address these topics at the corporate management level as well as at the level of operations. In order to achieve a lasting impact, it is important to develop a solid commitment regarding these topics at the corporate level with the expectation that the executives will communicate these issues in a fruitful way. A successful way to succeed with this objective is to involve corporate management with the actual delivery of training courses with crosscutting content. Although the ERP program has not included such an approach, Crosscutting issues have been addressed as an integral part of relevant courses. A general conclusion for the future is to ensure a solid engagement by the executives and senior managers at TANESCO. A constructive involvement from the organisation's top levels would have a vital impact on the rest of the organisation.

8.1 Gender awareness

Gender aspects have been considered when assigning staff to training courses. The issue however is that female technicians are not found in abundant supply in Tanzania as well as for most parts of sub-Sahara Africa. There is however, an awareness of gender issues as this topic has been frequently discussed in quarterly reports as well as annual meetings. There has also been a genuine interest from the staff of TANESCO to provide relevant indicators with regard to Crosscutting issues. A total of five women have taken part in the training programs of which one woman participated in the course about dam safety. See also Annex 3 - Gender Policy for NVE institutional programs.

8.2 Climate Change

Although the project is extremely beneficial from a Climate Change perspective, this point has not been commonly discussed. It can be assumed that there are so many important reasons for having efficient and reliable operations in the hydro power stations that further arguments are unnecessary. The climate change topic is however increasingly important and should be addressed whenever possible. A relevant way to do so is to stress the importance of hydropower also from a climate perspective. This would surely serve as an encouraging and motivating factor for the local staff of the hydropower plants.

8.3 Environmental

A number of actions have been made to remedy the previous existing oil leakages from e.g. intake cylinder gates that will prevent oil from finding its way to the river water. Oil leakages in the power house, even if fully wiped up and removed, creates an amount of unnecessary waste.

The replacement of old and obsolete equipment can be judged to create an improved working environment and reduces the risk of human injuries due to e.g. electrical faults. Well working equipment also reduces the need for repair and thus reduces the risk for human injuries during repair and fault corrective measures.

As a conclusion, it can be summarized that the ERP has reduced the risk for hazardous leakages of fluids to the environment and reduced the risk for human injuries due to better working equipment.

The course on Health, Safety and Environment is planned to take place in 2017 through internal resources at TANESCO.

8.4 Anti-corruption

The country-to-country agreement signed by the Norwegian Ministry of Foreign Affairs and the Government of the United Republic of Tanzania regarding development cooperation on capacity building and emergency repair of hydropower plants owned by Tanzania Electric Supply Company Limited prohibits all practices of corruption especially during procurement and implementation of the project (Article VIII Procurement).

TANESCO being the public owned organization uses public procurement Act 2011 which prohibits fraud and corruption and all related conducts at section 83 and 84. In addition, TANESCO uses the Public procurement regulations, 2013 that prohibits fraud and corruption and improper inducement as explained at section 78 & 79.

One of the statements in this act and regulations is that "*The public financed contracts shall proceed in a transparent and accountable manner during the procurement or disposal process and execution of contracts*".

One of the training courses within the capacity building area was contract management and negotiations, which equipped the employees on proper implementation of the contract. Discussions with TANESCO staff have confirmed the significant relevance of this course and the possibility to apply some of the lessons learnt on the procurement process of the ERP.

In addition, the TANESCO evaluation team members were also invited to Norway to take part in procurement of the Owner's Engineer. This approach was applied to further emphasize the importance of diligently performed procurement processes and to do so in an undisturbed manner.

In summary, the grant has been utilized according to the approved work and budgets. The contractors were paid for the works, which have been approved by the Owner's Engineer (Consultant) and certified by TANESCO. No corruption practices have been so far noticed.

8.5 Human Rights

The topic of Human Right has not been specifically addressed in this assignment.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Reform Process and the ERP project

Tanzania has entered into a reformation process of the electricity sub-sector with the objective to meet current and future demand for electricity, to reduce public expenditure on the Electricity Supply Industry (ESI), to attract private capital and to increase electricity connection and access levels. The ESI Reform Strategy and the Roadmap describe the intended reform initiatives and key actions covering the period from 2014 to 2025 (see Annex 7). Some of the main topics of the ESI include:

- Plan to unbundle the generation segment from transmission and distribution with an ultimate goal to attract new investments and potentially divest existing generation resources.
- 5-fold electricity capacity expansion by 2025
- Hydro Power capacity is expected to grow by a factor 4 until 2025.

In this context the Capacity Building and Emergency Repair of Hydro Power in Tanzania (ERP) project fits extremely well with current needs:

- The most efficient and sustainable way to contribute to these goals is obviously to make sure that existing units are operated efficiently as possible and over a long period of time.
- The divesting process is greatly facilitated if the units are in excellent condition and well maintained by a skilled staff.

The question is also how well the ERP project fits with corresponding initiatives by other Development Partners.

- In general, there are no ongoing conflicting initiatives. The ERP project is well-known and does not have a significant impact on other projects.
- There is however an area where further coordination would be useful. This is related to training facilities and is further discussed below.

There are relevant coordinating entities in place, e.g. the Energy Development Partner Group (EDPG). After a review of meeting notes complemented with local discussions, the general impression is that these initiatives are sufficiently well coordinated. The main obstacle is not a lack of coordination. The main obstacle appears to be the unpredictability of governing authorities. This makes it difficult to coordinate both the domestic conditions in Tanzania as well as international initiatives in the region.

Regarding the specific conditions of the private sector, the ERP project has had one very important benefit since the repaired hydropower plants will contribute to a more reliable power system in Tanzania. This is not only due to the extra power that will be generated. An additional benefit is the regulating function that hydropower has in the power system which contributes to an increased system reliability. If system reliability is too low, the only alternative is usually to install back-up diesel generators. Such installations involve both significant investment and high operating expenses.

9.2 Recommendations for Phase 2

In meetings with TANESCO several comments have been made with reference to a possible Phase 2. When aligning the needs of TANESCO with the original Programme document a number of relevant initiatives can be identified.

- Development of training facilities:
  A training facility in Tanzania would open the window for more training occasions compared to the current situation. The closest decent training location is currently Kafue Gorge Regional Training Centre (KGRTC) in Zambia. It is obvious that training at these facilities is costly. For this reason, only one or two individuals can participate at a time. In recent years, no such training has actually taken place in KGRTC at all. Other training locations have been Norway, which of course is even more expensive. It should however be underlined that a training facility is not a simple task to create. At meetings with TANESCO management, it was obvious that there is an aspiration to develop this capacity either in-house or at least in Tanzania. A recommendation would be to continue with a mixed structure, where some courses are held locally and some at locations that are more suitable to provide special courses. There are several vital issues that need to be addressed in a separate study before such decisions can be made:
  - What are the most urgent needs
  - How can longevity be assured
  - Develop capacity of TANESCO training school (TTS)
  - Sponsorship – e.g. Kikuletwa Hydropower Training Centre in Arusha, Tanzania
  - Possible satellite to Kafue Gorge Regional Training Center in Zambia (KGRTC)

- Maintenance training and implementation of CMMS at all hydro power plants:
  The importance of maintenance training and the implementation of relevant tools and procedures cannot be overemphasized. This is a matter of pure economics, security of supply and Health and Safety. Well-implemented maintenance procedures will avert the need for future ERP programs. For these reasons, the continuation of similar training activities should be seriously taken into consideration.

- The unbundling process as described above will result in an increasing demand for TANESCO to perform asset valuations of power generation assets. Therefore, it is very relevant for TANESCO to acquire relevant skills to estimate current values as well as the need and costs for necessary major overhauls.

- Indicators:
  The ERP program has been extensively monitored through regular quarterly and yearly reporting mechanisms. The regularity and contents of the reporting procedures have been performed according to common practices. They have provided a reasonable description of the actual progress. A difficulty of all such programs is to evaluate the actual achievements that are being made, especially regarding Capacity Building aspects. The defined indicators are more quantitative then qualitative (appendix 10.2) and should be supplemented with more qualitative indicators. The issue however is that such parameters are often difficult to describe. It is however often worth the effort.

9.3 Project delays

The project has gone through significant delays. These delays have been caused by planning difficulties as well as delayed payments to the contractors by TANESCO. Since similar delays most often are associated with additional costs, it is important to minimise payment delays. This is an important task for the future.

According to TANESCO the delays have mainly been caused by outage scheduling problems due to load demands. As a result, the delays have resulted in additional costs and inefficient use of existing hydropower resources due to limited generating capacity.

Another important explanation to project delays are late payments to the contractors from TANESCO. These delays have not only created an extra workload for the contractors. They have had a negative impact on the timely performance of ongoing work efforts. During the course of the assignment, significant efforts have been made to establish appropriate payment procedures, through direct contacts by the contractors as well as the owner's engineer. Unfortunately, these efforts have not led to any improvements. The reasons for these delays have not been explained by TANESCO. There are however no indications that they have been connected to any disapprovals regarding performed tasks. The inadequate payment discipline can neither be explained by a lack of formal complaints. The issue has been extensively handled at relevant project meetings.

9.4 Closing remarks and recommendations

Sufficient knowledge and workmanship is of essential importance when it comes to the operations and maintenance of hydro power plants. Incorrect repairs or operations can be devastating for the plant and can cause human injuries and casualties. The ability to preserve and develop the required skills and diligence of the operational staff is therefore of highest priority. This Capacity Building activity has been very beneficial for TANESCO in this sense. In addition, management skills regarding procurement and contract management have been significantly improved. What remains important is to sustain current standard and ensure a succession of the knowledge to cover natural staff turnover and to spread this expertise within the organization. As an example, internal workshops within selective fields can be arranged for e.g. dam safety issues and other emergency situations. Based on these observations the development of a training facility should be seriously considered. There are several way to do so, either in cooperation with the KGRTC in Zambia and / or the Kikuletwa Hydropower Training Centre in Arusha.

The importance of regular preventive maintenance cannot be overemphasized. In general, there is a good understanding of these issues at TANESCO. It should however be noted that there are some quite important maintenance efforts that are currently being pushed forward in time because they would require the complete shutdown of the effected hydropower units for more than a week, or in some cases the whole power plant. In the worst of cases, this reluctance could lead to e.g. a pipe break and a flooded hydropower station that can result in a number of month's downtime. It is therefore still very important to push for these issues and to continue raising awareness not only to maintain efficient power production but also to expand the generating units overall life expectancy.

A structured long-term maintenance-planning program with approved budgeting for purchasing of necessary spare parts and consumables is of highest importance in order to achieve sustained operations at the hydro power plants. Such procedures need to be significantly improved within the TANESCO organisation. A major step in this direction would be the full implementation of CMMS in all hydro power plants. This will however require additional training among existing staff with significant emphasis on detecting and repairing equipment irregularities. An additional component is how to include remedy actions in the preventive maintenance planning of the hydro power plants.

Through the emergency repair project, the five hydro power plants will once again be operational at its full capacity. It should however be emphasized that this situation will degrade over time if the required maintenance measures are not taken seriously. TANESCO has a "wish-list" of systems and equipment to be repaired and/or replaced in the hydro power plants. Some of these items were intended to be included in the ERP but were for various reasons excluded from the final scope. From a capacity perspective, TANESCO has the skills to perform these tasks without extensive external support. The main issue is if the required financial means can be allocated for this work. In the longer perspective, a more extensive rehabilitation and upgrading project for each of the hydro power plants will be needed to ensure a long-term high plant availability.

10 APPENDIXES

10.1 Cooperation area 1 – Emergency Initiative Management

OBJECTIVE: Assist TANESCO for emergency upgrading and immediately training of the personnel (see Annex 5).

INPUT	ACTIVITY	OUTPUT	OUTCOME
• Well informed, qualified, independent expertise • Motivated and engaged TANESCO personnel • Funds • Administrative systems as done by suppliers/ consultants/ or support	• Develop priority list for emergency initiative for all hydropower plants • Emergency rehabilitation of hydropower plants according to priority list • Preparation of immediate training needs analysis and emergency plan • Conduct emergency training programs and workshops.	• Improved conditions in TANESCO's hydropower plants according to priority list • TANESCO staff trained according to emergency training plan • Tailor-made courses for administration staff planned.	• Some hydropower plants rehabilitated to sustainable standard • Improved operational efficiency of TANESCO's hydropower plants
• INDICATORS	•	• At least 3 of hydropower plants rehabilitated to good operation condition • At least 10 persons attended training at different levels. • Emergency work for 5 hydropower plants carried out • Internal procedures made	• At least 10 % increase of electricity generated from hydropower • Operational cost (USD/kWh sold)

10.2 Result chain for cooperation area 2: Capacity building at TANESCO

OBJECTIVE: To Increase professional level and knowledge of the staff at TANESCO, and sufficient capacity to reach the goals set in the Power Sector Reform Strategy (PSRS), (see Annex 5).

INPUT	ACTIVITY	OUTPUT	OUTCOME
• Well informed, qualified, independent expertise • Motivated and engaged TANESCO personnel • Funds • Administrative systems and/or support	• Preparation of a capacity needs assessment, including assessment of existing training facilities • Preparation of capacity building and recruitment plan based on the capacity needs assessment including measures to ensure an appropriate gender balance • Planning and execution of seminars, workshops and training programs, including on-the-job training • Preparation of plan for upgrading of training facilities and workshops based on the needs assessment • Upgrading of training facilities and workshops according to plan including procurement of necessary tools • Support for scholarships and other targeted actions to recruit qualified people to the sector	• Staff trained according to capacity building and recruitment • Training facilities upgraded to appropriate level • Operation and Maintenance procedures prepared and implemented	• Capacity of TANESCO staff increased, especially within operation and maintenance • Staff recruited according to capacity building and recruitment plan
INDICATORS	•	• At least 6 TANESCO personnel trained according to capacity building plan • At least 60% of capacity building activities planned and executed according to the capacity building plan • Well-functioning O&;M procedures	• Number of employment contracts signed as a result of recruitment process according to recruitment plan • Number of turnover employees reduced by 10% • 75% of capacity building plan fulfilled

10.3 Training activities performed to date

The following training has been performed as local or overseas training to date:

1. PLC system
2. DC system
3. Dam safety
4. Contract Management and negotiation skills
5. Computer skills
6. Excitation system
7. Electro-hydraulic governor system

The number of participants for the training from each plant were as follows:

S/N	Course title	KIDATU	MTERA	KIHANSI	PANGANI	TOTAL
1	PLC (T)	3	3	3	2	11
2	DC System (T)	4	4	6	5	19
3	Dam safety (ICH, Norway)	1			1	2
4	Contract Management and negotiation skills (T) – experts from SA)	3	3	3	3	12
5	Computer skills (further info to be provided, T)					
6	Excitation system (T, local expats)	6	4			10
7	Electro hydraulics governing system (ICH, Norway)	4	3	3	3	13

T TANESCO location (by ICH, TTS/ KGRTC and experts from South Africa)
ICH International Center for Hydropower, Trondheim, Norway

10.4 On-the-job training activities performed to date

The following training activities was performed as on-the-job training:

1. CMMS Jobtech (computer maintenance management system).
2. Governor hydraulics fault tracing.
3. Operation and maintenance of electronic turbine governor. Fault tracing technique and interpretation of systems parameters.
4. Maintenance of AVR (static excitation system)
5. Operation and maintenance of chiller Plant. Fault tracing technique and interpretation of systems parameters

These training activities were performed at different power plants mainly in connection with the ERP finalization, testing and recommissioning of the plants. The number of participants for the training from each plant were as follows:

S/N	Course title	KIDATU	MTERA	KIHANSI	PANGANI	TOTAL
1	CMMS Jobtech	14		12		26
2	Governor hydraulics fault tracing		5			5
3	Operation and maintenance of electronic turbine governor. Fault tracing technique and interpretation of systems parameters			16		16
4	Maintenance of AVR				17	17
5	Operation and maintenance of chiller Plant. Fault tracing technique and interpretation of systems parameters			6		6

10.5 Indicators

a) Number of turnover employees reduced by 10 %

Currently, it is somewhat early to evaluate this indicator. In addition, the TANESCO employee turnover for the related group of staff for the last 5 – 10 years should be made available.

b) Increased number of staff with 10 persons

There is a continuously recruitment of technical personnel to TANESCO's hydro power plants. The following number of recruitments has been made during the last years:

Kidatu HPP: 2013 – 4
2014 – 9
2015 – 2
2016 – 2

Mtera HPP: 2015 – 3
2016 – 5

Kihansi HPP: 2013 – 1
2014 – 5
2015 – 4
2016 – 3

Nyumba ya Mungu: N/A

New Pangani Falls: N/A

In total, a number of 38 technicians were recruited to Kidatu, Mtera and Kihansi HPPs during the last 4 years. In order to determine overall turnover the numbers of how many technicians that have left should be made available.

Kidatu HPP

YEAR		TOTAL NUMBER OF EMPLOYEES		TOTAL NUMBER OF SEPARATIONS	
	TOTAL	MALE	FEMALE	MALE	FEMALE
2013	103	81	22	Nil	Nil
2014	100	75	25	6	1
2015	104	80	24	4	Nil

Mtera HPP

YEAR		TOTAL NUMBER OF EMPLOYEES		TOTAL NUMBER OF SEPARATIONS	
	TOTAL	MALE	FEMALE	MALE	FEMALE
2013	75	60	15	3	1
2014	74	60	14	2	0

11 ANNEXES

- Annex 1 - End-review ERP - Meetings
- Annex 2 - Training Packages
- Annex 3 - Gender Policy for NVE institutional programs
- Annex 4 - Programme Document (November 2010)
- Annex 5 - Emergency Repair Project 2011-2012 (April 2011)
- Annex 6 - MTERA Inspection Report
- Annex 7 - 2014-06 Tanzania Electricity Supply Industry Reform Strategy & Roadmap
- Annex 8 - Terms of Reference - End-review of Capacity Building and Emergency Repair of Hydropower Plants