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**Draft**

**UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION**

**AND**

**Ministry for Energy and Minerals (MEM)**

**The UNITED REPUBLIC of TANZANIA**

**Under GEF funded project on**

***Mini-Grids Based on Mini/Micro Hydropower Sources***

Report on

# Developing Institution for SHP Promotion in Tanzania

**August 2012**

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Report on

# Developing Institution for SHP Promotion in Tanzania


**Dr ARUN KUMAR**

International Expert (MHP)


August 2012

# EXECUTIVE SUMMARY

UNIDO/GEF project has been launched to create an environment favorable for implementation of a project to demonstrate SHP based mini-grids for rural electrification in Tanzania. The purpose of this study is to prepare a detailed feasibility report for establishing a SHP Technology Centre at the College of Engineering and Technology, University of Dar es salaam (UDSM), This Centre will build capacity to develop Small Hydropower (SHP) potential in Tanzania. It shall have a business plan including proposed structure and systems, recommendations for short medium and long term work plan, capacity building plan, list and specifications of instruments / equipments and other important items. The study shall also cover the necessary recommendations and plan for local fabrication of small scale turbines including potential technology transfer plans, capacity building needs and operational structures.

The Government of Tanzania is encouraging investment to expand generating capacity, distribution system and develop indigenous sources of energy.Tanzania has rain fed agriculture. TANESCO, a utility owned by Government of Tanzania, is responsible for all power functions in Tanzania.

At present, the expertise of the technical institutions on micro / mini hydropower based mini-grid is inadequate resulting in difficulty to sustain and replicate the micro / mini hydropower based mini-grid projects in the country.

SHP Technology Centre at the College of Engineering and Technology is proposed to be set up. The centre shall impart training in subjects directly relevant to SHP development. The centre shall provide technical assistance to develop 3.2 MW of hydropower on identified sites for demonstration of micro/mini/ small hydropower based mini-grids under the UNIDO/GEF financed programme.

The centre shall have structure comprising (a) education, training and research division and (b) advisory and technical services for surveys & investigations, feasibility reports, procurement specifications, engineering design for construction and operation of demonstration projects and equipment manufacturing. Necessary licenses will be arranged for the trained local fabricators to manufacture micro / mini hydropower equipments.

Support of existing instrumentation and workshops /laboratories of COET is desirable for the speedy and sustainable establishment of SHP Technology Centre.. This support to SHP Technology Centre may be on chargeable basis to advisory project/activity. Use of existing building for office and labs and creating additional space for SHP Technology Centre including renovating some existing space in CoET has been planned.

Faculty interested/committed to working in the field of SHP development shall be invited to engage themselves, depending on their expertise and interest, in various areas of small hydropower development. Additionally centre also requires full time staff (engineers, scientist, technicians etc).

There are some existing courses being offered at UG and PG level which may be suitably modified to give a focused learning for small and large scale hydropower.

There are a few specialized international institutions working for small hydropower development and their cooperation and support may be sought.

For establishing SHP technology centre and strengthening the existing Technology Development and Transfer Centre (TDTC) with equipment/machines, requirements for office equipments, computer and peripherals, design office, site investigations, surveys instruments and workshop have been worked out along with their specifications and costs.

CoET faculty with the support of international experts and turbine manufacturers may engage in developing and improving the design of turbines as standard products, Turbines of a few standard sizes and their adaptability / variability to suit the specific sites may be carried out by researchers at SHP technology centre. Training in this vital area will also be imparted to produce technical manpower.

Financial sustainability of SHP technology centre is proposed through activities e.g. training and capacity building, providing consulting services, project monitoring by independent experts, other activities that are involved in SHP development. Estimates of resource generation by carrying out a number of project activities as planned by the SHP Technology centre have been worked out and sustainability has been demonstrated.

Success of the centre will depend on team work, utilizing the existing facilities and expertise within and outside CoET and networking with the institutions for offering a comprehensive service support to the project developer.

The SHP Technology Centre is proposed to consider creating partnership with the Govt. Sector/ private sector / organizations to install facilities for simulation of actual SHP plants and the mini grids to be used for educational and training programmes, testing of SHP projects including turbines and other equipments and distance training in due course of time.

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| | |
|---|---|
| AHEC | Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee |
| CDM | Clean Development Mechanism |
| CoET | College of Engineering and Technology, University of Dar Es Salaam |
| EWURA | Energy and Water Utilities Regulation Authority, Tanzania |
| NORAD | Norwegian Agency for Development |
| GEF | Global Environment Facility |
| ICT | Information and Communication Technology |
| MEM | Ministry of Energy and Minerals, Govt. of the United Republic of Tanzania |
| MHP | Micro or mini hydro power |
| NGO | Non-Governmental Organization |
| PPA | Power Purchase Agreement |
| REA | Rural Energy Agency |
| REF | Rural Energy Fund |
| SHP | Small Hydro Power |
| SME | Small and Medium-Sized Enterprises |
| SPP | Small Power Project |
| SPPA | Standardized Power Purchase Agreement |
| SPPT | Standardized Power Purchase Tariffs |
| TANESCO | Tanzania Electric Supply Company |
| TDTC | Technology Development and Technology Transfer, CoET |
| UDSM | University of Dar Es Salaam |
| UNDP | United Nations Development Programme |
| USAID | United States Agency for International Development |
| UNIDO | United Nations Industrial Development Organisation |
| VETA | Vocational Education Training Authority |

# DEVELOPING INSTITUTION FOR SHP PROMOTION IN TANZANIA

## 1. BACKGROUND

Tanzania has a population of about 42 million. Less than 18% of its population has access to electricity from the national grid. About 75% of the population lives in the rural areas and only 2 % have access to electricity. The Government of Tanzania has placed rural electrification on its agenda for the promotion of which a number of measures have been taken including setting of Rural Energy Agency and Rural Energy Funds.

The country has areas which have perennial rivers and streams and steep drops and has high potential to generate hydropower. The estimated potential of hydropower is 4700 MW. In 2010 out of the total installed capacity of 1075 MW, the share of hydropower was 562 MW. The estimated potential of small hydropower (SHP) is between 300MW and 500 MW out of which only 24 MW has been developed so far by both the government and private sector. The national energy policy was reviewed in 2003, which provides for, among others, the development and utilization of indigenous renewable energy resources and technologies.

UNIDO/GEF project has been launched to create an environment favourable for implementation of several SHP projects. The project has following components:

a) Develop a total 3.2 MW installed capacity of hydropower on identified sites for demonstration of micro/mini/ small hydropower based mini-grids.
b) Join the government efforts in conducting techno-economic feasibility studies and prepare technically feasible and commercially viable SHP projects.
c) Build Capacity of stakeholders in developing micro/mini/small hydropower based mini-grids. For this purpose establish a SHP Technology Centre at College of Engineering and Technology (CoET).
d) Develop viable business models for micro-mini hydropower based mini-grids.

## 2. PURPOSE OF THE STUDY

The purpose of this study is to prepare a detailed feasibility report for establishing a SHP Technology Centre at the CoET, which shall have a business plan including proposed structure and systems, recommendations for short medium and long term work plan, capacity building plan, list and specifications of instruments / equipments and other important items. The study shall also cover the necessary recommendations and plan for local fabrication of small scale turbines including potential technology transfer plans, capacity building needs and operational structures.

The aim of this UNIDO/GEF project is to enable the country to use small hydropower based mini-grids to their potential for meeting the energy needs, especially of the rural areas, and for this purpose enhance indigenous capacity to prepare feasibility and detailed project reports undertake designing and implementation as well as operation and maintenance of SHP projects and to ensure their financial and technical sustainability. This report briefly covers items that help to place the capacity building programme in its social, economic and geographical aspects. One of the major outputs of the project is the establishment of SHP Technology Centre at the CoET, University of Dar-es-Salaam. Further an institution is to be identified that will undertake the manufacturing of turbines locally.

A mission to Dar es Salaam was undertaken by the international SHP expert during the June 06 to 11, 2012.

# 3. ABOUT TANZANIA

## 3.1 Location

The United Republic of Tanzania is located in Eastern Africa between longitude 29° and 41° East, Latitude 1° and 12° South. It has frontiers with: Kenya, Uganda, Rwanda, Burundi, Democratic Republic of Congo, Zambia, Malawi and Mozambique as shown in the Fig. 1.


**Fig. 1: Tanzania and nieghbouring countries**

The country has land area of 945,749 square km housing an estimated population of 41.9 Million (July 2010). The per capita GDP is USD 1,400 (2009). The population living in rural areas is about 75% (estimated in 2008). About 36% (estimated 2009) population lives in poverty. The per capita electricity consumption is about 46 kWh per annum which is growing at 13% per annum (Tanzania National Website; http://www.tanzania.go.tz/energy.html

## 3.2 Geography

Tanzania has the largest (land area) among the East African countries (i.e. Kenya, Uganda and Tanzania). It has pristine sandy beaches and Africa's highest and snow-capped mountain, Mt. Kilimanjaro. Tanzania is home to the world famous National Parks and Game Reserves. Administratively, Tanzania is divided into 30 regions, with 25 on the mainland, 5 on Zanzibar (3 on Unguja Island, and 2 on Pemba Island). The centre of Tanzania is a large plateau, which is part of the East African Plateau. The southern half of this plateau is grassland within the Eastern Miombo woodlands eco region, the majority of which is covered by the huge Selous National Park. Further north the plateau is arable land and includes the national capital, Dodoma.

Dar es Salaam is the commercial capital and major sea port for Tanzania Mainland and it serves neighbouring land-locked countries of Malawi, Zambia, Burundi, Rwanda, and Uganda, as well as Eastern DRC. Other sea ports include Zanzibar, Tanga, and Mtwara.

### 3.3 Climate & Rainfall

Tanzania has a tropical climate. It has two major rainfall regions i.e., unimodal (December - April) and bimodal (October -December and March - May). The former is experienced in southern, south-western, central and western parts of the country, and the latter is found to the north and northern coast. Tanzania's annual rainfall varies from 500-1,000 mm over the majority of the country with a national mean annual rainfall of 1,071 mm, but there is significant sub-regional variation: the Lake Tanganyika basin and the southern highlands can receive up to 3,000 mm annually (FAO, 2005) while about half the country receives less than 762 mm annually (Shemsanga et al., 2010). Rainfall map of Tanzania is given below at Fig. 2 .

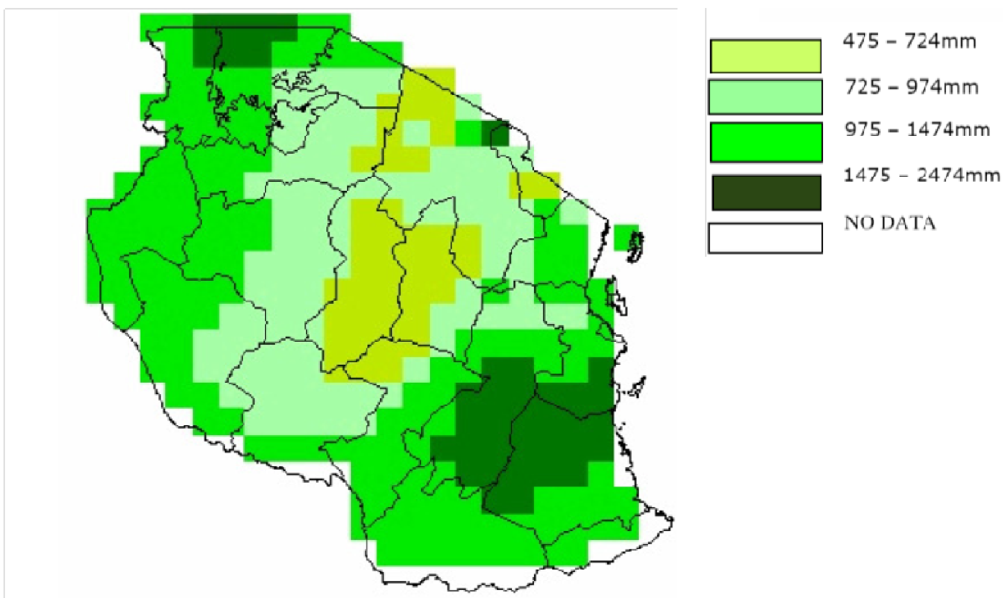


**Fig. 2: Annual Average Rainfall pattern in Tanzania**

### 3.4 Water Resources

Tanzania has sufficient water resources to meet most of its present needs. They include surface and underground sources. About 7 percent of the land surface is covered by 3 lakes viz Victoria (second largest fresh water lake in the world), Lake Tanganyika (second deepest lake in the world) and Lake Nyasa. There are also big rivers flowing to the lakes. Underground water is also another important source of water for both urban and rural settlement areas.

### 3.4.1 Surface Water

Surface water resources in Tanzania consist of lakes, rivers, springs, man-made reservoirs and natural ponds. The map below shows the river basins in Tanzania (Fig. 3).

About 50% of the surface run off water is derived from the main rivers flowing directly to the Indian Ocean and some of these are: Pangani, Wami, Rufiji and Ruvuma. The remaining 50 percent is divided into surface water drainage into the main internal drainage basins which have no outlet to the sea (Lake Rukwa, Bubu depression complex, Lake Eyasi and Lake Manyara), others flowing into lake Victoria (Meri, Maru and Kagera rivers), River Malagarasi draining into Lake Tanganyika and rivers Songwe and Ruhuhu draining southwards into Lake Nyasa Zambezi River system.

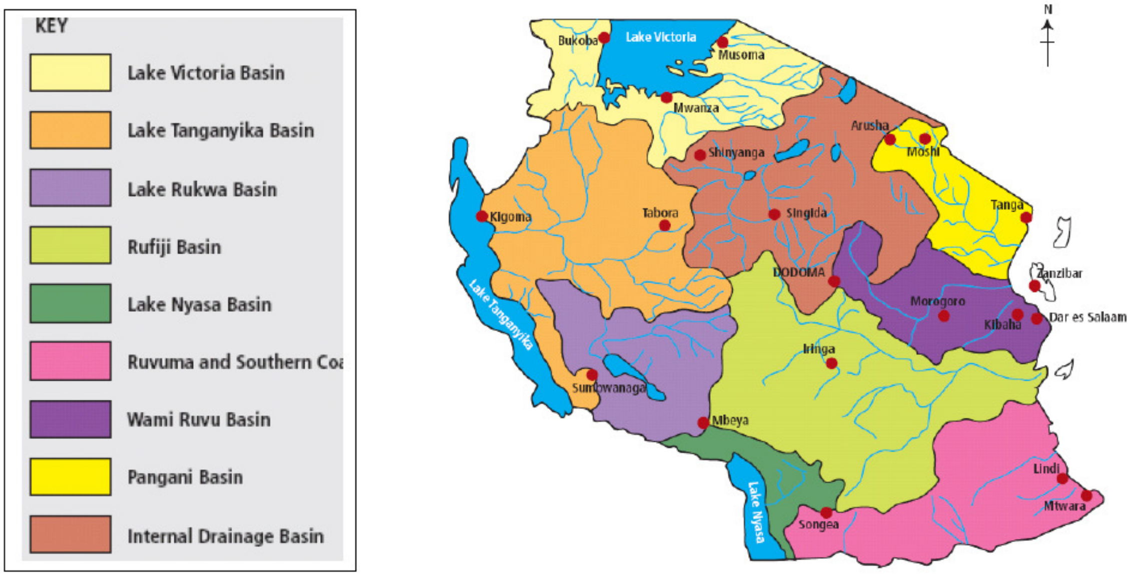


**Fig. 3: Water basins in Tanzania**

### 3.4.2 Water Management

The Government established Basin Water Offices for example, in the Pangani, Rufijiriver , Internal Drainage and Eyasi, Manyara and Bubu from the year 1991 onwards.. There are a total 362 hydrometric stations (river gauging), 135 meteorological stations, 289 rainfall stations and 269 ground water station in Tanzania. River basins and lake wise their distribution has been presented in table 1.

**Table 1:Water Resources Monitoring Network in Tanzania (Water Sector Status Report 2010)**

| S. No. | Water basin | Hydrometric stations (No.) | | | Meteorological stations (No.) | Rainfall stations (No.) | Ground water stations (No.) |
|---|---|---|---|---|---|---|---|
| | | Fair condition | Rehabilitation | Total network | | | |
| 1. | Pangani river | 15 | 53 | 68 | 15 | 41 | 43 |
| 2. | Rufiji river | 20 | 71 | 91 | 18 | 0 | 27 |
| 3. | Wami-Ruvi river | 25 | 10 | 35 | 47 | 33 | 45 |
| 4. | Lake Victoria | 4 | 19 | 23 | 14 | 46 | 56 |
| 5. | Internal Drainage | 0 | 37 | 37 | 11 | 100 | 30 |

| S. No. | Water basin | Hydrometric stations (No.) | | | Meteorological stations (No.) | Rainfall stations (No.) | Ground water stations (No.) |
|---|---|---|---|---|---|---|---|
| | | Fair condition | Rehabilitation | Total network | | | |
| 6. | Lake Rukwa | 0 | 23 | 23 | 8 | 8 | 6 |
| 7. | Lake Tanganyika | 2 | 32 | 34 | 14 | 45 | 15 |
| 8. | Lake Nyasa | 2 | 28 | 30 | 5 | 12 | 17 |
| 9. | Ruvuma and Southern Coastal Rivers | 2 | 19 | 21 | 3 | 4 | 30 |
| | **Total** | **70** | **292** | **362** | **135** | **289** | **269** |

### 3.5 Energy

Petroleum, hydropower and coal are the major sources of commercial energy in the country. The biomass energy resource, which comprises fuel-wood and charcoal from both natural forest and plantations, accounts for 93 per cent of total energy consumption. Petroleum is imported. The transport sector is the main consumer of petroleum products. However natural gas is available.

Electricity subsector contributes about 0.6 per cent of total energy consumption. Electricity is mainly generated from hydropower and recently thermal power stations have been installed. There are plans to connect with neighboring countries of Zambia and Uganda to the national grid to boost the supply of electricity. Only three quarters of the country (mainly urban areas) is connected to the national grid. It is intended that the rest of the country, including an estimated 8,200 villages be supplied with electricity to check deforestation. In addition there are plans to supply power to Kenya and Malawi from Tanzania.

Tanzania has per capita electricity consumption of 46 kWh per annum and is growing at the rate of 11 - 13 per annum. The government is encouraging investment to expand generating capacity, distribution system and develop indigenous sources of energy.

There are other indigenous alternative sources of energy which include coal. Tanzania has 1,200 million metric tons of Coal, which could provide energy for paper mills, cement factories, agriculture and household consumption, and generation of power. Wind and solar are other sources of energy but have not been developed. Very little attempt has been made to develop these sources of energy.

Tanzania has rain fed agriculture. Food crop production dominates the agriculture economy and 5.1 million ha. are cultivated annually, of which 85 percent is under food crops. It should, be leaving a large amount of agricultural residue in the form of straw and stalk, which has the potential of being converted to fuel, electricity and ethanol.

TANESCO, a utility owned by Government of Tanzania, is responsible for all power generation functions in Tanzania. There are a few power projects now owned by independent power producers (IPPs) which feed the National grid and isolated areas as well. TANESCO's generation system consists mainly of Hydro and Thermal based generation. Hydropower contributes 73% of total power generated during 2009–10. Gas and Thermal contributed the remaining amount. During the year 2010 the total units generated to the grid and isolated plants were 4,938 million units. Present electricity generation in Tanzania (TANESCO document) in presented in table 2.

**Table 2: Present Electricity Generation in Tanzania (2010)**

| | |
|---|---|
| Hydro generation – grid | 562 MW |
| Thermal – grid | 444 MW |
| Diesel/NG/Coal – off grid | 54 MW |
| Imports – (Zambia, Kenya, Uganda) | 15 MW |
| Total | 1075 MW |

Projected Energy Mix by the year 2025 has been assessed under master plan studies by TANESCO and is given in Fig. 4.

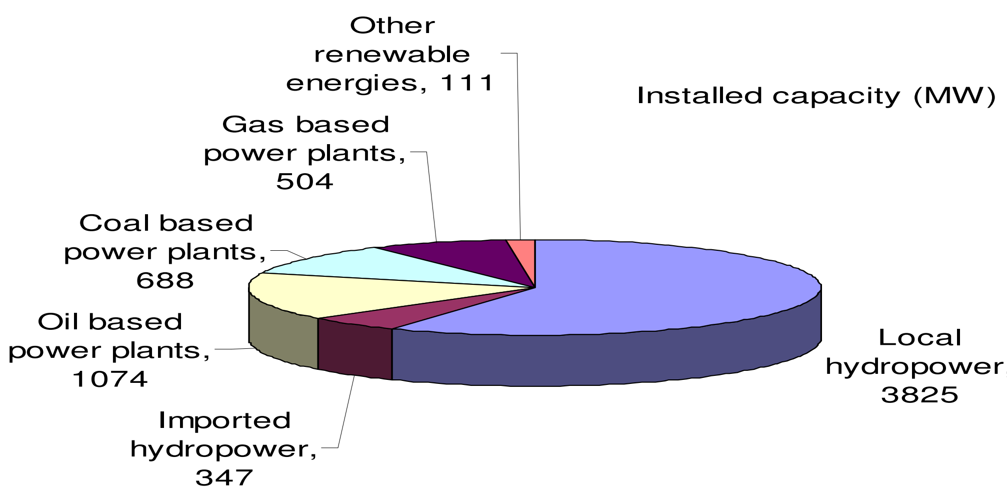


**Fig. 4: Energy Mix by the year 2025 in Tanzania**

Electricity network of Tanzania existing as well as planned is shown in Fig. 5.

## 3.6 Hydropower

### 3.6.1 Potential and Plants

In Tanzania, Hydropower Potential is estimated as over 4,700 MW and it is concentrated mainly in six river basins. Rufiji River Basin covers 20% of the total national area. Pangani River Basin covers areas from northern highlands and peaks of Mt. Meru and Mt. Kilimanjaro to Pare Mountain Ranges. Kagera River Basin drains to Lake Victoria whereas Malagarasi River Basin drains to Lake Tanganyika. Rumakali River Basin drains to Lake Nyasa and Ruvuma and River Basin is contiguous border river between Tanzania and Mozambique

As per TANESCO Master Plan studies (2009), the potential of hydropower up to 3,000 MW is proposed to be developed by the year 2025 with 12 large hydropower plants with capacity ranging from 1200 MW to 8 MW.

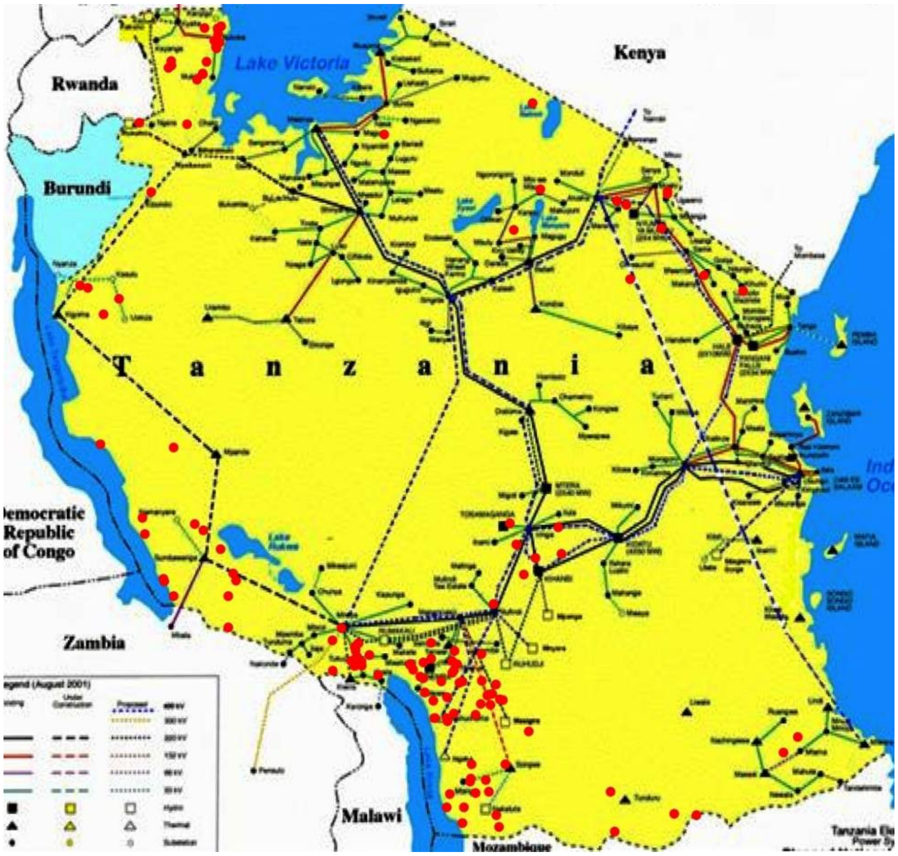


**Fig. 5: Electricity GRID Network in Tanzania**

### 3.6.2 Classification of Hydropower Projects

Hydropower classification as followed in Tanzania is given as below:

Medium and Large above 10 MW
Small = 2.0-10.0 MW
Mini = 0.5-2.0 MW
Micro < 0.5 MW

## 3.7 Hydropower Development in Tanzania during Different Periods

Historical development of Hydropower in Tanzania can be broadly grouped into 3 periods with varying pace of development. First group may be Colonial era to pre Ujamaa (socialism) before1967 when only a few namely Mandera, Kikuletwa (1.16 MW), Tosamaganga (1.2 MW), & Mbalizi (0.3 MW) small hydro plants were installed. Data on these projects is not reliable but these plants are associated with cash crops and missionary churches. The second period as Post independence and pre reforms era from 1967 to 1992 has Nyumba ya Mungu (8MW), Uwemba (0.8MW) and a few missionary churches based small hydro. However there was an overall decline in SHP development from the government side during this period. Private sector was also inactive. Donor institutions funded Studies in Rukwa, Kigoma, Mbeya and Ruvuma river basins. Thereafter period known as Liberalization period (1992-present) has seen several policies, legislative support for SHP development. A master plan for rural electrification was developed. Private sector participation was encouraged. Several efforts were made for SHP identification/ reconnaissance Studies in the country. Government has gone for demonstration projects. A few private sector projects namely Suma (tea), Mwenga, Mufindi, Ndolela, Luhololo (tea), Pwagu-Njombe etc were developed. Plantations, farms and factories were privatized.

## 3.8 SHP Potential

134 Sites having a potential of 300 MW have been identified. Only 15.47 MW has been developed so far. Locations of these plants have been shown in Fig. 6. These 134 sites were further classified on the basis of head and discharge and is given in the table 3. In a recent reassessment of SHP potential, sites with potential capacity of 485 MW have been identified for small scale hydropower (up to 10 MW). The details of the new assessment are yet to be published.

**Table 3: Categorisation of 134 SHP identified SHP sites**

| Head | | Discharge | |
|---|---|---|---|
| meters | **% of sites** | **$m^3$ per sec** | **% of sites** |
| < 10 | 4 | < 1.5 | 33 |
| 11 to 50 | 43 | 1.5 to 5 | 32 |
| 51 to 100 | 21 | 6 to 10 | 12 |
| 101 to 200 | 22 | 11 to 20 | 12 |
| ➢ 200 | 21 | >20 | 11 |

### 3.8. 1 Identified SHP Potential Sites

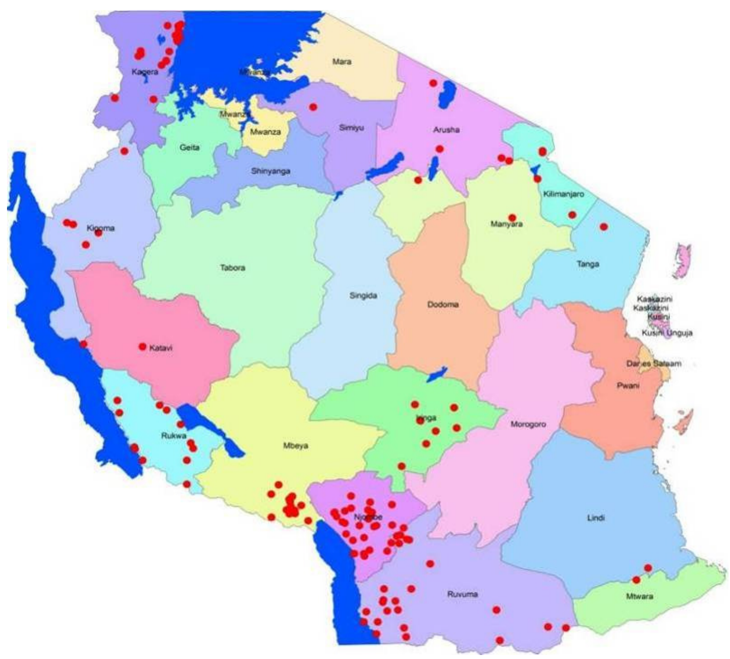


**Fig. 6: SHP Potential Sites (134 nos. for 300 MW) in Tanzania**

There are several existing weirs and small dam which may be developed for small scale hydropower even if these are seasonal in generation. These may be developed in hybrid mode preferably along with biomass gasifier, failing which, diesel. A typical weir site in Tanzania may be seen at Fig. 7. The potential capcities of these sites are yet to be assessed as these types of sites were not developed in Tanzania. SHP projects on these sites will have minimum adverse environmental impact, will need short time for planning, issue of licenses and execution and obtaining funds and, therefore, can be developed easily. Many of them are close to load centres and thus shall be economically viable as long and expensive transmission lines are avoided. In India and Nigeria (Essan 2012) these have been developed very successfully. Typically these may be developed as shown in Fig. 8.

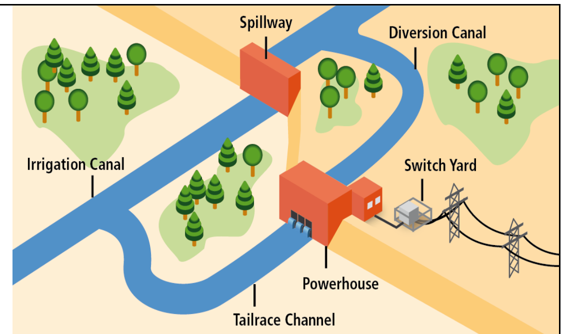


**Fig 7: Typical Existing weir in Tanzania– Possible Development for SHP**
(Water Sector Status Report 2010)

**Fig. 8: Typical Some Existing Dam Toe/weir Type SHP**
(**Source:** Kumar et.al. 2011 IPCC)

The discussion above shows that mini grid based on renewable energy, particularly small hydropower in areas where there are perennial streams and rivers with the desired head, can provide electricity to the rural population and meet their energy needs. As stated earlier, in areas where the streams are not perennial they need to be developed in hybrid mode with biomass energy. Certain barriers have been identified and are being addressed.

Small hydropower sites mostly shall be run of river type in Tanzania as shown in Fig. 9. However, some existing weirs, dams may also be developed for SHP as shown in Fig. 10.

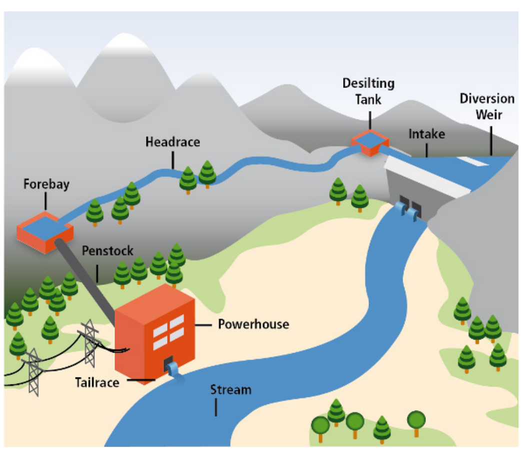


**Fig. 9: Typical Run of River Type SHP**
(**Source:** Kumar et.al. 2011 IPCC)

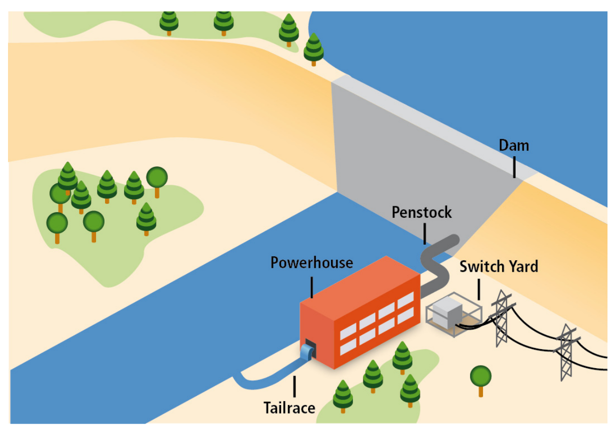


**Fig. 10: Typical Existing Canal / Weir Type SHP**
(**Source:** Kumar et.al. 2011 IPCC)

## 3.9 Legal Framework for Small Scale Hydropower

Important acts, policies and legal framework relevant to Small scale Hydropower Development in Tanzania are as follows:

- National Land Policy (1995)
- National Environmental Policy (1997)
- National Wild Life Policy (1998)
- National Forest Policy (1998)
- Land Regulation (2001)
- Energy and Water Utilities Regulatory Authority (EWURA) Act, 2001.
- Water Policy (2002)
- National Energy Policy (2003).
- Environmental Management Act, 2004.
- EIA and Audit Regulations (2005)
- Rural Energy Act, 2005.
- Electricity Act, 2008.
- Standard Small Power Purchase Agreement and Tariff (SPPA/T) for small Power Producers up to 10 MW, 2012.

The details of these acts and policies may be seen from the websites of respective ministry/organisation. Small scale power producers (SPP) are being encouraged in new policy regime. An installed capacity of about 50 MW is being developed for which power purchase agreement have been signed with TANESCO. SPP hydropower developers as per TANESCO records who signed agreement are Mwenga – Mufindi (3 MW), Mapembasi – Njombe (10 MW), AHEPO – Mbinga (1 MW), EA-Power – Tukuyu (10 MW), St. Agnes – Songea (7.5 MW), Kikuletwa II Kilimanjaro (7 MW) and Darakuta Mini Hydro (0.88 MW).

## 3.10 Barriers to SHP Development in Tanzania

On the basis of several studies, barriers have been identified that come in the way of improving the rural energy situation in Tanzania. These include the following:

a) Inadequate technical capacity including human resource and institutions needed for energy development, particularly SHP and for carrying out tasks such as:
    - planning for energy,
    - undertaking survey and investigation,
    - preparing feasibility and detailed project reports,
    - designing of works,
    - project implementation,
    - operation and maintenance and evaluation of projects.
b) Lack of programme, plans and projects for rural energy development.
c) Lack of a shelf of feasibility reports for early take off by the private sector
d) Absence of indigenous manufacturing capacity of turbines, generating and related equipment
e) Lack of integration of SHP with biomass and other renewable energy based power plants for hybrid configuration.
f) Insufficient awareness and participation of community and lack of experience sharing
g) Lack of Feed-in-tariff (FiT) to promote the RE based electricity generation

h) Low power plant factor resulting in high electricity/generation cost
i) Low demand for commercial and industrial power resulting in low purchasing power of the target communities in the rural areas
j) Low grid availability to the potential sites

Out of these barriers actions for mitigation of two barriers namely inadequate technical capacity for developing small hydropower and absence of capacity for fabrication of equipment including technology transfer are addressed and appropriate measures proposed in this assignment report.

### 3.11 Rural Energy Agency

The Rural Energy Agency (REA) was established by the Government as an institutional framework to mobilize, coordinate and facilitate private and public initiatives. It was started in October, 2007 and provides enabling regulatory framework. It has developed standardized small power purchase agreements (SPPAs), standardized small power purchase tariffs (SPPTs) and issued simplified regulations for SPPs and comprehensive guidelines for project developers. It also provides matching grants for pre-investment activities, for technical and market studies, technical assistance to sector institutions, financial institutions, project developers and arranges Carbon finance training. Eligible projects supported by the REA include both grid extension and off-grid projects. The small hydropower (supply into main grid & distr. net., supply to mini grid & distr. net, supply into main grid, supply into mini grid and green field), solar packages/solar lanterns; wind; biomass; and energy efficiency are also covered for REA support..

### 3.12 Regulatory Support for SHP Development

Energy and Water Utilities Regulatory Authority (EWURA) The Government of Tanzania (GoT) through the Ministry of Energy and Minerals (MEM) and in collaboration with the World Bank during 2007 adopted the Standardized Power Purchase Agreements (SPPA) and Standardized Power Purchase Tariffs (SPPT) for interconnecting and selling power to the Main grid and Mini-grids in Tanzania. The Standardized Tariff is adjusted annually. Tariff for the year 2012 for the sale of electricity announced in Feb 2012 by EWURA is 152.54 TZS/kWh for main grid connected and 480.50 TZS/kWh for mini grid connected projects. (1 USD= 1580 TZS).

## 4. CAPACITY BUILDING FOR SHP DEVELOPMENT

As mentioned above inadequate technical capacity is one of the main barriers for SHP development. A project for capacity building for SHP is proposed as below:

### 4.1 Purpose

The purpose for capacity building is to create institutional mechanism for developing capacity involving human resource development and capacity to manufacture turbines and other equipments for exploiting the potential of Micro/Mini/Small hydropower in Tanzania and provide electricity to the rural population based on mini-grids.

### 4.2 Goal

The above purpose is to be achieved through the following measures

a) Set up a National Small Hydropower Technology Centre at the CoET, University of Dar es salaam (UDSM) which may perform the following functions

   i. Provide technical assistance to develop 3.2 MW of hydropower on identified sites for demonstration of micro/mini/ small hydropower based mini-grids under the UNIDO/ GEF financed programme. Technical assistance may involve all the needed help in surveys and investigations, preparation of feasibility reports, design of civil, electrical and mechanical equipment, local manufacture / fabrication of turbines and other equipment for SHP projects, implementation of projects, developing the needed manpower for implementation as well as operation and maintenance of SHP projects.
   ii. Create institutional capacity for providing technical education and training to the Tanzanian people so that the country has adequately educated and trained manpower. This trained manpower may be available in the country so that the Mini/Micro/Small Hydropower Development Plan prepared for the year 2025 can be realized and subsequently all estimated potential (300 to 500 MW) can be developed. Suitably educated and trained professionals in the following disciplines, among others will be needed.

      - carrying out surveys and investigations and preparing feasibility reports
      - detailed designing of civil, electrical and electro-mechanical works,
      - design of mini grids to cover the rural areas in the command of SHP plant.
      - manufacture and procurement of turbines and other equipment,
      - implementation of projects,
      - operation and maintenance of the power plants and the mini-grids.

b) The SHP Technology Centre shall also undertake R&D work to resolve the problems that may be faced in implementing and operating the SHP projects.
c) Create indigenous capacity to manufacture / fabricate hydropower equipment in Tanzania and for that purpose, in identified units, facilitate the development of skills and transfer of technology to them

### 4.3 Strategy for SHP Development

The strategy to achieve the purpose and goals of capacity building by the National SHP Technology Centre is discussed below.

#### 4.3.1 Establishment of SHP Technology Centre to Build Capacity

At present, the expertise of the technical institutions on micro / mini hydropower based mini-grid is inadequate resulting in difficulty to sustain and replicate the micro / mini hydropower based mini-grid projects. A national micro / mini / small hydropower technical centre with trained personnel, necessary equipments and tools is proposed to be established. . The centre is expected to provide technical support for various other technical institutions in Tanzania for facilitating continuous development of micro / mini hydropower based mini grid projects. The Centre itself will first require to build its own capacity, and thereafter undertake, capacity building activities such as training, introducing academic programmes and formulation of standards etc.

In addition, during the period of UNIDO/ GEF assistance, the SHP Technology Centre will provide all the technical assistance in the various aspects of preparation and implementation of the projects to develop 3.2 MW of hydropower on identified sites for demonstration of micro/mini/ small hydropower based mini-grids.

### 4.3.2 Technology transfer for local fabrication of micro / mini hydropower equipments

At present there is no local fabrication/manufacturing of hydro-power equipments in Tanzania and all these have to be imported. A thorough demand assessment for local hydro-power equipments will be carried out initially by SHP technology centre. Also, existing local capacity in manufacturing micro / mini hydropower equipments will have to be evaluated and a few interested suppliers for micro / mini hydropower equipments will be identified. Based on the evaluation, capacity will be built for the identified interested suppliers through training, experience sharing. Provision of fellowships for eligible suppliers in getting long term training in other countries with advanced manufacturing technology is also proposed.

### 4.3 3 Manpower, Skill Requirement and availability for SHP Development

Hydropower involves a multi-disciplinary approach for planning, design, execution, operation & maintenance. Civil, electrical, mechanical, electronic engineering and socio-economy are the disciplines in which hydropower personnel need to be trained. Being small in size, it cannot afford the luxury of having a specialist for each discipline. Small hydropower may need personnel having fairly good background in each of these fields. Due to rather difficult conditions in the areas where hydropower sources exist, volunteers to take up hydropower as their field of expertise are not easily available. Training local people, especially at Diploma & Technician levels, may be a feasible option. Designing multi disciplinary specialisation course(s) at different levels to match the requirements is required.

On the basis of study of some SHP projects, an optimistic estimate for a plant of 1 MW (an average size) the manpower requirement of different levels of knowledge/skills at different stages have been made and is given in table 4.

**Table 4: Manpower requirement for SHP project at different stages**

| Stages of project development | Engineering | Diploma | Technician | Social sciences |
|---|---|---|---|---|
| Planning | 1 | 1 | 2 | 1 |
| Design | 1 | 1 | 0 | 0 |
| Execution | 1/2 | 2 | 1 | 0 |
| O & M | 1/4 | 1 | 4 | 1/4 |
| Total | 2.75 | 5 | 7 | 1¼ |

The capacity building programme will need to be continued even after the Demonstration Projects have been completed. The estimated manpower requirement for the development of full potential is given in table 5 . The National SHP Technology Centre alone may not be able to educate and train technical personnel in such large numbers. Other academic institutions having resources and interest in the programme will need to be associated in the education and training programme of the area. Thus a network of academic institutions will need to be developed for this purpose.

**Table 5: Manpower requirement for development of 500 MW of SHP potential in Tanzania**

| Stages of project development | Engineering | Diploma | Technician | Social sciences |
|---|---|---|---|---|
| Planning | 500 | 500 | 1000 | 500 |
| Design | 500 | 500 | 0 | 0 |
| Execution | 250 | 1000 | 500 | 0 |
| O & M | 125 | 500 | 2000 | 125 |
| Total | 1375 | 2500 | 3500 | 625 |

## 5. REQUIRED SPECIALIZATIONS AND SKILLS FOR SHP DEVELOPMENT

There are the several disciplines of expertise required for SHP development. Developers of SHP can afford only few numbers of people and hence the personnel involved for SHP development need to have multi tasking skills.

**5.1 For project development** specializations and skills are required in the following areas:

a.) Identification of potential sites
b.) Hydrometric measurements
c.) Investigations: (i) Geotechnical, (ii) Hydrological
d.) Surveys (i) Energy Demand and Availability, (ii) Topographical
e.) Economic and Financial Analysis
f.) Report preparation prefeasibility/feasibility
g.) Engineering Design, Construction Drawing and Technical Specifications of: (i) Civil Works, (ii) E&M Works and (iii) Transmission and Distribution Works
h.) Execution of Turnkey SHP Projects
i.) Project (i) Management / Implementation, (ii) Supervision and (iii) Monitoring
j.) Training
k.) System studies
l.) Environmental Impact Studies cumulative impact
m.) Any other items of work

**5.2 For Civil Works s**killed personnel are required in the following areas:

- Concrete pumps
- Foundation Treatment / Stabilization
- General Construction,
- Tunneling and underground works
- Underwater services
- Waterproofing and linings
- Materials processing
- Pneumatic gates
- Special Construction equipment
- Special Construction material

**5.3 For Hydraulic Machinery and Hydro Steel Works** specialization/skill shall be required in the following areas

- Turbines
- Governors
- Gates
- Valves
- Intake works
- Penstocks
- Penstock specials
- Pumps
- Speed increasers
- steelworks/foundries

**5.4 For Electrical works** specialization/skill shall be required in the following areas

- Generators
- Electrical governors
- Auxiliaries
- Cooling systems
- Switch gear
- Transformers
- Refurbishment.
- Control and Diagnostics Systems
- Communication
- Monitoring instruments

## 6. SHP TECHNOLOGY CENTRE

### 6.1 Location

In the background of the need for capacity building a Small hydropower (SHP) Technology Centre is proposed to be established at the College of Engineering Technology (CoET), University of Dar Es Salaam CoET. The host institution, its present structure, system and the activities are described in some detail below which shall be helpful in understanding and developing the SHP Technology Centre.

### 6.2 College of Engineering and Technology, Host Institution

#### 6.2.1 History of CoET

With the establishment of Faculty of Engineering (FoE) in 1973 at the University of Dar Es Salaam (UDSM), engineering education and training in Tanzania was started with the support of the German Government through Deutsche Gesellschaft fur Technical Zusammenarbeit (GTZ). Later FoE and the then institute of production innovation (IPI) were combined for enhancing the capacity and capability to respond to societal demands for solutions to professional, technical and technological problems. Subsequently, on December 15$^{th}$, 2001 the then FoE and IPI were disestablished and following Faculties were established:

- Civil Engineering and the Built Environment (CEBE)
- Electrical and Computer Systems Engineering (ECSE), and
- Mechanical and Chemical Engineering (MECHE)

Thereafter on September 29$^{th}$, 2005 the College of Engineering and Technology (CoET) was formally established as the first fully fledged Campus College of the University of Dar es Salaam.

#### 6.2.2 CoET Structure

CoET has six academic departments and two units viz. the Technology Development and Transfer Centre (TDTC) and the Bureau for Industrial Cooperation (BICO). The six academic departments viz. Chemical and Mining Engineering (CME), Structural and Construction Engineering (SCE), Electrical and Computer Systems Engineering (ECSE), Mechanical and Industrial Engineering (MIE), Transportation and Geotechnical Engineering (TGE) and Water Resource Engineering (WRE).

CoET reckons that globalization and other challenges which face Africa, like poverty and environmental degradation must be conformed with a well-educated and trained society equipped with high-level know-how and technical skills. It has mission to deliver high quality and competitive training in engineering and technology; research and technology development and transfer outputs; industrial consultancy and knowledge intensive services that are recognized nationally and internationally. It works for enhancing efficient utilization of natural resources, entrepreneurship and innovativeness among engineers and hence, stimulating sustainable development. All the academic, departments/units have inter linking with BICO (Consultancy Bureau) and TDTC (Technology Development Cell).

### 6.2.3 Organization and Management of CoET

The principal heads the college and is assisted by two deputies – one for academics and the other for administration. The college is governed through a college board which is responsible to the university SENATE. The six departments are headed by Heads who oversee administrative and academic functions assisted by coordinators and administrators. TDTC and BICO have very lean structures and are both headed by Managers who report to the Deputy Principal (Administration) and/or Deputy Principal (Academic) accordingly. The college promotes the culture of recognition and commendation to individuals whose performance is observed to be exemplary, and appreciation of quality.

### 6.2.4 Human Resource

CoET has a total 381 employees as of December 2009 directly employed by UDSM on permanent or contract terms. This number includes 201 academic staff, 116 technical staff and 64 administrative staff. About 36% of academic staff are in the rank of senior lecturer and above. At present, about 25% and 20% of academic staff have B. Sc. and M. Sc. degrees as their highest qualifications while the remaining 55% have PhDs plus teaching and professional experiences of up to 30 years. CoET has highly trained workforce in various disciplines. Through various programmes of Tanzanian government and development partners, especially GTZ/DAAD, TGT, NORAD, SDC, Sida/SAREC, NUFFIC and others, various academic, technical and administrative staff members had the training within Tanzania and overseas.

### 6.2.5 Existing Physical Resources at CoET

CoET has a built-up space with a total floor area of 21,500 sq.m at the main campus and 12,800 sq.m at the former TTCL staff college, Kijitonyama. The following facilities, among many others, are used for teaching and learning, research and technology development, consultancy and services to industry and can be easily used for SHP development by the proposed SHP technology centre of CoET:

(i) Soil mechanics, hydraulics and water resources, and structures and building materials testing laboratories;
(ii) Structures and Materials technology laboratory with facilities for ultrasonic crack detection, hardness and testing of strength of reinforced concrete metals and other building materials, heat treatment, and micro-structure and chemical composition analysis.
(iii) Highway and Transportation and Surveying laboratories.
(iv) Two laboratories for water quality analysis and one chemical laboratory equipped with chemical and biological analysis facilities including a Gas-Chromatograph/Mass spectrometer (GCMS), and Bio-reactors;
(v) Energy laboratories with facilities for various tests in research, consultancy and services. Equipment available in these laboratories include: engine test rig, bomb calorimeter, hot-wire anemometer, compressor test rig, air-condition and refrigeration test rig, pump test rig, cooling tower, concentric tube heat exchanger and Pelton turbine test rig.
(vi) Four machine workshops equipped with metal working machines including a CNC lathe and computer controlled flame cutting machine;
(vii) Computer laboratories and other facilities;

In addition to above there are other laboratories which are used for other areas of engineering.

### 6.2.6 Financial Resources

The college is financed through three main sources namely, government, development partners and self-generated funds through student fees, and consultancy and services activities. Government funds appropriated through UDSM covers mostly salaries of employees and administrative expenses like vehicles and buildings maintenance, utilization costs, office expenses, and teaching related costs. The college receives limited budget subventions for research and technology development and transfer activities which have the potential for producing technologies that have impact on poverty reduction.

Scholarship Opportunities for Postgraduate Studies related to hydropower, renewable energy and water resources are available from various sources like ANSTI (water resources engineering candidates), DANIDA (Water resources and environmental engineering), WATERNET (Water related scientific studies within SADC, Kenya and Uganda), ATP-Nile Basin Initiative (Competitive scholarships within the Nile basin countries) and NORAD (Renewable Energy Programme).

### 6.2.7 Recent Activities of CoET

#### 6.2.7.1 International Funded Research Projects

European Union for Promoting Renewable Energy in Africa (PREA), NUFU for Cost Effective biodiesel and /or bioethanol process, Biogas production for rural energy supply, Belgium Government through UNESCO for Nile FRIEND Project, AICAD for Development of Integrated Water Pumping and Electricity Generating, Wind System for Remote Applications, Investigation of Levels of Biogas Utilization from Lighting to Electricity Generation in Rural Areas in Tanzania and Low Cost Housing

#### 6.2.7.2 Nile Friend Project

CoET is developing rainfall-runoff modeling component and aims at developing a tool for flood forecasting; design of irrigation projects; data interpolation; and forecast of rainfall patterns from historical records in gauged catchments of the Nile basin. Hydropower Research Themes has been undertaken in clusters of the NBCBN-RE by CoET along with University of Dar es Salaam- (Coordinator) Burundi, Kenya, Rwanda, Uganda and Ethiopia. Renewable energy project covering tropical biomass and agricultural waste, policy innovation systems for clean energy security, Alternative Energy for Sustainable Development, Environment Protection and Poverty Reduction in Tanzania (ESEPRIT) are few research projects demonstrating the capability of the institute.

#### 6.2.7.3 Efforts in Renewable Energy

College is also offering a Masters of Science Degree Programme in Renewable Energy since 2007/08 academic year. CoET is collaborating with two International Programmes namely NOMA and PREA financed by NORAD of Norway and the European Union, respectively. The collaboration involves other Universities in the region including among others Makerere University in Uganda, Eduardo Mondlane University in Mozambique and Witwatersrand in South Africa. It also involves NTNU Trondheim in Norway, Dortmund University in Germany and three other European Universities. Some scholarships for students have been provided for. The CoET has started offering the Distance Sustainable Energy Engineering (DSEE) Master Programme.

### 6.2.8 Technology Development and Technology Transfer

The Technology Development and Transfer Centre (TDTC) is one of the unique distinctions of CoET where technology development and transfer activities take place. TDTC has a lean structure, which comprises a Manager, two Deputy Managers; one for Technology Development (TD), and the other for Technology Transfer (TT), two secretaries, an accountant, a clerical staff, and a driver-cum-messenger. The Centre has a multipurpose workshop with 20 technical staff of different cadres. CoET outreach programmes are also coordinated by TDTC. The outreach programmes staffs include three (3) Incubator Mangers, three (3) Incubator Fields Assistants and one SME/Gatsby Clubs Coordinator. In addition, TDTC has at its disposal all academic and technical staff in the six CoET academic departments.

### 6.2.9 Bureau for Industrial Cooperation (BICO)

BICO was established by the then FoE in July 1990. The objective of the Bureau is to enhance the capability of CoET so that it can effectively contribute to the development of the country. Specific objectives of BICO are:

(i) To provide quality engineering and other learned and knowledge-based consultancies to industries and other organizations
(ii) To provide other expert professional services to industries and other organizations
(iii) To deliver continuing professional development courses to practicing engineers in industries and other organizations

Since its inception in 1990 BICO has contributed significantly to providing engineering and non-engineering solutions to the numerous problems that confront our industry and society. BICO's niche area, however, is in learned and knowledge intensive consultancy in engineering and technology, and related aspects.

### 6.3 National Centres for SHP Development in other Countries

While devising the structure and systems for the Technology Centre, the model adopted for setting up the Alternate Hydro Energy Centre, (AHEC) of Indian Institute of Technology Roorkee, India has been studied and is detailed here. It shall be useful to refer to it for sustainability and impressive contributions made by them for SHP development in the respective countries. Similarly national reference centre of small hydropower plants of Brazil (CERPCH) may also be studied though Brazilin centre had more focus on awareness, advisory services and policy advocacy. Brief details and work carried out by them are given in Annexure V.

### 6.4 Devising Structure and Systems for the SHP Technology Centre

The SHP Technology Centre may be established initially in the form of a UNIDO/GEF sponsor a Centre of Excellence for SHP development which may be sub sustaining for its other than academic activities which shall continue to be main part of CoET budget. The CoET shall be hosting the Project Management Unit (PMU) of UNIDO/GEF project and setting up the SHP Technology Centre

As host institution, CoET has proposed to provide the facilities to project management office for the Project Management Unit (PMU) - Project Manager, Premises for the Centre, conference rooms for workshops and trainings, Technology Development and Transfer Centre (TDTC) workshops for turbines manufacturing, SHP design office and staff; Involvement of local as well as international collaborators (whom CoET experts have been working with for quite some time) with particular and relevant expertise (e.g., electrical controls and generators designers and manufacturers).

The SHP Technology Centre will be established for capacity building, providing technical support to small and large scale hydropower producers, NGOs, and other technical institutions and facilitate technology transfer for manufacturing of micro/mini/small hydropower equipments. The issue of providing flexibility with a business approach by the SHP Technology Centre is crucial for its sustainability. The flexibility in engagement and procurement of services and goods needs to be handled in a manner acceptable to the institute /university administration with a view of assisting MEM and REA for early realisation of the SHP development activities and sustainability.

### 6.5 Functions (Mandate) of the SHP Technology Centre

It is necessary to spell out the functions of the Centre to achieve the objective for which the Centre is being established. It will have the following functions

#### 6.5.1 Immediate

A. To develop manpower in Tanzania for harnessing Small Hydropower. The centre may begin with building necessary capacities for the developers of identified projects with a capacity of 3.2 MW to be established within the project period. for this purpose the centre will spearhead relevant activities including

   a) Imparting education at the undergraduate and post graduate levels.
   b) Imparting training, tailored for short term and medium term, to engineering / technical staff in subjects directly relevant to hydropower development such as
      - surveys & investigations
      - Preparation of Feasibility and Detailed Project Reports,
      - Engineering designing and construction drawings
      - Procurement specifications and tendering
      - Implementation and monitoring of projects.
      - Performance Testing of the SHP plants and of the turbines.
      - Concept of Environmental Impact Assessment as well as cumulative impacts assessment of Hydropower projects

B. Provide consultancy services in the above activities/areas.
C. Adapt available Guidelines and Standards for Small/Mini/Micro hydropower projects.
D. Undertake relevant R&D independently and in coordination with other academic and research institutions and with industry.
E. Build similar capacity in other educational institutions in Tanzania having interest and resources to engage in education, training, research and consultancy. The institutions as shown in table no. 11 offer teaching programmes relevant to hydropower and may be candidates for developing capability in SHP education, training and research.
F. Continue these activities beyond the project period in order to harness the estimated SHP potential of 300 MW to 500 MW and sustain the same.

### 6.5.2 Long Term

a) To promote SHP, carry resource assessment; maintain National Databases including awareness generation and demonstration etc.
b) Formulate National Standards for equipment and structure; Provide National laboratory for performance testing and certification.
c) To provide technical support for renovation and modernisation of existing Small Hydro Stations.
d) To carry out Environment Impact Assessment and eco-restoration studies.
e) To co-operate and collaborate with other National, Foreign and International Organisations in the field of Small Hydro.
f) To continue the activities of training, education, consultancy and R&D

## 6.6 Stakeholders in SHP Technology Centre

It will be helpful to identify potential stakeholders in the proposed Centre. These are

a. College of Engineering Technology, USDM.
b. Rural Energy Agency (REA) – A body to promote rural energy projects, and assists investors to develop businesses using Rural Energy Funds (REF)
c. Commission for Science and Technology (COSTECH)
d. Consultants and Consultancy Agencies
e. Government and private power developers

f. Equipment Manufacturers
g. Small and Medium Enterprises
h. Policy makers
i. Utilities
j. Financing institutions and donors
k. Academic institutions and researchers

## 6.7 Proposed Structure of SHP Technology Centre

Considering the scale of the activities of the centre and involvement of CoET to meet its mandate and objectives, a structure as in outlined the line diagram as Fig. 11 is proposed to have two major activity groups as follows:

i) *Education, Training and Research* – For Formal and Informal Training Programme, Education and finding solutions to the technical problems faced by the SHP industry through Research and Development, testing in the laboratory, documentation, reference, library etc.

ii) *Advisory and Technical services* – For Surveys & Investigations, Feasibility reports, Procurement specifications, Engineering Design for Construction and Operation of Demonstration Projects and Equipment manufacturing

Support of Administration, Finance and Accounts required in common to all the activity groups, is also proposed. This support shall also be available to the Advisory Board of SHP technology centre. The advisory board should also have a representative from one of the collaborating academic institutions.

Support of existing instrumentation, workshops/laboratories of COET is essential for the speedy and sustainable growth of SHP Technology Centre. Different laboratories in various departments of the COET should provide support to various activities of SHP Technology Centre by according priority to the work of SHP Technology Centre. This support to SHP Technology Centre may be on chargeable basis to the project/activity. This shall keep staff/faculty interested in working at the centre and shall lead to win-win situation. However COET should not levy the institutional charges as the work emanates from one of its own centres. The resources of the SHP Technology Centre will be shared among all the divisions depending on the needs. Likewise the CoET should also provide the support of its faculty members to the SHP Technology Centre when the need arises.

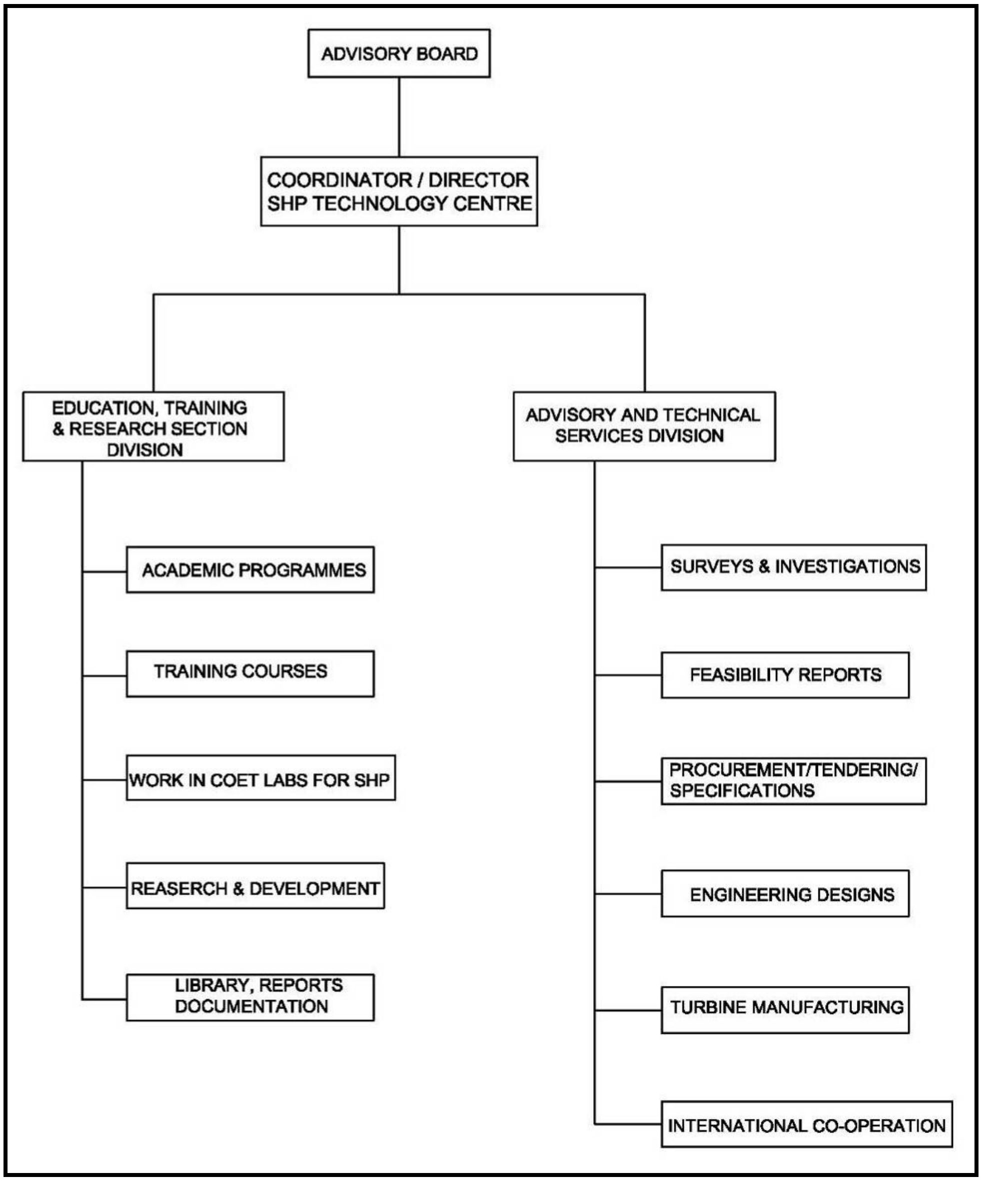


**Fig. 11: Suggested administrative structure for SHP Technology Centre at CoET**

### 6.7.1 Education, Training and Research Division

This division will be responsible for

a) formal educational programmes i.e. Under Graduate, Post Graduate & Ph.D. programmes
b) Formal and informal short, medium and long term training programmes.
c) Plan and carry out Research and development in the field of small scale hydro; upgrading technology and solving special field problems.
d) Research and Development activity can be a part of the academic programmes or otherwise.
e) Library, documentation and references

f) Testing in different laboratories of CoET for SHP projects
g) International Cooperation, extension, publications, contracts, and public relation, exhibitions. Interaction with Government/other agencies outside Tanzania including US, EU and UN organisation is required to know latest technologies, arranging international workshops/symposium U.N. organisation

This division will follow CoET- UDSM rules and regulation as formal training education is only possible under CoET rules and regulation. The course curriculum etc. will be governed by CoET academic board.

### 6.7.2 Advisory and Technical Services Division

This division will be responsible for implementation aspects and shall plan a general role for centres availability, growth and sustainability. The activation by this group shall be as follows:

a) Planning and field Investigations for preparation of Preliminary Feasibility Reports (PFR), feasibility reports and Detailed Project Reports (DPR) of SHP Projects
b) Carrying out Environmental Impact Assessment using CoET by SHP Technology Centre resources.
c) Design; Construction and Operation and Maintenance of model SHP's in different parts of the country. The facilities and staff of this group will consist of experts in engineering Design, Construction drawings and Operation and Maintenance for civil, electrical, mechanical, electronics and hybrid system of SHP projects.
d) Procurement/ tendering including specifications for goods and services (Bid documents).
e) Project monitoring and possible shooting
f) Environment impact assessment
g) For Manufacturing of Turbines and other components, selection of organisations that will take up manufacturing of turbines and other equipment, Technology transfer and development related to turbine, generator, electrical controls, governors and hydro mechanical equipments. TDTC of COET shall be the main focal point for manufacturing aspects.

Working in collaboration with outside agencies for design, preparation of DPR of international SHP projects shall be desirable. Further training of manpower engaged in SHP technology centre in specialised fields and obtaining assistance of international consultants will be required. For this purpose exposure of centre's manpower to latest technologies adopted by more developed /other developing / economies countries is considered essential.

Further it is proposed that expertise with a organisation engaged in similar activities in USA e.g. Army Corps of Engineers, IC-SHP of Hangzhou, China and AHEC-IIT Roorkee in India be utilised. This could be made under Bilateral or UNDP or other programmes so that experts from those organisations could be obtained for the Centre in Centre and Tanzanian staff could also go to USA /China/India for training/specialisation.

## 6.8 Technology Development and Technology Transfer for Manufacturing Turbines to other Manufacturers

The National Micro / Mini / Small Hydropower Technical Centre at CoET will be a centre for capacity building for local manufacturing of micro / mini hydropower equipment, especially, the micro-turbines. The training will take place in the Technology Development and Transfer Centre (TDTC) workshop in CoET, where, the technology innovation and research activities take place. The training components may include planning and designing aspects of the equipment, actual fabrication of the equipment and marketing strategies.

There are some instances recently by other training institutions e.g Dar es Salaam Institute of Technology (DIT) and Arusha Technical college (ATC) in manufacturing and assembling the cross flow turbine and extending the technical support for the electrical and mechanical works for micro hydro projects.(Moshi GG 2012).

The training will be provided by the international experts along with national experts. It may be planned to start the equipment manufacturing activities simultaneously along with the execution of demonstration sites. Under this project, efforts may be made to use the locally fabricated equipments in the replication sites in Tanzania. An experienced and standard turbine manufacturing company may be subcontracted for the transfer of technology to the local manufacturers. Necessary licenses will be arranged for the trained local fabricators to manufacture micro / mini hydropower equipments as technology transfer. Quality control procedures and standards would be created and recommended to the Tanzanian government for implementation across the country for SHP projects.

There are several entrepreneurs who can be encouraged and promoted for developing, manufacturing, assembling, erecting and installing the electrical and mechanical components in Tanzania. Nyumbu - Tanzania Automotive Technology Centre (TATC), Renewable Energy Development Company (T) Limited - (REDCOT), Small Industries Development Organization (SIDO), Ulaya and Hydro Mill Ltd., SDS Technologies Ltd. and Auto Mech Limited have shown interest in entering into small hydropower related works. Auto Mech limited having an extensive experience in fabrication and can easily manufacture penstock, gates, valves, flywheels and base plates for SHP works. SDS Technologies Ltd has extensive experience and is the channel partner of several reputed electrical controls and production devices in Tanzania.

## 6.9 Proposed Infrastructure & Equipment for SHP Technology Centre

### 6.9.1 Office Building and Infrastructure

Use of existing building for office and labs and creating additional space for SHP Technology Centre including renovating some existing space in CoET may be planned. If required some additional space (about 200 sq. m.) may also be added as a separate building by leveraging additional sources later.

### 6.9.2 Staff requirement and deployment for SHP Technology Centre

It is proposed that the faculty and staff interested/committed to working in the field of SHP development be invited to engage themselves, depending on their expertise and interest, in various areas of SHP development. As the faculty shall have the major responsibility of teaching and research, the centre requires full time staff (engineers, scientist, technicians etc). The placement of these staff should be done at the earliest so that centre starts taking up the activities as envisaged.

Tanzania has a large pool of retired personnel from utilisation and different offices having experience in various aspects of hydropower and power sector. It has been observed that these experts do not work due to non availability of a platform for providing services in an organised manner. This centre should capture the opportunity of utilising the expertise by identifying and engaging them with desired monetary and other incentives. Hydropower expertise comes through long experience. It is strongly recommended that CoET also should use the experts for covering several topics of different courses proposed to be modified/ inducted in the UG and PG programmes and by SHP centre for various short term training courses. These experts may be engaged as consultants on mutually agreed terms and conditions. A suggestive staff structure at SHP Technology Centre during the Project Stage is given in Table 6.

**Table 6: Staff Structure at SHP Technology Centre during the Project Stage**

| S. No. | Position | Qualifications & Experience | I year | | II to IV year | |
|---|---|---|---|---|---|---|
| | | | Faculty CoET (Part time) | Full time staff | Faculty CoET (Part time) | Full time staff |
| 1. | Coordinator /Director | • Experience in small scale hydropower with entre perusal outlook<br>• Master's Degree in Civil/electrical /mechanical Engineering Full time (with additional duties of teaching and research | 1 | – | 1 | – |
| 2. | Deputy coordinator/ Division (Advisory Services) | • Experience in management of organisation<br>• Having experience in hydropower for design or construction desirable<br>• Degree in civil/electrical/mechanical | – | 1 | – | 1 |
| 3. | Design engineers (Advisory Services) | • Degree in Civil/hydraulics/water resources<br>• Experience in small hydropower investigations and survey | 1 | 1 | 1 | 1 |
| 4. | Staff/SHP Design (Advisory Services) | • Degree in Civil/Electrical Engg<br>• Experience in civil works designs, specifications | 1 | 1 | 1 | 2 |
| 5. | SHP Manufacturing | • Degree in Mechanical /electrical/ production engineering<br>• Having experience of mechanical production/ fabrication | 1 | 1 | 1 | 1 |
| | | Total | 4 | 4 | 4 | 5 |
| | Support<br>• Drafting on AutoCAD/ CAD/CAM<br>• Remote sensing<br>• Technical for water measurement<br>• Senior Technical Assistant | | 3 (part time) | 4 | 5 | 6 |

As the activities are picked up by the SHP Technology centre, the staff structure may be updated in due course. A midterm review shall be highly useful. One or more staff faculty may be working on each aspect at this centre with necessary financial compensation.

## 7. ADDITIONAL ACTIVITIES TO BE UNDERTAKEN BY CoET THAT MAY BE PROPOSED BY SHP TECHNOLOGY CENTRE

### 7.1 Suggestive Changes in Existing Educational Programmes at CoET

#### 7.1.1 Existing Course Frame Work

It is felt that minor changes in the Undergraduate and Post Graduate programmes being offered for the present by CoET may disseminate knowledge about hydropower among students of different engineering disciplines. At present these are highly compartmentalised courses and do not provide the choice to the students to pursue courses in minor subjects from other departments. The candidates are thus deprived of the opportunity to get exposed to subjects like energy, environmental impacts, water resources, small hydropower and renewable energy. In the table below in the last column, “Remark”, suggestions are made to introduce changes that will allow flexibility to students so that they can study hydro energy related courses. The course units for graduate and post graduate can be seen from the following tables 7, 8 and 9:

**Table 7: Table for B.Sc. (Engineering) Teaching Structure**

| Year | Core units | Optional units | Other | Total | Remarks |
|---|---|---|---|---|---|
| I | 37 | | | 37 | - |
| II | 38.5 | | 2 (PT) – during summer break | 40.5 | Optional courses up to 6 units on energy, small hydro, water resources, environment impact assessment and renewable energy may be offered to all disciplines. |
| III | 24 | 8 + 6* | 2 (PT) – during summer break | 40 | |
| IV | 12 | 12 | 6 (Project) + 2 (PT) – during summer break | 32 | |
| Total | 111.5 | 26 | 12 | 149.5 | |

*outside of CoET but other deptt of UDSM

**Table 8: Table for M.Sc. (Engineering) Teaching Structure**

| Year | Core units | Optional units | Other | Total | Remarks |
|---|---|---|---|---|---|
| I | 23-25 | 6 | | 30 | Optional courses up to 3 units on energy, small hydro, water resources, environment impact assessment and renewable energy may be offered to all disciplines |
| II | 6 units for dissertation | | | 6 | |
| Total | 23-25 | 6 | | 36 | |

**Table 9: Table for PG Diploma (Engineering) Teaching Structure**

| Year | Core units | Optional units | Other | Total | Remarks |
|---|---|---|---|---|---|
| I | 14 | 8 | - | 22 | Optional courses up to 3 units on energy, small hydro, water resources, environment impact assessment and renewable energy may be offered to all disciplines |

### 7.1.2 Introduction of Courses in Existing Programmes

There are four existing courses being offered presently for 1 specific discipline / branch of engineering ((EN-434 Renewable Energy Technologies (3 U), EN-436 Power Plants (2 U), WR-450 Water Resources Management (1 U), WR-470 Environment Impact Assessment (2 U)). These programmes very easily can accommodate the above said courses as optional courses at least for 9 undergraduate branches (more is better). One additional course may also be offered as optional subject to this list of courses. The content of the course has been designed and has been included below.

Similarly, for post graduate diploma programmes in 6 branches and MS programmes in 9 branches, 5 existing courses have been identified for being offered as optional subjects to these programmes. These courses are WR-642 Development of SHP (2 U), EN-618 Energy Policy and Planning (3 U), EN-434 Renewable Energy Technologies (3 U), EN-436 Power Plants (2 U), WM-659 GIS & Database Management (3 U), WM-649 Environment Impact Assessment (3 U) and WM-643 Socio Economics of Water and Environment Resources.

Introduction of these highly relevant courses shall be useful for creating awareness and interest in the subject of hydropower specifically small hydro, energy and water related environmental issues. These have been presented Programmes in the following table 10:

**Table 10: Programmes and Courses Proposed at CoET**

| Programme | Discipline | Name of Paper on SHP to be introduced | Core / Optional |
|---|---|---|---|
| **1** | **2** | **3** | **4** |
| B.Sc. | Civil and Structural Engg<br>Civil and water resources engineering<br>Civil and Transportation Engg<br>Electrical Engg<br>Electrical Power Engg<br>Electro-Mechanical Engg<br>Industrial Engg and Management<br>Mechanical Engg<br>Production Engg | 1. New SHP Development (3 U)<br>2. EN-434 Renewable Energy Technologies (3 U)<br>3. EN-436 Power Plants (2 U)<br>4. WR-450 Water Resources Management (1 U)<br>5. WR-470 Environment Impact Assessment (2 U)<br><br>Detailed contents of the courses are given at Annexure-V. | Elective at least 3 units |
| | Practical Training of Two months in 1st year, 2nd year and 3rd year of B.Sc. course | | |
| | | | |
| PG Diploma | Civil and Water Resources Engg<br>Civil and Structural Engg<br>Civil and Transport Engg<br>Electrical Engineering<br>Mechanical Engg<br>Electronics and Information Technology | 1. WR-642 Development of SHP (2 U)<br>2. EN-618 Energy Policy and Planning (3 U)<br>3. EN-434 Renewable Energy Technologies (3 U)<br>4. EN-436 Power Plants (2 U)<br>5. WM-659 GIS & Database Management (3 U)<br>6. WM-649 Environment Impact Assessment (3 U)<br>7. WR 627 Legal and Administrative aspects of water management (2)<br>Detailed contents of the courses are given at Annexure-V. | Optional |
| MS | Water Resources Engg in Hydrology<br>Water Resources Engg in Water | 1. WR-642 Development of SHP (2 U)<br>2. EN-618 Energy Policy and Planning (3 U) | Optional |

| Progra mme | Discipline | Name of Paper on SHP to be introduced | Core / Optional |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| | Management<br>Integrated Water Resources Management<br>Construction Management<br>Electronics Engg<br>Electrical Power Engg<br>Renewable Energy<br>Design and Production Engg<br>Sustainable Energy Engg (Distant Learning) | 3. EN-434 Renewable Energy Technologies (3 U)<br>4. EN-436 Power Plants (2 U)<br>5. WM-659 GIS & Database Management (3 U)<br>6. WM-649 Environment Impact Assessment (3 U)<br>7. WM-643 Socio Economics of Water and Environment Resources<br>8. WR 627 Legal and Administrative aspects of water management (2)<br>Detailed contents of the courses are given at Annexure-V. | |

### 7.2 Collaboration and Building Capacity in Other Technical Institutions in Tanzania

In addition to CoET, there are other engineering/ technical institutions/colleges which can also impart the required education and training and support capacity building activities, especially at the level of diploma and technician, which is critical. CoET should extent trainer's training of these institutions. In the table 11, the kind of programmes that are offered in each institution are mentioned

**Table 11: Different Institutions with Qualifying Certificates/ Degrees**

| S. No. | Institution | Qualification awarded | Disciplines of the short term programme offered |
|---|---|---|---|
| 1 | University of Dar es Salaam, College of Engineering and Technology | Degree, Diploma | Civil, Mechanical, Electrical, Water Resources, Electromechanical, Environmental studies |
| 2 | Ardhi University | Degree, Diploma | Survey, Mapping, Environmental studies |
| 3 | Dar es Salaam Institute of Technology | Degree, Diploma | Civil, Mechanical, Electrical, |
| 4 | Mbeya Insititute of Science and Technology | Degree, Diploma | Civil, Mechanical, Electrical |
| 5 | Arusha Technical College | Diploma, FTC | Civil, Mechanical, Electrical |
| 6 | St Joseph University | Degree, Diploma | Mechanical, Electrical |
| 7 | Rwegalulila Water Resources Institute | Diploma, FTC | Water Resources |
| 8 | Dodoma Rural Development Institute | Certificate | Energy, Business, Entrepreneurship |
| 9 | VETA Training Centers | Certificate | Electrical, Mechanical |

### 7.3 Collaboration with Other International SHP Institutions

There are a few specialized international institutions working for small hydropower development. These institutions are equipped to provide technical assistance including capacity building through training, advisory services and special programmes. These institutions are mentioned in table 12.

**Table 12: International Organizations for Possible Co-operation for SHP Development**

| S. No. | Institution | Country | Training | Advisory support | Special programme for capacity building |
|---|---|---|---|---|---|
| 1. | International centre for small hydropower | Hangzhou, China | Offers various duration training courses to International participants | Available | To be explored from China government |
| 2. | Alternate Hydro Energy Centre, IIT Roorkee | Roorkee, India | Offers 2 week duration training course and M.Tech programme in “Alternate Hydro Energy Systems” for developing and neighbouring countries | Available | To be explored under ITEC programme of government of India for special training, advisory services may be available. |
| 3. | National Centre of Reference in SHP | Itajubá – MG – Brasil | Offers workshops, elective subjects to MS programme students | Available | To be explored however there is a barrier of language being Portuguese area |
| 4 | International centre for hydropower | Trondheim, Norway | Offers 3 week duration training course for hydropower development. These covers the large hydro mostly | Not Available | To be explored from NORAD under special aid programmes are developed |

The government of Tanzania may approach the respective governments for providing support in training in various activities related to SHP development. This can be done in a number of ways by these institutions such as by accepting sponsored candidates from Tanzania and or deputing foreign experts to Tanzania for providing on job training especially on demonstration projects for investigation, planning, design and O&M.

## 7.4 Proposed Capacity Building Activities at SHP Technology Centre

Short terms as well as long term capacity building and business development activities are recommended as follows:

### 7.4.1 Short Term Activities

#### 7.4.1.1 Capacity building

Following short term activities may be undertaken:

- Strengthen human resources capacity immediately by short term ,workshops, training (including hands on and field training) and study tours in the country and other place

- Strengthen the institutional mechanism for understanding, evaluation, supporting, financing, integrating at various levels (government, public utilities, regulatory, financing institutions, developers (eg REA, TANESCO, IPPs, NGOS, Other technical universities and Institutes), consultants, manufacturers and suppliers)
- Organisation of short term tailored courses for already passed out students
- Strengthening of existing laboratories and libraries in select institutions
- Organisation of training of teachers who could teach these courses and to prepare teaching manuals for them,
- Visit of faculty and staff to water resource management schemes and hydro power projects, participation in survey, investigations, and preparation of reports, designs, and execution.

### 7.4.1.2 Advisory

a. Carryout field surveys, field investigations, collection of data for hydrology, topographical, geotechnical and power demand for pilot and other IPP owned SHP projects
b. Prepare the feasibility report for pilot and other IPP owned SHP projects
c. Carryout engineering designs for civil structures, drawing the specifications, bill of quantities, engineering designs for electrical works, selection of equipments, design of controls and power transmission lines
d. Prepare the construction schedule
e. Periodic site supervision and project monitoring
f. Collaboration for equipment manufacturing

### 7.4.1.3 Training Area

Areas for training have been identified and are given in table 13. In addition to regular courses short duration training programme of six weeks duration are also proposed at Diploma and Degree engineering levels to be conducted for persons who have already completed their formal education courses. Nine short term training programmes are suggested to be offered to various teachers and other target participants of 4 days to 5 days duration. These have been given in table 14. Detailed course contents for the proposed short term training programmes are given in Annexure-VI.

It may be appreciated that these courses and trade trainings are not only related to SHP development but also relevant for undertaking the jobs in water related works e.g. drinking water, irrigation works, drainage works, sewerage and conservation. These personnel trained under this area shall have continued job opportunities.

**Table 13: Suggestive Training areas by SHP Technology Centre at SHP Technology Centre at different levels**

| **(a) Preparatory works** | | | **Diploma engineering** | **Science social** | **Engineering** |
|---|---|---|---|---|---|
| 1. | Field investigation | Identification of required works | √ | | √ |
| | | Marking the location of works | √ | | √ |
| | | Detailed topographical surveys | √ | | |
| | | Hydrological observations | √ | | |
| | | Geological investigations | √ | | |

| (a) Preparatory works | | | Diploma engineering | Science social | Engineering |
|---|---|---|---|---|---|
| | | Geotechnical investigations | √ | | √ |
| | | Environmental studies | | √ | √ |
| | | Cumulative environmental studies | | | |
| | | Power demand surveys | √ | √ | |
| | | Power evacuation surveys | √ | | √ |
| 2. | Preparation | Prefeasibility report/Reconnaissance report | | √ | √ |
| | | Feasibility report | | √ | √ |
| 3. | Tender specifications | | √ | | √ |
| 4. | Detailed engineering and construction drawings | | | | √ |
| **(b) Construction work** | | | | | |
| 1. | Civil | Construction of works including works in river | √ | | √ |
| | | Appropriate technology and material | | | √ |
| | | Quality controls and checks | | | √ |
| 2. | E&M works | Erection | √ | | √ |
| | | Commissioning | √ | | √ |
| | | Testing | √ | | √ |
| **(c) Operation and maintenance** | | | | | |
| | | Operators training to operate | √ | | √ |
| | | Maintenance of plant | √ | | √ |

**Table 14: Proposed short term training courses**

| S. No. | Title of course | Duration | Target participants |
|---|---|---|---|
| 1. | Small Hydropower Development including feasibility Report preparation | 10 days | Govt., private, Regulators, financial institutions, teachers |
| 2. | SHP development, Business models, Financing and Policies of small hydropower projects | 3 days | Govt., private, Financial institutions, Regulators |
| 3. | O&M of SHP Stations | 10 days | Govt., private developers, NGOs, teachers, consultants |
| 4. | Policy maker | 1 day | Senior bureaucrats and technocrats, minister |

Thus activities required to be undertaken by SHP Technology centre are summarised as follows:

A. For establishment

1. Deployment of core and project staff
2. Procurement of Equipment for laboratory, office and design
3. Repair, rehabilitation and procurement of machinery for TDTC
4. Training of COET and Project staff in specific areas with others
5. Study tours in Tanzania and abroad
6. Deployment of and interaction with international experts to work on shp

7. Designing and adopting courses( subjects) related to shp development in the existing UG and PG programme by adjusting the optional subjects
8. Development of additional space

B. For normal activities

1. Developing the network of stakeholders
2. Mapping of potential sites for SHP projects
3. Carrying out the surveys and investigations for SHP sites
4. Preparing the feasibility reports
5. Carrying out the detailed engineering designs and constructions drawings
6. Preparing the specifications for procurement
7. Project monitoring and trouble shooting
8. Carrying out environmental impact assessment including cumulative impacts
9. Carrying out the training programmes

B. For fabrications of the Turbines

1. Assessing the existing capacity and willingness of other technical institutions for getting involved in SHP development for capacity building. Evaluating the existing local capacity on micro / mini hydropower equipment fabrication and identification of potential / interested fabricators.
2. Conducting training and transferring technology to the identified interested fabricators
3. Licensing the trained fabricators
4. Foreseeing the manufacturing process and devising the means to sustain the process.

### 7.4.2 Long Terms Activities

Following long term activities for capacity building are proposed:

- Degree programmes in renewable energy with emphasis on small scale hydropower
- Introduction of new courses in existing degree programmes in the areas relevant to small scale Hydro Power Development at UG and PG level of engineering and science.
- Vocational training (including hands on and field training) for surveys, filed measurements, monitoring, execution
- Strengthen the institutional mechanism for documentation and preparation manuals for clear understanding, evaluation, supporting, financing, integrating at various levels (government, public utilities, regulatory, financing institutions, developers, IPPs, consultants, manufacturers and suppliers)
- Continue the advisory support for field investigations, prefeasibility reports, feasibility reports, detailed engineering designs and constructions drawings, detailed specifications, project execution trouble shooting, project monitoring, performance testing and evaluation, Project evaluation

### 7.4.3 Introduction of New Elective Courses for UG, PG and other Students

It is proposed that new courses in the area of small hydropower, water resources development and environment, may be introduced as elective / mandatory courses within the ongoing degree/diploma programmes in engineering/arts/science. Suggested courses as given in table 12 may be introduced in other technical institutions.

### 7.4.4 Introduction / strengthening industrial technician training

Technician Trades highly relevant to small scale hydropower projects may be offered by COET to the trainers of for Industrial Technician Training institutes and are suggested as below:

* **Civil Trade,** Surveying and discharge measurement, Construction, Water quality, Water quantity/discharge

* **Electrical Trade,** Cabling, Control/Switchboard/Instrument, Transformer, Generator, Pumps, Compressors, Valves and Gates, Metering

* **Mechanical Trade,** Hydraulic turbines, Piping, Welding/Fabrication, Machining, Erection

It is recommended that above said trades which shall have direct utility in hydropower, water resources, water supply and sewerage projects should be offered by vocational training centres. These also will ensure sustainable employability. The funding for such programme should be supported by Govt. of Tanzania and donors as these are for sustainable development.

It is heartening to note several technical institutes have started diploma courses in renewable energy including small scale hydropower (Moshi GG 2012).

## 7.5 Business plan for SHP Technology Centre

It is proposed that SHP Technology Centre should provide an advisory and other short term activities as soon as possible. A list of activities which could be performed by SHP Centre has been prepared and is given below as table 15. For performing these activities the necessary assistance and participation from teachers and students of different departments within COET and engaging some of experienced individuals (might have retired or available as free lancer) may be taken. REA, MEM and TANESCO may give preference to SHP technology centre over private national and international consultancy groups as single source or without going through the tendering related exercise especially in the early stage.

**Table 15: Business plan for SHP Technology Centre**

| S. No. | Activities | Sources | |
|---|---|---|---|
| | | COET | Outsourced |
| **A.** | **Project development , Training and consultancy activities** | | |
| 1. | Identification of potential sites | √ | √ |
| 2. | Hydrometric measurements | √ | √ |
| 3. | Investigations- Geotechnical, | √ | √ |
| 4. | Investigations- Hydrological | √ | √ |
| 5. | Surveys for Energy Demand and Availability | √ | √ |
| 6. | Surveys- Topographical | √ | √ |
| 7. | Economic and Financial Analysis | √ | √ |
| 8. | Report preparation prefeasibility | √ | √ |
| 9. | Report preparation feasibility | √ | √ |
| 10. | Engineering Design, Construction Drawing and Technical Specifications of Civil Works | √ | √ |

| S. No. | Activities | Sources | |
|---|---|---|---|
| | | COET | Outsourced |
| 11. | Engineering Design, Construction Drawing and Technical Specifications of E&M Works | √ | √ |
| 12. | Engineering Design, Construction Drawing and Technical Specifications of Transmission and Distribution Works | √ | √ |
| 13. | Execution of Turnkey SHP Projects | | √ |
| 14. | Project Management /Implementation | | √ |
| 15. | Project Supervision | | √ |
| 16. | Project Monitoring | √ | √ |
| 17. | Performance testing | √ | √ |
| 18. | Training | √ | √ |
| 19. | System studies | √ | √ |
| 20. | Environmental Impact Studies | √ | √ |
| 21. | cumulative impact studies | √ | √ |
| 22. | Any other items of work | √ | √ |
| **B.** | **Manufacturing of turbines and equipments** | | |
| 1. | Design and development of turbine | √ | |
| 2. | Fabrication of turbine | √ | √ |
| 3. | Technology transfer for manufacturing of turbine | √ | |
| 4. | Technology transfer for installation and maintenance of turbine | | √ |
| 5. | Technology transfer for electronic load governor | √ | √ |
| 6. | Assembling and installation of electronic load governor | | √ |
| 7. | Training for technology transfer to local manufacturers | √ | √ |

## 8. TIME SCHEDULE

The timeline for capacity building, technology transfer and advisory services expected in the first 4 years are given in table 16.

**Table 16: Schedule for Capacity Building and Business Development Activities by SHP Technology Centre**

| S. No. | Year | 2012 | | | 2013 | | | | 2014 | | | | 2015 | | | | 2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Month | 10 | 11 | 12 | 1-3 | 4-6 | 7-9 | 10-12 | 1-3 | 4-6 | 7-9 | 10-12 | 1-3 | 4-6 | 7-9 | 10-12 | 1-3 | 4-6 | 7-9 | 10-12 |
| | Activities | | | | | | | | | | | | | | | | | | | |
| **CAPACITY BUILDING/STRENGTHING** | | | | | | | | | | | | | | | | | | | | |
| **1.** | Placement of staff | × | × | | | | | | | | | | | | | | | | | |
| **2.** | Capacity building | | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **2.1** | Procurement of books/publications | | | × | | | | | | | | | | | | | | | | |
| **2.2** | Procurement of lab equipment | | × | × | × | × | | | | | | | | | | | | | | |
| **2.3** | Study tours in Tanzania | | × | | | × | | | | × | | | | × | | | | × | | |
| **2.4** | Study tours Abroad | | | | × | | | | | | | | × | | | | | | | |
| **2.5** | Renovation of the office/lab | × | × | × | | | | | | | | | | | | | | | | |
| **2.6** | Procurement of office equipment | | × | × | × | × | | | | | | | | | | | | | | |
| **2.7** | Procurement of workshop equipment | × | × | × | × | × | | | | | | | | | | | | | | |
| **2.8** | Procurement of software for design and planning | | | × | × | × | | | | | | | | | | | | | | |
| **2.9** | Procurement of software for manufacturing | | | × | × | × | | | | | | | | | | | | | | |
| **SHORT/LONG TERM** | | | | | | | | | | | | | | | | | | | | |
| **3.** | Revision of courses at the COET | | | | × | × | × | × | | | | | | | | | | | | |
| **4.** | Conducting the technical training programmes | | | | | | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **5.** | Conducting the feasibility reports | | | | | | | | × | × | × | × | × | × | × | × | × | × | × | × |
| **6.** | Carrying out of mapping of potential sites in selected regions | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **7.** | Train water basin authorities and empower them to undertake reconnaissance studies for the potential sites | × | × | × | | | | | | × | × | × | | | | | | | | |
| **8.** | Participate in site verification for the identified potential sites | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **9.** | Prefeasibility Report | | | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **10.** | feasibility report | | | × | × | × | × | × | × | × | × | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **11.** | Engineering Design, Construction Drawing and Technical Specifications of Civil Works | | | | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **12.** | Engineering Design, Construction Drawing and Technical Specifications of E&M Works | | | | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **13.** | Engineering Design, Construction Drawing and Technical Specifications of Transmission and Distribution Works | | | | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | |
| **14.** | Execution of Turnkey SHP Projects only for trouble shooting | | | | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **15.** | Project Monitoring | | | | | | | | | | | | | | | | | | | |
| **16.** | Training Programmes for different Stakeholders | | | | × | | | | | | | | | | | | | | | |
| **17.** | System studies | | | | | | | | | | | | | | | | | | | |
| **18.** | Environmental Impact Studies | | | | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **19.** | cumulative impact studies | | | | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **20.** | Miscellaneous | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **MANUFACTURING AND TECHNOLOGY TRANSFER FOR TURBINES** | | | | | | | | | | | | | | | | | | | | |
| **21.** | Renovation and procurement of machines | × | × | × | | | | | | | | | | | | | | | | |
| **22.** | Design and Development and or Transfer of Technology for Turbine | | | | × | × | × | × | × | | | | | | | | | | | |
| **23.** | Technology Development and or Transfer of Technology for other equipment (ELC) | | | | | × | × | × | × | × | | | | | | | | | | |
| **24.** | Expression of interest and selection of potential manufacturers | | × | × | × | × | | | | | | | | | | | | | | |
| **25.** | Training for manufacturing capacity to local manufacturers | | | | | | | × | × | × | × | × | × | × | × | × | × | × | × | × |
| **26.** | Training for assembly and installation | | | | | | | | | | | | × | × | × | × | | | | |
| **27.** | Technology transfer for installation and maintenance for turbines | | | | | | | | | | | | | | | | | | | |

## 9. EQUIPMENTS FOR SHP TECHNOLOGY CENTRE AT CoET

### 9.1 For Investigations, Planning and Design Work

CoET has submitted its requirement to UNIDO for establishing SHP technology centre and strengthening TDTC with equipment/machines. These requirements comprise office equipments, computer and peripherals, design office, site investigations and surveys instruments and workshop. In addition to the equipment suggested by COET a comprehensive list of instruments has been prepared and has been added to this list and is given at Annexure VII. Detailed specifications of the instruments are available at Annexure VIII.

### 9.2 For Fabricating Turbines and Other Products

For fabricating the turbine and other products, strengthen of the TDTC of CoET a list has been provided by CoET for procuring new as well as repairing/over hauling existing equipments of TDTC. Many of the equipments are in good working conditions. Besides turbine manufacturing, there are other equipments/works required for electrical and mechanical components of SHP projects which may also be manufactured / assembled in Tanzania. Electronic load controller and ballast load are other important components which may be assembled in Tanzania. These equipments are as follows:

**Electrical works**

(a) Electrical Generator
(b) Electronic load controller
(c) Electronic governor
(d) Control panels
(e) Switchyard
(f) Distribution transformers and lines

**Mechanical works**

(a) Penstocks of various sizes
(b) Gates
(c) Valves
(d) Flywheel
(e) Hoisting mechanism
(f) Cranes
(g) Pumps
(h) Other auxiliaries

Some of the equipment are already being manufactured in Tanzania. For instance, Tanzania Steel Pipes (TSP) is engaged in fabricating all types of Steel pipes suitable for penstocks and head race pipes. Auto Mech Ltd at Dar es Salaam is capable of fabricating the gates, penstocks and specials.

Flame Cutting M/C (Oxy-acetylene, cut upto50mm), Plasma Cutter, Air Compressor (4 HP), Tool Boxes (Vanadium/chrome assorted, Trolley type; complete with mechanical tools) are proposed. Repairs/over hauling of Lathe Machine (Al-pin 350,Big Lathe), Lathe Machine(Pfeifer), Lathe machine (Wailer), Lathe Machine (Al-pin-50), Small Milling Machine, Milling Machine, Drilling Machine, Radial Drilling machine, Shaper, Bending Machine, Welding transformers (5pcs) and Power Saw is also recommended. In addition to above some electrical equipments and bench is recommended for procurement.

As the turbine and other equipment manufacturing has never been done in Tanzania, it is advisable to have technology transfer specially for the units sized below 200 kW from reputed international groups with demonstrated capability of manufacturing and supplying high quality turbines suitable for application in the developing world. Turbine design and manufacturing is a highly specialised area of expertise and borrowing skills in this area will be a useful decision.

However, CoET faculty in corporation with others may engage in developing and improving the design of turbines as standard products. SHPs are site specific and designing / manufacturing turbines for each site in small hydro range is time consuming and expensive. Hence few standard sizes and their adaptability / variability to suit the specific sites may be carried out by researchers at SHP technology centre.

It is in this contexts technology transfer for manufacturing turbine and load controller will be highly useful. Experience gained in Nepal, Indonesia and in India in the past and in Nigeria (Essan 2012) recently has demonstrated usefulness of such technology transfer.

Possible organisations / groups who may be interested in diversifying for manufacturing turbines, load controller and other components of SHP projects should be encouraged through facilitation of meetings with business groups for technology transfer and building capacity by training for manufacturing turbines and other parts. PMU and SHP technology centre may invite expression of interest from the interested manufacturing groups country wide for SHP turbine manufacturing and electronic load controller etc.

## 10. ESTIMATED BUDGET

Of the items mentioned at para 9 along with annexure VII, some equipment/instrument/facility are existing and shall be provided by CoET and some will have to be purchased/ provided by partner institutions. For the basic machines listed, most of them are available at TDTC workshop but some of them need to be repaired and some need to be purchased. The Cost estimate for purchasing various items and for repair of TDTC machines, rehabilitation of Design office has been worked out by CoET. The budget estimates have been prepared and are given in table 17.

**Table 17: Expenditure and sustainability for Establishment of SHP Technology Centre**

**In USD**

| S. No. | Items | Project Phase | During 5-8 years |
|---|---|---|---|
| **A.** | **NON -RECURRING EXPENDITURE** | | |
| 1a | Office equipments | 224,100 | Not provided. The centre shall be able to demonstrate its usefulness and requirement for up gradations or additional infrastructure and getting additional resources |
| 1b | Design and drawing office | | |
| 1c | Office furniture and space conditioning | | |
| 2 | Rehabilitation of design office | | |
| 3 | Laboratory and field Instruments | | |
| 4 | Library | 50,000 | |
| 5 | Additional space | Not Provided | |
| 6 | Technology transfer | 125,000 | |
| 7 | Equipment/ machinery for fabrication of turbine and others | 33,510 | |
| 8 | Training including study tours (6 national training @20000 + 2 study tours @30000) | 180,000 | |
| 9 | Contingency (10% of 1 to 8) | 61,261 | |
| | **Sub Total** | **673,871** | |
| **B.** | **RECURRING EXPENDITURE** | | |
| **1** | **Salaries** | | |

| | | | |
|---|---|---|---|
| 1a | Faculty of COET(Coordinator @ 500 pm for 4 yrs+ Faculty @400 pm for 7 man yr+ manufacturing @500 pm for 4 yr) on Part time | 81,000 | 113,400 |
| 1b | Project Staff (advisory Division in charge @ 2000 pm for 4 yrs+ surveys/Design/manufacturing @1500 pm for15 man yr) | 366,000 | 512,400 |
| 1 c | Project support Staff (part time staff of COET @ 200 pm for15 man yrs+ surveys/Design/ manufacturing @800 pm for 18 man yrs) | 208,000 | 291,200 |
| 2 | Travel | 150,000 | 210,000 |
| 3 | Office consumables | 100,000 | 140,000 |
| | **Sub Total** | **905,000** | **1,267,000** |
| **C.** | **Total Expenditure and Income** | | |
| 1 | **Expenditure** | | |
| | Total Non recurring + Recurring | **1,578,871** | **1,267,000** |
| 2 | **Income** | | |
| | Resources generation | 551,000 | 1,264,000 |
| | Grant (UNIDO/GE Project) | 1000,000 | 0 |
| | | **1,551,000** | **1,264,000** |

## 11. FINANCIAL SUSTAINABILITY OF ACTIVITIES OF SHP TECHNOLOGY CENTRE

For setting up the Centre funds have been committed by various organisations and the Government. Therefore, the Centre will be established easily. However, it is necessary to ensure that arrangements are put in place so that the Centre is financially sustainable and continues to render the services for which it is being established. In order to achieve this sustainability the measures mentioned below are suggested.

The cost of each activity that the SHP Technology Centre will undertake is worked out and the cost be recovered from the activities carried for the beneficiary organisations / companies / individuals.

As a matter of policy the government should ensure that the organisations that take part in the SHP development programme should make provisions in their budgets for the following purposes:

i. Training and capacity building
ii. Obtaining Consulting Services
iii. Project monitoring by independent experts
iv. Other activities that are involved in SHP development,

SHP Technology Centre should charge for organising training on the basis of cost of imparting that training. The organisation that deputes its personnel for training should bear this cost. Every project provides funds for project preparation, project implementation, monitoring as a certain percentage of the project cost. Funds are also provided for capacity building and awareness generation. The general experience is that project preparation including surveys and investigations may cost 2 to 3% of the project cost. Likewise project implementation may cost about 4% of the project cost. Capacity building may involve 0.5 to1% of project costs. Out of this order of funding, some portion may be available to SHP Technology Centre for meeting the recurring expenditures on its establishment for providing consulting services and training.

That this suggestion is workable will be clear from the analysis of economics of the SHP project that are to be set up under the project. With a broad estimate, for a 3 MW capacity SHP project by taking 9 Million US$ as project cost, a sum of 5 to 8% easily can be attributed towards preparation of feasibility reports, designs, testing, capacity building and monitoring as indicated above. Thus a sum of US$ 0.45 to 0.72 Million towards this activity should be available. Further about 20 to50 MW capacity is expected to be installed by private sector within the next 5 years and accordingly opportunity for a sum of 3 to 7.5 million US$ is expected for the consultancy part. These estimates easily show that the activities related to SHP programme shall be sustainable. For funding for educational programmes and R&D, it is reasonable to expect the Govt. of Tanzania to provide funds for them directly as part of normal funding to CoET- UDSM.

Resource generation by carrying out a number of project activities as planned by the SHP Technology centre has been worked out during the UNIDO/GEF project period (4 years) and 4 years thereafter the project period and is shown in Table 18. The demonstration project shall be completed during the first 4 years and SHP Technology centre shall be able to charge the activities by deploying the required staff and experts.

**Table 18: Resource Generation during UNIDO/GEF project and after period**

| S. No. | Items | UNIDO/GEF Project Period | | During 5-8 years | |
|---|---|---|---|---|---|
| | | **Quantity and rate** | **amount** | **Quantity and rate** | **amount** |
| A. | **Project development and consultancy activities** | | | | |
| 1. | Identification of potential sites | 1 project | 10,000 | 2 project | 20,000 |
| 2. | Hydrometric measurements | 5 project | 10,000 | 5 project | 15,000 |
| 3. | Investigations - Geotechnical, | 0 | - | 0 | - |
| 4. | Investigations- Hydrological | 2 project | 20,000 | 4project | 40,000 |
| 5. | Surveys for Energy Demand and Availability | 2 project | 10,000 | 4 project | 20,000 |
| 6. | Surveys- Topographical | 2 project | 10,000 | 4 project | 20,000 |
| 8. | Prefeasibility Report | 5 reports | 20,000 | 10 reports | 40,000 |
| 9. | feasibility report | 3 projects | 90,000 | 7 projects | 280,000 |
| 10. | Engineering Design, Construction Drawing and Technical Specifications of Civil Works | 3 projects | 90,000 | 4 projects | 160,000 |
| 11. | Engineering Design, Construction Drawing and Technical Specifications of E&M Works | 3projects | 45,000 | 4projects | 80,000 |

| S. No. | Items | UNIDO/GEF Project Period | | During 5-8 years | |
|---|---|---|---|---|---|
| | | **Quantity and rate** | **amount** | **Quantity and rate** | **amount** |
| 12. | Engineering Design, Construction Drawing and Technical Specifications of Transmission and Distribution Works | 3projects | 15,000 | 4 projects | 40,000 |
| 13. | Execution of Turnkey SHP Projects only for trouble shooting | 2 projects | 10,000 | 4 projects | 40,000 |
| 14. | Project Management /Implementation only planning | 2 projects | 10,000 | 4 projects | 40,000 |
| 15. | Project Supervision | 2 projects | - | 2 projects | - |
| 16. | Project Monitoring | 2 projects | 10,000 | 8 projects | 80,000 |
| 17. | Performance testing by COET directly | 1 project | - | 1 project | - |
| 18. | Training | 2 | 1,000 | 10 | 5,000 |
| 19. | System studies | nil | - | nil | - |
| 20. | Environmental Impact Studies | 2 projects | 40,000 | 2 projects | 60,000 |
| 21. | cumulative impact studies | 1 project | 40,000 | 1 project | 80,000 |
| 22. | Any other items of work | lump sum | 10,000 | lump sum | 40,000 |
| | Sub total | | 441,000 | | 1,060,000 |
| B. | **Manufacturing of equipments** | | | | |
| 1. | Design and development of turbine | one set | 0 | | 0 |
| 2. | Fabrication of turbine | one set | 0 | | 0 |
| 3. | Technology transfer for manufacturing of turbine | one set | 0 | 2 sets | 20,000 |
| 4. | Technology transfer for installation and maintenance of turbine | one set | 0 | 4 sets | 10,000 |
| 5. | Technology transfer for electronic load governor | one set | 0 | 4 sets | 2,000 |
| 6. | Assembling and installation of electronic load governor | one set | 0 | 4 sets | 1,000 |
| 7. | Training for technology transfer to local manufacturers | one set | 0 | | 1,000 |
| 3 | Design, Coordination supervision of SHP projects for Execution taken up for SHP projects | 2 projects | 100,000 | 3 projects | 150,000 |
| 4 | Miscellaneous | lump sum | 10,000 | | 20,000 |
| | sub total | | 110,000 | | 204,000 |
| | **Sub Total** | | 551,000 | | 1,264,000 |

It is evident that after the UNIDO/GEF project period the SHP Technology Centre shall be able to established/sustain. The basic understanding for such success shall be team work, utilizing the existing facilities and expertise within and outside CoET and networking with the institutions for offering a comprehensive service support to the project developers, government agencies and other organization.

The SHP Technology Centre is proposed to consider creating partnership with the Govt. Sector/ private sector / organizations to install facilities for simulation of actual SHP plants and the mini grids to be used for educational and training programmes, testing of SHP projects including turbines and other equipments and distance training in due course of time.

These facilities may be made open to other African countries for training and education of candidates and testing of projects and equipment in other countries. Consultancy services can also be made available for the development of SHP in other African countries.

As the developers of hydropower in Tanzania will use the national resource i.e., water, it will be proper for the government to impose a tax on the developer for water used. A part of this money could go towards meeting the expenses of the National Centre. The Government could, by regulations or through condition of financing, prescribe that a part of the project cost should be spent on education/training of the staff and procuring professional services for the preparation of the project, its implementation and monitoring. Hydropower sites are often maintained ecologically sound and rich in tourism; these can be used to promote tourism thus generating revenue.

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**ANNEXURE-I**

**MISSION PROGRAMME TO TANZANIA**

**International SHP Expert during** 06-10 June 2012

| Time | Institution to meet | Person to meet |
|---|---|---|
| **DAY ONE:** | **WEDNESDAY, 06-JUN-12** | |
| **13:25** | Arrival in Dar es salaam | |
| **14:30** | Rural Energy Agency (REA) | Mr Bengiel H. Msofe<br>Mr Elineema. Mkumbo |
| | | |
| **DAY TWO** | **THURSDAY, 07-JUN-12** | |
| **09:00** | Tanzania Electric Supply company Limited (TANESCO) | Mr Godwin E. Mnzava<br>Mr. Kato Kabaka |
| **11:00** | Energy and Water Regulatory Authority (EWURA) | Mr Mathew Mbwambo<br>Mr. Godfrey H. Chibulunje<br>Mr. Ng'anzi Jumaa Kiboko |
| **12:00** | Ministry of Energy and Minerals (MEM) | Mr. Leonard Ishengoma<br>Mr. Ngereja M. Mgejwa |
| **14:30** | College of Engineering and Technology (CoET), University of Dar es salaam (UDSM) | Dr. Preksedis M. Ndomba,<br>Prof. Felix W. Mtalo |
| **16:30** | Tanzania Electric Supply company Limited (TANESCO) | Mr. Cosmas L M Masawe<br>Mr. James Luchagulla |
| | | |
| **DAY THREE:** | **FRIDAY, 08-JUN-12** | |
| **11:00** | College of Engineering and Technology (CoET), University of Dar es salaam (UDSM) | Dr. Preksedis M. Ndomba,<br>Prof. Felix W. Mtalo |
| **14:30** | Centre for Sustainable Modern Energy Expertise (TaTEDO) | Mr. Estomih N. Sawe,<br>Mr. Leonard Pesambili |
| **16:00** | Rural Energy Agency (REA) | Mr Bengiel H. Msofe<br>Mr Elineema Mkumbo |
| | | |
| **DAY FOUR** | **SATURDAY, 09-JUN-12** | |
| **11:00** | Auto Mech Limited | Mr. Ramesh Patel,<br>Mr. Nassir J Karim |
| **12:30** | SDS Technologies Limited | Mr D.N. Pathak |
| | | |
| **DAY FIVE** | **SUNDAY, 10-JUN-12** | |
| | Discussions (Arun Kumar, Jossy Thomas and Emmanuel Michael) | |
| | | |
| **DAY SIX** | **MONDAY, 11-JUN-12** | |
| **09:00** | Workshop on launching of UNIDO/GEF project on Mini/Micro hydropower promotion in Tanzania | |
| **17:05** | Departure to base | |

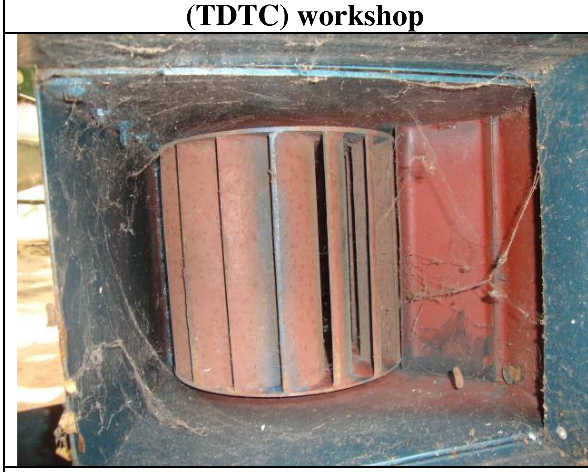
**ANNEXURE-II**

**PHOTOGRAPHS TAKEN DURING MISSION TO TANZANIA IN JUNE 2012**

**Technology development and transfer (TDTC) workshop**

**Technology development and transfer (TDTC) workshop**

**Cross flow turbine developed by COET student**



**Cross flow Runner developed by COET MS student**

**Working Model**

**Mechanical laboratory** | **Geotechnical laboratory**

**Surveying lab – COET – Civil Engineering** | **TaTEDO (NGO), Dar es salaam**


**Auto Mech Ltd. – Potential Workshop for hydro mechanical works**

**SDS Technologies Ltd., - Potential workshop for Electrical control Work**



**Cross flow turbine fabricated and assembled by Chuo Cha Ufundi Arusha - Arusha Technical College (Moshi GG 2012)**

**ANNEXURE-III**

## SUMMARY OF IDENTIFIED SMALL HYDROPOWER SITES S IN TANZANIA AND THEIR LEVEL OF STUDY

| Main Basin | | River | Site Name | Capacity (kW) | Study Level | Load Centre | Current Supply |
|---|---|---|---|---|---|---|---|
| Rufiji | 1 | Ruhudji | Njombe Falls | 2000 | Identified in Reconnaissance Study | Njombe | SFDG |
| | 2 | | Kifunga falls | 2600 | Identified in Reconnassance Study | Njombe | SFDG |
| | 3 | | Hagafiro | 5000 | Identified in Reconnaissance Study | Njombe | SFDG |
| Lake Tanganyika | 4 | Malagarasi | Igamba Falls | 7600 | Prefeasibility Level of Study | Kigoma | SFDG |
| | 5 | | Ruchugi | 1000 | Identified in Reconnaissance Study | RE | NCS |
| | 6 | | Mtambo | 2400 | Prefeasibility Level of Study | Mpanda | SFDG |
| | 7 | | Mkuti | 630 | Identified inReconnaissance Study | RE | NCS |
| | 8 | Luiche | Luiche | 7800 | Prefeasibility Level of Study | Kigoma | SFDG |
| | 9 | Luiche | Mwoga | 266 | Prefeasibility Level of Study | Kasulu | NCS |
| | 10 | Kalambo | Kalambo | 18000 | Identified in Reconnaissance Study | Sumbawanga | SFDG |
| | 11 | Kawa | Kawa | 2000 | Idendified in Reconnaissance Study | RE | NCS |
| | 12 | Luamfi | Luamfi | 1200 | Identified in Reconnaissance Study | RE | NCS |
| | 13 | Luegele | Luegele | 15000 | Identified in Reconnaissance Study | Mpanda & RE | SFDG |
| Lake Rukwa | 14 | Songwe | Songwe | 1000 | Identified in Reconnaissance Study | Mbozi | Grid |
| | 15 | Lupa | Lupa | 2800 | Identified in Reconnaissance Study | Chunya | Grid |
| | 16 | Lukwale | Lukwale | 900 | Identified in Reconnaissance Study | RE | NCS |
| | 17 | Wuku | Wuku | 2500 | Identified in Reconnaissance Study | Chunya | Grid |
| | 18 | Yeye | Yeye | 2500 | Identified in Reconnaissance Study | RE | NCS |
| | 19 | Rungwa | Rungwa | 9000 | Identified in Reconnaissance Study | Chunya | Grid |
| | 20 | Lukima | Lukima | 4000 | Identified in Reconnaissance Study | Chunya | Grid |
| | 21 | Msaidia | Mtozi | 34000 | Identified in Reconnaissance study | Sumbawanga | SFDG |
| | 22 | Mtozi | Mtozi | 2400 | Identified in Reconnaissance Study | Sumbawanga | SFDG |
| | 23 | Mbende | Mbende | 1100 | Identified in Reconnaissance Study | RE | NCS |
| | 24 | Mamba | Mamba | 155 | Identified in Reconnance Study | RE | NCS |
| | 25 | Filongo | Filongo | 415 | Identified in Reconnaissance Study | RE | NCS |

| Main Basin | | River | Site Name | Capacity (kW) | Study Level | Load Centre | Current Supply |
|---|---|---|---|---|---|---|---|
| | 26 | Mpete | Mpete | 55 | Identified in Reconnaissance Study | RE | NCS |
| | 27 | Chuku | Chuku | 850 | Identified in Reconnaissance Study | RE | NCS |
| | 28 | Kirambo | Kirambo | 280 | Identified in Reconnaissance Study | RE | NCS |
| | 29 | Muse | Muse | 520 | Identified in Reconnaissance Study | RE | NCS |
| | 30 | Luiche | Luiche | 1100 | Prefeasibility Level of Study | Sumbawanga | SFDG |
| | 31 | Msofwe | Msofwe | 8000 | Identified in Reconnaissance Study | Sumbawanga | SFDG |
| | 32 | Mba | Mba | 3000 | Identified in Reconnaissance Study | Sumbawanga | SFDG |
| | 33 | Kilemba | Kilemba | 530 | Identified in Reconnaissance Study | RE | NCS |
| | 34 | Mbalizi | Songwe | 760 | REHABILITATION | Mbeya | Grid |
| | 35 | Nzovwe | Nzovwe | 3000 | Prefeasibility Level of Study | Sumbawanga | SFDG |
| Pangani | 36 | Kihurio | Seseni | 700 | Identified in Reconnaissance Study | Grid | Grid |
| | 37 | Ihindi | Seseni | 1740 | Identified in Reconnaissance Study | Grid | Grid |
| | 38 | Ndungu | Goma | 1740 | Identified in Reconnaissance Study | Grid | Grid |
| | 39 | Bombo | Higilili | 1740 | REHABILITATION | Grid | Grid |
| | 40 | Kikuletwa | Kikuletwa I | 1200 | REHABILITATION | Grid | Grid |
| | 41 | Kikuletwa | Kikuletwa II | 11000 | Feasibility Level of Study | Grid | Grid |
| Little Ruaha | 42 | Tosamaganga | Little Ruaha | 1428 | REHABILITATION | Iringa | Grid |
| Lake Eyasi | 43 | Mto wa Simba | MWS | 700 | Identified in Reconnaissance Study | RE | NCS |
| | 44 | Mbulu | Hainu | 8100 | Identified in Reconnaissance Study | RE | NCS |
| | 45 | Pinying | Pinying | 450 | Identified in Reconnaissance Study | RE | NCS |
| Lake Victoria | 46 | Kasongeye | Kasongeye | 840 | Identified in Reconnaissance Study | RE | NCS |
| | 47 | Kaonjuba | Kaonjuba | 800 | Identified in Reconnaissance Study | RE | NCS |
| | 48 | Ngono | Ngono | 2460 | Identified in Reconnaissance Study | RE | NCS |
| Ruvuma | 49 | Ruvuma | Nakatuta | 9500 | Feasibility Level of Study | Songea | SFDG |
| | 50 | Ruvuma | Sunda falls | 3000 | Prefeasibility Level of Study | Tunduru | SFDG |
| | 51 | Muhuwesi | Kwitanda | 800 | Prefeasibility Level of Study | Tunduru | SFDG |
| | 52 | Ruvuma | Upper Ruvuma | 2000 | Prefeasibility Level of Study | Songea | SFDG |
| | 53 | Ruvuma | Hanga | 550 | Identified in Reconnaissance Study | RE | NCS |

| Main Basin | | River | Site Name | Capacity (kW) | Study Level | Load Centre | Current Supply |
|---|---|---|---|---|---|---|---|
| Lake Nyasa | 54 | Yungu | Yungu | 90 | Identified in Reconnaissance Study | Mbamba bay | NCS |
| | 55 | Mbawa | Mbawa | 1800 | Identified in Reconnaissance Study | RE | NCS |
| | 56 | Luwika | Luwika | 1400 | Identified in Reconnaissance Study | RE | NCS |
| | 57 | Ruhuhu | Luaita | 190 | Identified in Reconnaissance Study | RE | NCS |
| | 58 | Ruhuhu | Lilondi | 1400 | Identified in Reconnaissance Study | RE | NCS |
| | 59 | Ruhuhu | Kitiwaka | 5100 | Identified in Reconnaissance Study | RE | NCS |
| | 60 | Malisa | Malisa | 1250 | Identified in Reconnaissance Study | RE | NCS |
| | 61 | Mbaka | Mbaka | 8000 | Identified in Reconnaissance Study | Tukuyu | Grid |
| | 62 | Kiwira | Kiwira | 25000 | Prefeasibility Level of Study | Tukuyu | Grid |
| | 63 | Sawa | Kipata | 108 | Identified in Reconnaissance Study | WINO WARD-SONGEA | MHDW |
| | 64 | Mgombezi | Mgombezi rapids | 182 | Identified in Reconnaissance | WINO WARD-SONGEA | MHDW MHDW |
| | 65 | Mgombezi | Lower Kapongo | 622 | Identified in Reconnaissance Study | WINO WARD-SONGEA | MHDW |
| | 66 | Mgombezi | Upper Kapongo | 233 | Identified in Reconnaissance Study | WINO WARD-SONGEA | MHDW |
| | 67 | Limkerenge | Limkerenge Falls | 367 | Identified in Reconnaissance Study | WINO WARD-SONGEA | MHDW |
| | 68 | Welela | Welela | 97 | Identified in Reconnaissance Study | WINO WARD-SONGEA | MHDW |
| | 69 | Litowa | Upper Litowa | 433 | Identified in Reconnaissance Study | WINO WARD-SONGEA | MHDW |
| PANGANI | 70 | Pangani | Mandera | 21 | Feasibility Study | Tanga | Grid |
| | | | | 239402 | | | |

SFDG - Supplied from Diesel Generation, NCS - Not Connected with any Supply, MHDW - Micro-hydro Plant at Welela

These details pertain to only 70 sites. The details of the remaining sites were not available.

**ANNEXURE-IV**

## ABOUT NATIONAL CENTRES FOR SHP DEVELOPMENT IN OTHER COUNTRIES

### 1. Alternate Hydro Energy Centre (AHEC) –IIT Roorkee, India

Alternate Hydro Energy Centre (AHEC) was established in the Indian Institute of Technology Roorkee (formerly University of Roorkee) with initial sponsorship of Ministry of New and Renewable Energy, Govt. of India in the year 1982, to promote power generation through the development of Small Hydropower projects (SHP) and development of decentralized integrated energy systems in conjunction with other renewable energy sources. The centre grew as a centre of excellence for small scale hydro power as well as conservation of water bodies and serves all stakeholders of the small scale hydropower through provision of advisory services, education and training and database management.

AHEC-IITR works for small hydropower development as an exclusive academic center of IIT Roorkee focusing on SHP development and is recognized as National Resource Centre for Small Hydropower. It has been providing professional support to government and private stakeholders in the field of small hydro power development covering planning, detailed project reports, detailed engineering designs and construction drawings, technical supervision of turnkey execution / equipment supply, renovation and modernization of SHP stations, and techno-economic appraisal.. Some of its important activities/facilities and contributions are as follows:

- Real time Digital Simulator of SHP plants for training.
- Expertise with equipment for field testing and performance evaluation of SHP stations.
- Preparing the National Standards/ Code of Practices for SHP development (31 standards).
- Preparing Systematic State Master Plans for SHP and remote village electrification.
- Setting up of an international level Hydro Turbine Testing Laboratory capable of testing hydraulic turbines, controls, monitoring, pumps and CFD

AHEC has been imparting training regularly to the field engineers and technologists through short-term training courses to create trained human resource in India and the neighboring and developing countries. AHEC offers two Master of Technology (M.Tech.) programmes in "Alternate Hydro Energy Systems" and "Environmental Management of Rivers and Lakes". Three elective courses for undergraduate classes of any discipline across the institute each semester and Ph.D. programme are also offered by AHEC.

AHEC was setup with financial support of the government of India initially for seven years thereafter the centre was supported on net deficit financing basis with only limited support of about 20% of establishment expenditure. Later on expenditures on establishment for education and on advisory service were separated. AHEC has been financially self supporting for advisory work for the last 12 years and strengthening its infrastructure with equipments by using surplus generated through advisory services.

AHEC has entered in to networking and collaborative arrangements with national educational institutions viz. Jadavpur University, Kolkata, National Institute of Technology, Bhopal and other technical/engineering institutions including Dr. Bhim Rao Ambedkar National Institute of Technology, Jalandhar, National Institute of Technology, Hamirpur, National Institute of Technology, Srinagar and North-Eastern Regional Institute of Science and Technology, Itanagar. These institutions have taken part in many activities together. It also collaborates with the International Centre for Hydropower Norway, International Centre for small hydropower China and National reference centre for small hydropower in Brazil.

AHEC has the distinction of working on hydropower related activities in inter-disciplinary mode and faculty from different departments of the Indian Institute of Technology Roorkee viz civil, electrical, mechanical, earth science, earth quake, management, humanities and hydrology along with other institutions and individual experts offer technical and academic support for hydropower projects, teaching and research whenever needed. Both the post graduate programmes offered by AHEC involve multi disciplinary expertise. Thus staff structure of the centre is thin with only 7 faculty and 15 support staff on regular cadre and about 25 on projects.

Several assignments of national importance have been carried out with inter disciplinary team of the institute and other institutions and experts. AHEC being part of Indian institute of technology Roorkee has access to the entire infrastructure and expertise in different areas required for small hydropower development. It has also served as an expert institution to many state governments in the field of small scale hydro power by providing required expertise to create & strengthen database, to provide promotional support, to create network for sharing resources, to train manpower, to investigate and plan SHP, to plan & execute village hydro projects, to renovate and modernize the existing SHP stations and to carry out techno-economic appraisals of independent power producers' proposals,.

By way of international cooperation AHEC has organised 21 international training programmes of 2 week duration on various aspects of small hydropower development where 506 participants from 63 countries participated. 12 training programmes sponsored by African and East Asian countries have been organized in AHEC. Through International Technical and Economic Cooperation programme of the Government of India candidates are pursuing M Tech programme since 2010 onwards.

AHEC has been instrumental in getting several cooperation agreements with foreign universities from developed and developing world. These include School of Technology and Architecture, Lucerne, University of Applied Sciences, HTA, Switzerland, Federal University of Itajuba, UNIFEI, Brazil, Water Resources University, Hanoi, Vietnam, University of Peradeniya, Srilanka and Voith Hydro, Heidenheim, Germany.

AHEC has enrolled 309 post graduate students who have worked on different research problems related to small scale hydropower, renewable energy sources and environment management of rivers and lakes. During last 5 years about 250 research papers including one third in referred journals have been published by students and teachers in AHEC. 36 research scholars have registered for their Doctoral degree in AHEC out of which 16 have been already awarded during last 10 years. Over 2350 candidates from the country have been trained through 116 short term training course during last 10 years. AHEC has developed two new designs of water mills for grain-grinding and for mechanical/electricity generation purpose for the hilly region of the country.

The support of the Ministry of New and Renewable Energy, Govt. of India has been directed towards enabling the Centre to acquire state-of-art facilities in the area of SHP.

While taking note of the role AHEC has played so far for the development of the small scale hydropower sector, the Indian Parliamentary Standing Committee on Energy (2010-11) in its 16th report on the theme of small and mini hydro projects submitted to Parliament on March 18, 2011 recommended that "AHEC, IIT, Roorkee should work as a premier institution in the development of small hydro technology in the country paving the way for economic and efficient development of the technology and be a torch bearer for other technological institutes". The Committee also recommended that the Ministry should strengthen the AHEC and provide all support in encouraging it to boost the research and development activities in the small hydro sector. More details may be seen at http://www.iitr.ac.in/departments/AH/pages/index.html and http://ahec.org.in/

## 2. National Reference Centre of Small Hydro Power Plants (CERPCH), Brazil

Another show case for University based centre for small hydro is the National Reference Centre of Small Hydro Power Plants (CERPCH), is located in the Federal University of Engineering of Itajubá (Unife) Brazil. The centre was created in 1998, under the auspices of the Permanent Forum of Renewable Energies of the Ministry of Science and Technology, in which they also created Brazilian Wind Power Energy Centre, located in the Federal University of Pernambuco - UFPE, the Brazilian Thermal Solar Energy Development Centre - SOLAR GREEN, installed in the Papal Catholic University of Minas Gerais - PUC-MG, the Electric Power Research Center - CEPEL and the Biomass Reference Centre - CENBIO, installed in the University of São Paulo - USP.

CERPCH work on the small hydro power p development through information network, projects, researches, scientific and technological development and also the encouragement of the instruction and training in this field of performance, besides the accomplishment of events.

Moreover, the reference centre is also an interface between the entrepreneur that seeks new business opportunities in the energy market and the investor that looks for attractive financial returns that result from the construction and use of Small Hydro Power Plants - SHP. Furthermore, with the growing need of investments and development of projects in the area it will be necessary trainings, services and consultancies, in which CERPCH would be analyzing, managing and giving technological support. It spreads information through its regular periodical Revista PCH Noticias & SHP News**,** and the accomplishment of scientific technical events such as the SHP Market and Environment Conference. Besides it is responsible for the production of books and guidelines as well as the accomplishment of specialization courses mainly in Portuguese. For small hydro projects it develops basic Projects, Inventory Studies, Retrofitting Projects and Repowering of Hydropower Plants.

Details can be assessed http://www.cerpch.unifei.edu.br/en/quem_somos.php

**ANNEXURE-V**

## COURSES PROPOSED TO BE MODIFIED/INTRODUCED AT CoET

### 1. EN 618 ENERGY POLICY AND PLANNING

**Learning Objectives:** as the majority of the candidates will be engineers, this unit has as its role to stress the political and institutional aspects of an idea. It is not enough to develop something theoretically and practically if one does not set some targets on how to convert it into a government policy initiative.

**Course Content:** Introduction, Issues and scope for policy input, Issues, resources, development, Clarifications, Issues and Preferences (consultation), Drafting and discussions, Institutional Framework, Legal framework, Policy implementation. Monitoring, Policy Strategies for Implementation, Energy policy content

**Assessment:** Coursework 40% & Written University Examination 60%

**References:**


1. **Winter, G.**, *Blueprint for Green Management,* McGraw-Hill Book Company, London, 1994.
2. **David R. Cope**, *Energy Policy and Land-Use Planning: An International Perspective (International Series in Experimental Social Psychology)*, Pergamon, **ISBN-13:** 978-0080313238
3. **Sam Moyo & Mike Sill,** Energy Policy and Planning in Southern Africa, African Books Collective, Oxford, 1999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### 2. WR 642 DEVELOPMENT OF SMALL HYDROPOWER

**Objectives:**

- Presenting the concept of energy for rural areas.
- Presenting the aspects regarding electricity production by mini hydro plants
- Presenting technical design aspects of micro hydropower plants.
- Presenting the layout of small hydropower plants components and guidelines.

**Delivering format:** 50 hours lectures, 20 hours design exercise. It will include demonstrations and field visits to construction or existing mini hydro sites

**Course Content:** Energy for Rural development, Measurements – discharge and head. Estimation of a flow duration curve, design flow Determination of power and energy potential, site selection and layout, water diversions civil works, fore bay, water conveying structures, penstocks, gates, valves, tailrace . Sediment problems, settling tanks, Turbine specifications, cross flow turbines, pelton, turgo Francis, Kaplan runners, options for coupling. Generators – synchronous and asynchronous, voltage, phase frequency, switch gear and protection equipment. Mechanical versus Electrical Energy options AC versus DC generation. Governing, phase control, power transmission, inverters.

Economic considerations – cost benefit approach for socio-economic selection.

**Design Exercises** Students will be allocated real field conditions for case study designing and submission of full project report

**Assessment:** Coursework 40% & Written University Examination 60%

**References:**


1. **US Bureau of Reclamation**, Design of Small Dams, Oxford and IBH Publishing Co. Pvt Ltd – 1984
2. **Allen R. Inversion**, Micro hydropower Sourcebook, NRECA International Foundation – Washington DC - 1990
3. **R. Holland**, Energy for Rural Development, International Water Power and Dam Construction Vol. 34 NR. 12 December 1982
4. **Juan Mala**, Design Criteria for Typical Civil Works for Mini hydropower plants projects, Small Hydropower Plants"NRECA 1980
5. **Uli-Meir,** Local Experience with Micro-hydro Technology , SKAT – ATOL, St. Gallen, 1985
6. **Uli Meir, Eisenring M, Chapallaz J.M.**, Civil Enginering in Micro hydro projects, SKAT, 1986


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## 3. DP 671 HYDROPOWER ELECTRICAL EQUIPMENT

**Objectives:** The objective of this course is to train the candidates on small hydro generation, protection and control equipments which are all of electrical nature. At the end of the course, the students shall be able to: Design, size, select or judge the performance of these systems.

**Course Content:** Introduction of electrical works and controls, sizing of single phase and three phase generators; Power factor and power factor correction methodologies; Characteristics, specification and testing of generators & excitation systems; Transformers, circuit breakers; Electro-mechanical/Electronic governors, Protection and control of generation stations, Design of auxiliary and grounding system; Supervisory control and data acquisition (SCADA) and integrated computer control system for SHP station; Switch yard equipments. Planning and layout of Electrical Equipment, estimating unit size, number and type; Power and control system : Generator protection, transformer protection, Bus-bar protection and feeder protection, Single line schematic and detailed wiring diagram Cable selection, scheduling and routing, Insulating coordination; Digital Integrated Control and Protection System for SHP ; Switchyard : Selection of equipment, Layout of switchyard equipment ; Auxiliary system, auxiliary power, grounding system, D.C. System and D.C. batteries; Lighting system, ventilation system, fire protection.

**Teaching Methods:** Lectures, demonstrations, practical, seminar discussions

**Assessment:** Coursework 40% & Written University Examination 60%

**Reference books:**


1. **Anthony J. Pansini, Kenneth D. Smalling**, Guide to Electric Power Generation, 2nd Edition, The Fairmont Press, Inc., 2005, ISBN 0824709276
2. **Anthony J. Pansini,**, Electrical Transformers and Power Equipment**,** The Fairmont Press, Inc., 1999, ISBN 0881733113
3. **Dale R. Patrick, Stephen W. Fardo**, Rotating Electrical Machines and Power Systems, The Fairmont Press, Inc., 1997, ISBN 0881732397

4. **Mohammad Shahidehpour**, Communication and Control in Electric Power Systems: Applications of Parallel and Distributed, Wiley-IEEE, 2003, ISBN 0471453250
5. **Arthur Wright, Christos Christopolulos**, Electrical Power System Protection, Springer, 1999, ISBN 0412817608

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## 4. WR 643 HYDRAULIC STRUCTURES IN HYDROPOWER

**Objectives:**
The objective of this course is:
- To present the design and operation of the hydraulic structures required in hydropower plants.
- To present the design and selection methods for the appurtenant structures on dams
- To present reservoir operations and problems

**Delivering Format:**
- 55 hours lecture and 10 hours practical in 15 weeks.
- Site visit to Hydropower plant and related hydraulic structures

**Course Content:** Dams and barrages, classification of dams, design concepts and criteria, data topographical, geological, hydrological. Reservoirs data, reservoir problems, sedimentation in reservoirs, planning of dams, mass curve analysis, seepage through embankment dams, slope stability, Concrete Dams, types of concrete dams, spillways, classification, types of spillways, weirs, side channel, siphon, shaft types, design concepts and criteria, energy dissipation, terminal structures, stilling basins, bucket dissipaters. Diversion and intake works, trash racks, water conveyance structures, canals, pressure tunnels penstocks, water hammer surge chambers, power house layout options and components – machine hall, generators, exciters, transformer, synchronization, switch room, battery room, control room, Draft tube and tailrace

**Practical:** Specific energy experiments in open channels, Surge tank experiments

**Assessment:** Coursework 40% & Written University Examination 60%

**References:**

1. **Thanikacham, V.**, Hydraulics and Hydraulic Machinery, Tata McGraw Hill Publishing Co. Ltd. 1994
2. **Sherard, Wordwand Gizienski and Clavenger**, Earth and Earth rock dams
3. **Massey, B.S.**, Mechanics of Fluids, -Van Natrand Reinhold
4. **Dandekan, M.M. sharma K.N.**, Waterpower Engineering, Vikas Publishing House – India (1991)
5. **Arved J. Raudkivi A.A. Balkema**, Sedimentation Exclusion and Removal of Sediment from diverted water, Rotterdam – 1993
6. **Maurice Albertson, Rahim KIA, A.A. Balkema**, Design of Hydraulic Structures 89, Rotterdam – 1989
7. **U.S. Department of Interior** – Bureau for Reclamation, Design of Small Dams, Oxford, IBH Publishing Co. Pvt. Ltd – 1984

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5. **WR XXX : Small Hydro Power Development ( a new course)- to be available to all UG students**

**Objectives: To provide basic knowledge about Small Hydro Power Technology and SHP project designs.**

**Delivering format:** 40 hours lectures, 20 hours design exercise. It will include demonstrations and field visits to construction or existing mini hydro sites- 3 units

**Course Content:**

1. Necessity and Importance of harnessing small hydro power; National policies, laws & clearances; Small hydro power scenario and type of schemes.(6)
2. Site selection and investigations; Environmental aspects; Flow duration, water power studies; Cost estimation. Economic and financial aspects.(9)
3. Diversion structures & power channels; Desilting arrangements, forebay tank and balancing reservoir. Penstock and power house building(9)
4. Types of turbines and their selection; Gates and valves; Governing system (mechanical & electrical).(8)
5. Load forecasting.(2)

Types of generators– synchronous and induction; Protection & controls, Power evacuation system. (8)

**Assessment:** Coursework 40% & Written University Examination 60%

**References:**


1. Adam Harvey, "Micro hydro design manual", Intermediate Technology, 1993
2. Fritz , "Small Hydro Mini Power Systems" , McGraw Hills1994
3. Emil Mosonyi , "Water power development", Vol.1&2 ,Nem Chand & Bros 2009
4. Small Hydro Stations. (Publication No. 305), Central Board Of Irrigation and Power 2010
5. Civil Engineering Guidelines for Hydroelectric Projects. (Vol.4-Small Hydro), ASCE,1989
6. P.S. Nigam, "Hand book of Hydroelectric Engineering", Nem Chand & Bros, 1985(2001)
7. Hand book Hydro-electric Engineering Practice Vol.1,2 &3 by Guthrie Brown, CBS Publication, 1984


**6. WR XXX : Small Hydropower Planning & Management ( a new course) to be available to all PG students**

**Objectives:** The Course gives an overview of small hydropower projects, and its process of development and management

**Delivering format:** 40 hours lectures, 20 hours design exercise. It will include demonstrations and field visits to construction or existing mini hydro sites

1. Water Resources Development, Purposes, Relevance of SHP development, types of hydro projects. Electricity act, Constitutional provisions, process of development, allotment of sites, opportunities ( 7)
2. Small hydropower planning on existing structures and new sites(3)
3. stream gauging, different methods for stream gauging, Rainfall, Runoff and its estimation by different methods peak flood estimation, estimation, demonstration of instruments (6)
4. flow duration studies , Assessment of power potential, and Installed capacity (6)
5. Topographical, geological and power evacuation surveys and investigations, demonstration of instruments (3)
6. Site selection for shp projects (4)
7. Different Types of Project reports and their relevance (4)
8. Different project implementation methods (4)
9. financing of projects, cost estimated for different components, financial and economic analysis, CDM for SHP management of SHP, (5)

**Assessment:** Coursework 40% & Written University Examination 60%

**References:**

1. Adam Harvey, "Micro hydro design manual", Intermediate Technology, 1993
2. Fritz , "Small Hydro Mini Power Systems" , McGraw Hills1994
3. Gulliver and Ardnt, " handbook of Hydro Electric Engg", McGraw Hills1993
4. Manual on Planning and design of Small Hydroelectric projects Stations. (Publication No. 305), Central Board Of Irrigation and Power 2009
5. Civil Engineering Guidelines for Hydroelectric Projects. (Vol.4-Small Hydro), ASCE 1989
6. P.S. Nigam, "Hand book of Hydroelectric Engineering", Nem Chand & Bros, 1985(2001)
7. Guide on How to Develop a Small Hydropower Plant , ESHA, 2004

**WR 642 DEVELOPMENT OF SMALL HYDROPOWER**

**(be dropped as it stand alone as course for general idea of shp but with all technical details but with financing, policy, environmental and social issues)**

**7 MG 623 PROJECT MANAGEMENT** *(Existing course)*

**Learning Objective:** All the practical issues in this unit are meant to create awareness in the student's mind of the other aspects of a project if it is to be a success. Quite often good ideas fail to go off the ground because of mismanagement, poor tendering and inadequate procurement procedures.

The objective of the course is to enable participants to understand the process and tools of project management: This includes:

Course Outline

- **Integration management: T**he Overview to the key (Adaptability).
- **Scope management:** Project Initiation and Project Planning.
- **Time management:** Estimating, time tracking, and performance and progress measurement (project administration).

- **Cost management: E**stimating performance and progress measurement, Project Initiation stage through business case analysis;
- **Contract management** this shall include legal aspects of contracts and discussion of standard contracts for procurement of professional services, goods and works
- **Human resources management**: definition of roles and responsibilities, joint reviews, performance evaluations and project reviews;
- **Communications management**: Project Planning and executed both in Project Execution and Project Wrap-up (the reviews and performance improvement activities in wrap-up represent additional means of communicating project status, success, and process improvement ideas);
- **Risk management** addressed in Project Initiation, Project Planning, and Project Execution. It is also specifically identified within the Project Approval Process; and
- **Procurement Strategies and Management** is discussed within the Project Initiation Stage (under the business case - options analysis section).
- **Project Evaluation** will be presented from the project managers' point of view and also from an independent reviewer's point of view;
- **Management of Project Teams;** provision of the skills required to successfully manage project teams successful team culture, assess team members' abilities and make appropriate assignments, then define authorities and accountabilities, including rewards and consequences.

**Assessment:** Coursework 40% & Examination 60%

**Reference Books:**


1. **James P Lewis**, Fundamentals of Project Management: developing core competencies to help outperform the competition AMACOM Div American Mgmt Assn, 2007.
2. **Frederick L. Harrison, Dennis Lock**, Advanced Project Management: A Structured Approach, Gower Publishing, Ltd., ISBN 0566078228, 2003
3. **Scott Berkun,** The Art Of Project Management, O'Reilly, ISBN 0596007868, 2005.
4. **Eric Verzuh,** The Portable MBA in Project Management, John Wiley and Sons, SBN 0471268992, 2003.


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## 8 WR 640 A HYDROPOWER (*For Civil Engineering Background candidates)*

**Objectives:** The objectives of this course include the following;

- To present fundamental principles of electrical power production and concentrate on hydropower.
- To present the hydropower development worldwide and regionally.
- To present the basics of hydropower planning.

**Delivery Format:** 40 hours lectures and 10 hours practical in 15 weeks. **(3 Units).**

- *Energy Resources and types of generation (1)*
- *Hydrological analysis: stream gauging, stage discharge curves, peak flow estimation, mass curves and Flow duration curves (5)*
- *Estimation of power potential (3)*
- *Peak load and base load stations (1)*

- *Firm and secondary power (1)*
- *Pondage and storage(1)*
- *Choice of power plants and their classification (1)*
- *Components of hydropower plants: intakes, desilting tank, tunnel, penstock, forebay tank, surge tank, power channels etc., powerhouse (8)*
- *Special problem of African regions – silt and land slight (4)*
- *Types of turbines and their characteristics and provision for testing (6)*
- *Preliminary dimensioning of powerhouse (2)*
- *Power plant equipment, instrumentation and controls (4)*
- *Economic considerations: pricing of electricity, regulatory aspects, investment planning (4)*
- *Policies and laws (2)*

**Assessment:** Coursework 40% & Examination 60%

**References:**


1. Gulliver and Arndt, "Handbook of Hydropower Engineering" McGraw Hill Inc. 1991 ISBN. 0-07-025193-2
2. *Guthrie Brown, J., "Hydro Electric Engineering Practice", CBS Publishers & Distributors, New Delhi (1984).*
3. *Nigam, P.S., "Handbook of Hydroelectric Engineering"*
4. *Civil Engineering Guidelines for Hydroelectric Projects", ASCE.*
5. *Wang, "Modern Power System Planning"*
6. Annund Killingtveit: Nils R. Saalthum (1998), Hydrology for Hydropower Development Series No. 7, NTNU Hydraulic Engineering division
7. Peter L. Payne, The Hydro, Aberdeen University Press (ISBN 0-08-036584-1)
8. Linsley R.K. et-al Hydrology for Engineers, McGraw Hill Co.


## 9 WR 640 B HYDROPOWER (*For non -civil Engineering Background candidates)*

**Objectives:** The objectives of this course include the following;

- To present fundamental principles of electrical power production and concentrate on hydropower.
- To present the hydropower development worldwide and regionally.
- To present the basics of hydropower planning.

**Delivery Format:** 40 hours lectures and 10 hours practical in 15 weeks. **(3 Units).**

- *INTRODUCTION: Type of Hydro-electric development, classification, Techno Economic studies for capacity size & type. (2)*
- *Hydraulic Turbines and Governor: Types; selection criteria, Model testing, specifications. Speed rise and Pressure Rise, studies for performance requirements. (6)*
- *Hydro Generator and Excitation System: Types; selection; Characteristics; Specification; Testing (4)*
- *Power Transformer: Types; Characteristics; Specification and Testing (3)*
- *HV Circuit Breaker: Types; Characteristics; Specification and Testing (4)*
- *Power evacuation arrangements; main single line diagram; interconnected with grid (6)*

- *Control & Protection: Protective Relaying and Metering of Hydro Generators; Turbines, Transformers, Bus Bars and Outgoing Feeders, control and Monitoring System for Turbines, Generators, Exciters; transformers; Breakers, Power Plant Start/Stop, running control and Annunciation(4)*
- *Electrical Auxiliaries: Auxiliaries Power; DC System; Power & Control Cables and Cabling; Lighting System; Grounding System (4)*
- *Mechanical Auxiliaries: EOT Crane; Cooling Water System; Dewatering and Drainage System; HP & LP compressed Air System; Fire Protection; Ventilation and Air conditioning (3)*
- *Switchyard Equipment: Isolators, Potential Transformers, Current Transformer; Lighting Arrestors; Switchyard and Structures (2)*
- *Erection, Commissioning and Field Testing Renovation and*
- *Modernization (4)*

**Assessment:** Coursework 40% & Examination 60%

**References:**


1. American Society of Mechanical Engineers, "Mechanical Design of Hydro Plants"
2. Army Corps of Engineer, "Design Standard"
3. BIS, "Standards (Relevant)"
4. Demon, David M., "Hydro Plant Electrical System"
5. Gutterie Brown, J., "Hydro-Electric Engineering PRACTICE", Vol. II E&M.
6. IEEE & IEC "standards (Relevant)"
7. Masony E, "Water Power Development"
8. USBR, "Design Memorandum and Standards"


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**10 WM 649 Environmental Impact Assessment**

**Delivery Format:** 40 hours lectures and 10 hours practical in 15 weeks. **(3 Units).**

**Objectives**

1. To develop an understanding of environmental implications of water resources projects
2. To develop skills for identifying, analysing and managing environmental effects of water resources projects.
3. To develop a critical understanding of national and international policies and legislation dealing with EIA

**Content**

1. Purposes of EIA
2. Strategic environmental assessments
3. Stakeholder involvement during an EIA
4. Screening and scoping
5. Methods of impact identification, analysis and assessment
6. Measures for managing environmental impacts
7. Reporting and reviewing EIA reports
8. Ethical considerations concerning EIA
9. Evaluation of the validity of an EIA
10. Incorporation of EIA results in decision-making
11. Environmental monitoring
12. *Concept of cumulative impact assessment (CIA)*
13. *CIA for hydropower projects on rivers*

14. EIA policies and legislation in East and Southern Africa, multilateral funding agencies (World Bank, EU, ADB etc.)
15. Case study (e.g. use WCD evaluation of Kariba; if necessary combined with proposed Batoka Gorge dam?)
16. Fieldwork

**References:**

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**11 WM 659 Geographical Information Systems and Database management**

**Delivery Format:** 40 hours lectures and 20 hours practical in 15 weeks. **(3 Units).**

Objectives:
To enable students to use GIS in solving water resources planning and management problems; and to establish databases for the effective management of water resources data.

**Course contents:**

1. Data requirements in water resources management (4h lect)
2. Water occurrence and availability, water use, water users, water rights, land rights, water infrastructure, billing etc.
3. General concepts of water resources data processing (4h lect)
4. Methods of data entry, data quality control, computer files, data analysis and display, data transfer (imports and exports from/into other systems and applications, linkage with GIS systems
5. Workshop: designing a database system for a water resources system (8h nonlect)
6. Data analysis using GIS (4h lect; 4h nonlect)
7. Workshop: designing an integrated system GIS/database system for a water resources system (12h nonlect)
8. Introduction to modelling in GIS (6h lect; 6h non lect)
9. Modelling of ground- and surface water
10. Workshop: designing a GIS-based water resources information system (12h nonlect)

**Assignments:** Based on a well developed and fully documented case of a water resources system. Requires the adoption of a standard software programme for GIS

**References:**

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**12 WR 627: LEGAL AND ADMINISTRATIVE ASPECTS OF WATER MANAGEMENT (**2 UNITS)

**Course Objectives:**
To give dossier to engineering students on legal and institutional arrangements that are necessary mechanism to manage water resources. The course shall include Tanzania, regional as well as international laws.

**Delivery Format:** 40 hours lectures and 10 hours practical in 15 weeks. **(2Units).**

**Course contents:**
Principal legislation governing water resources management in Tanzania. Existing water legislation. The Water Utilisation act with later amendments. Water users/stakeholders in

water resources management. Status of traditional use of water. Granted water rights. Water right administration. Water basins and water offices in Tanzania. Water resources management institutions in Tanzania. The roles of Ministry of Water, Principal Water Office: Basin water Officers; Basin Water Boards: Use of water fees. Public representation in the planning process. The role of stakeholders in water resources management. International water law. International water resources organisations. The roles of : UN;FAO;UNESCO; WMO; UNDP; World Bank; Examples of water legislation and organisations in other countries.

**Reference:**

1) Pieter van der Zaag, (1999), Water Law and Institutions (WROM 506) M Lecture Notes, UZ, p161.
2) Robert Rangsley et. Al (1994), International River Basin Organisation in Sub-Saharan Africa, World Bank Publications No. 250, p70.
3) Echo Knusisto, (1998), International River Basins and Use of Water Resources, Finish Environmental Institute, p64.

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**13 WR 643 Socio-Economic Aspects of Water and Environmental Resources**

Objectives

To introduce students to key socio-economic issues related to water resources management and development.

**Delivery Format:** 40 hours lectures and 10 hours practical in 15 weeks. **(3 Units).**

**Course contents:**

1. Introduction
   1.1 Key Socio-Economic Aspects and Issues (2h lect.?)
   1.2 Context of water use in developing countries and linkages with different environmental issues (2h lect; 2h nonlect)
2. Disciplinary focus
   2.1 Socio-cultural aspects of water use, e.g. attitudes, perceptions, values, and indigenous systems of knowledge (4h lect.; 6h.non lecture e.g. paper on articles)
   2.2 Economic aspects of water use, e.g. resource valuation and pricing, cost recovery and pricing, economic rights to water, optimal water use and efficiency, cost benefit analysis; resource/environmental/ecological economics; national resource accounts. (10h lect.?; 6h non lect)
3. Other Socio-Economic Issues
   3.1 Gender and Equity, e.g. access, control, power and affordability (2h lect.)
   3.2 Water Users, Water Contestations and Resolution; Access to water; Water Security versus Water Independence (and virtual water) (4h lect.; 4h nonlect)
   3.3 Demographic and Spatial Issues, Urbanization, Natural Disasters, Rural Marginalization, Effects of Technology (2h lect.; 4h nonlect.)

Institutional Development, Stakeholder Involvement, Role of Government and NGOs; Water Users Groups; CBNRM Approaches, Participatory Methodology (6h lect.?; 6h nonlect.)

**ANNEXURE-VI**

## SHORT TERM TRAINING COURSES

**I Course Title: Small hydropower development including feasibility report preparation**
**Objectives:**

Small Hydro Offers a wide range of benefits especially for rural areas. Feasibility report and other reports are important tools for investment decision. It has been found that the quality and contents of reports needs improvement and adequate coverage of different details. The course is aimed to equip the participation with the desirable required knowledge for preparing feasibility report and provide the participants an insight to SHP, site selection potential assessment, planning and design of civil works, selection of E&M equipment and financial aspects

**Contents:** The course shall cover following:

- Topographical survey
- Hydrological survey
- Geological survey
- Load survey
- Socio-economic survey
- Power evacuation survey
- Use of Modern Techniques such as GPS, RS and GIS for conducting investigations and assessment.
- Environmental aspects
- Survey for construction material
- Flow duration and installed capacity estimation
- Overview of SHP Development
- Country Policy for SHP Development
- Small Hydropower and Rural Electrification
- Different types of reports for Small hydropower
- Environmental impacts
- Structure for pre- feasibility report and feasibility report
- Optimal utilization of stream potential
- Project hydrology and power potential
- Installed capacity and energy generation
- Planning and preliminary design of civil works (weir, desilting tank, channel, forebay tank, surge tank, penstock, powerhouse, access road)
- Selection and specifications of Electro-mechanical Equipment/Works including power evacuation
- Cost estimation
- Financial analysis
- Clearances
- Case studies

**Duration**: 10 days

**Pre-requisites for participation**:

Civil/Agriculture/Mechanical/Rural/Electrical Engineers, Technical Institutions (ITC etc), Private companies into civil engineering/electricity sector/water resources/consulting companies, individuals, financial institutions, Government institutions

**Desirable qualification:** Civil/Agriculture/Electrical/Mechanical/Rural Engineering Diploma/ Degree or otherwise experienced personnel

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**II Course Title : O&M of SHP Stations**

**Objectives:**

Operational and maintenance of hydropower station is a specialized aspect. The course is aimed to provide basics of the electro-mechanical equipments, upkeep, operation and maintenance during running of the plant.

**Contents:**

The course shall cover following:

- Basics of Hydro turbines and their auxiliaries
- Operational problems and maintenance in turbines
- Operational problems in generators
- Contral and protection equipments
- Operational limitations and application consideration in transformers
- Standards and practices for operation and maintenance of electro-mechanical equipments
- Latest technology for maintaining reliable electrical connection
- Renovation, life extension and upgrading of existing stations

**Pre-requisites for participation**:

Civil/Agriculture/Mechanical/Rural/Electrical Engineers, Technical Institutions (ITC etc), Private companies into electricity operating companies, individuals, Government institutions

**Duration**

**10 days**

**Desirable qualification:** Civil/Agriculture/Electrical/Mechanical/Rural Engineering Diploma/ Degree or otherwise experienced personnel

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**III Course Title :**
**Business Model, Policies and Financing of Small Hydropower Projects**

**Objectives:**

Business model and Financing of small hydropower in Tanzania is still in the infancy stages. Most of the possible developers are financial institutions either are not aware of the technology, incentives and provisions through the legislation for its deployment or options on various model are not available. The course shall aim to improve the awareness and details of different types of business models for small hydropower projects in Tanzania, and financing issues involved so that deployment is accelerated

**Contents:**

- Different types of small hydropower projects
- Small hydropower components and technologies
- Business models for SHP
- Policies
- Barriers and mitigation for SHP development
- Structure for financing in the form of feasibility report
- Cost estimation
- Environment impacts assessment
- Financial analysis
- Financial appraisal
- Clearances and different acts
- Electricity Regulatory support
- Power purchase agreement
- Role of lenders engineers
- Global references of financing
- Benefits under CDM
- Case studies

**Pre-requisites for participation**:

Financial institutions, Government institutions, regulators, donors, private entrepreneurs, potential REEs in the Hydro potential area, Technical institutions

**Duration: Three days**

**Desirable qualification:** Financial/Management Engineering Diploma/ Degree or otherwise experienced personnel

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## IV. Course Title: SHP Development Policy and Implementation

**Objectives:**

Absence of the right policy and conducive environment for SHP development is one of the main barriers for its development. The course shall aim to improve the awareness and details of policies and it impact on society and development.

**Contents:**

- Global scenario for small hydropower developments vis-à-vis Tanzania
- Types and components of small hydropower projects
- Barriers for SHP development and their mitigation

- Business models for SHP
- Direct and indirect benefits
- Need for a policy to encourage the development of Small Hydro projects
- Case studies

**Duration: One day**

**Desirable qualification:** Senior bureaucrats and technocrats, minister, Managing Director

**ANNEXURE-VII**

## EQUIPMENTS FOR SHP TECHNOLOGY CENTRE

(i) Equipment for SHP Technology Centre and TDTC:

CoET has submitted in April 2012 its requirement to UNIDO for establishing SHP centre and equipment/machine for TDTC. The office equipments, computer and peripherals, design office, site investigations and surveys instruments and workshop are given as follows

### 1. Equipment/Items to be purchased (Design office/office/machine lab)

| S. No. | Item | Description | QTY | Unit Price (US$) | Amount (US$) |
|---|---|---|---|---|---|
| 01 | Computers | HP-Desk Top | 5pcs | 1000 | 5000 |
| 02 | Printers | Laserjet HP M1522n Printer/Scanner/Copier/Fax. | 2pcs | 431 | 862 |
| 03 | UPS | APC-650 | 5Pcs | 120 | 600 |
| 04 | Laptops | DELL XPS15 | 3pcs | 1200 | 3600 |
| | Photocopier | 25 cpm colour | 2 | 10000 | 20000 |
| 05 | Drawing Boards | A0 (Adjustable) | 3pcs | 800 | 2400 |
| 06 | Design/drawing softwares (Commercial) | Auto CAD, Arc GIS, Solid work , general softwares | 1 set | 20000 | 20000 |
| 07 | Scanner | $A_0$ Paper size | 1 | 10000 | 10000 |
| 08 | Drawing Instruments | - | - | Lump sum | 1000 |
| 09 | Plotter | HP Designjet 510 | 1pc | 2500 | 2500 |
| 10 | Tables | 4’x2’ | 3 | 400 | 1200 |
| 10 | Chairs | Harmonize | 3 | 350 | 1050 |
| 11 | Vehicle | 4WD | 1 | 30000 | 30000 |
| 12 | Flame Cutting M/C | Oxy-acetylene, cut upto50mm | 1Pc | 20,000 | 20,000 |
| 13 | Plasma Cutter | | 1pc | 4000 | 4000 |
| 14 | Air Compressor | 4 HP | 1pc | 500 | 500 |
| 15 | Tool Boxes | Vanadium/chrome assorted Trolley type; complete with mechanical tools | 2pcs | 200 | 400 |
| 16 | Miscellaneous | | | | 22000 |
| | **Total** | | | | **145,112** |

## 2. Repair of Machines at TDTC

| S. No. | Type of Machine | Repair | Repair cost (Tsh.) |
|---|---|---|---|
| 01 | Lathe Machine ( Al-pin 350,Big Lathe) | Major repair (Major Overhaul) | 2,000,000 |
| 02 | Lathe Machine(Pfeifer) | Minor repair, general service | 1,000,000 |
| 03 | Lathe machine (Wailer) | Minor repair | 600,000 |
| 04 | Lathe Machine (Al-pin-50) | Major Overhaul | 1,500,000 |
| 05 | Small Milling Machine | Minor Repair | 500,000 |
| 06 | Milling Machine | Minor repair | 700,000 |
| 07 | Drilling Machine | General service | 400,000 |
| 08 | Radial Drilling machine | Major overhaul | 1,500,000 |
| 09 | Shaper | Minor repair | 500,000 |
| 10 | Bending Machine | General service | 400,000 |
| 11 | Welding transformers (5pcs) | General service | 600,000 |
| 12 | Power Saw | General service | 300,000 |
| | **Total** | | **10,000,000** |
| | | | **USD 6,330** |

## 3. Rehabilitation of design offices at TDTC

| S. No. | Item | QTY | Unit Cost (Tsh.) | Amount (Tsh.) |
|---|---|---|---|---|
| 1 | Repainting, Partitioning and general repair | 2 rooms | Lump sum | 3,000,000 |
| 2 | Carpet | 2 pcs | 300,000/= | 600,000 |
| | **Total** | | | **3,600,000** |
| | | | | **USD 2,280** |

## 4. Laboratory and Field Instruments for Investigations, Planning, Design and Monitoring

Additional instruments required for investigations, monitoring and design are suggested in three groups namely civil works, electrical works and mechanical works. The estimated cost of each instrument is also indicated.

USD

| Equipment | Quantity | Rate | amount |
|---|---|---|---|
| **Civil works for topographical surveys, hydrological and topographical studies** | | | |
| Flow Meter (Salt based conductivity type) | 2 | 2000 | 2000 |
| Flow Meter – Acoustic Doppler Current Profiler for | 1 | 12000 | 12000 |

| | | | |
|---|---|---|---|
| rivers and open channels of small Hydropower stations | | | |
| Propeller Water Velocity Meter | 5 | 2000 | 10000 |
| Portable Electro-Magnetic Type Current Meter | 1 | 6000 | 6000 |
| Portable clamp-on type ultrasonic flow meter for pipes | 2 | 8000 | 16000 |
| Hand-held Global Positioning System (GPS) | 5 | 1000 | 5000 |
| Hand-held Global Positioning System (DGPS) | 1 | 3000 | 3000 |
| DISTO Meter | 2 | 1000 | 2000 |
| Altimeter | 5 | 300 | 1500 |
| Total station | 1 | 10000 | 10000 |
| Digital Camera | 5 | 300 | 1500 |
| Laser Distance Meter | 2 | 200 | 400 |
| Eco Sounder | 1 | 20000 | 20000 |
| Weirs Plate (Steel) | 5 | 200 | 1000 |
| Measuring Tapes | 10 | 10 | 100 |
| **Sub Total** | | | **90,500** |
| **Electrical Works** | | | |
| Hand-Held Digital Multi meter | 2 | 300 | 600 |
| Tong Tester | 2 | 500 | 1000 |
| Digital Tachometer - Contact Type | 2 | 300 | 600 |
| Digital Tachometer - Non Contact Type | 1 | 1,000 | 1000 |
| Infrared Thermometer | 2 | 1,000 | 2000 |
| Digital Megger | 1 | 5,000 | 5000 |
| Three-Phase Clamp-On Portable Power And Energy Analyser | 1 | 7,000 | 7000 |
| Test Bench equipment for Speed Governors, Turbines and synchronous generators, including an islanded operation real-time simulator | 1 | 140,000 | May wait |
| **Sub Total** | | | **17,200** |
| **Mechanical** | | | |
| A Working Model | | | |
| closed Circuit Pelton Turbine | 1 | 10,000 | May wait |
| Closed Circuit Francis Turbine | 1 | 10,000 | May wait |
| Kaplan Turbine | 1 | 10,000 | May wait |
| (a) Differential Pressure Transducer | 2 | 1,200 | 2400 |
| (b) Immersible Pressure Transducer | 1 | 1,200 | 1200 |
| (c) Gauge Pressure Transmitter | 1 | 1,200 | 1200 |
| Sub Total | | | 4800 |
| Grand Total of funds for **Laboratory and Field Instruments** | | | 112,500 |

**ANNEXURE – VIII**

## SPECIFICATIONS FOR EQUIPMENTS FOR SHP TECHNOLOGY CENTRE

### 1. Flow Meter (Salt based conductivity type)

Compact and portable flow stream meter based on salt dilution method with probes and all accessories

- Read out in liter per second
- Robust construction sealed to IP 65
- Highly portable battery operated
- Microprocessor controlled
- Using alkaline AA batteries
- Auto start and stop logging
- Rugged box to carrying in the field
- User manual

### 2. Portable Horizontal Acoustic Doppler Current Profiler

**Port Channel Master for** rivers and open channels

Technical Specifications

Operating Frequency : 600 KHz
No. Of Cells : 1-128
Maximum Profiling Range: 80 m
Accuracy : + 0.5%
Operating Power : 9-18 VDC
Weight in air : 4.7 Kg
Weight in Water : 2 Kg
5m Power/Communication Cable
Tool Kit, User Guide, Operation manual and shipping crate, WIN-HADCP software for real time data collection and calculation of discharge by index method and carrying case
Cable
Q-Monitor –H Software for discharge monitoring

### 3. Propeller current meter

Propeller diameter : 100 to 125 mm
Flow velocity range : 0.1 to 2.5 m/s,
Water depth : 0.5 to 1.0 m
Accuracy : ±1% or better,
Application mode : Fixing on rod or pipe & cable suspended
Mounting fixture : 16 current meters each along with sturdy removable clamp suitable for mounting them on MS/SS pipes of 25x75 mm elliptical cross-section and four pipes of this type of 6 m length.

### 4. Portable Electro-Magnetic Type Current Meter

Electro-Magnetic Velocity Measuring System
Type Flow Sens for use on 20 mm $\phi$ rod consisting of

Electronical sensor with 5m cable and universal fastening Possibilities (as universal current meter F1)

- Big control display for clear operation
- Memory : to 1000 measuring valuee
- RS 232 interface, neck belt
- Transport case
- Accuracy: ± 0.5%, Resolution: 1.0 mm/s
- Zero stability: better than 5 mm/s

Cable
Rod 20 mm $\phi$, 3 m long, 3 sections
Made of non-corrosive steel, dm-graduation point and base plate
Direction indicator for rod 20 mm $\phi$
Interface cable (Flow sens- PC/Laptop)
Canvas Bag

**5. Portable clamp-on type ultrasonic flow meter for pipes**

Specifications

| | | |
|---|---|---|
| Application | : | Measurement of water flow rate in pipes in the field |
| Principle of Measurement | : | Ultrasonic transit time |
| Modes of Measurement | : | Direct and Reflection modes |
| Velocity Range | : | ± 10 m/s |
| Accuracy | : | ± 0.5% or better |
| Pipe Dia. | : | 0.3 m to 6 m |
| Display | : | Digital and Graphical LCD Panel |
| Outputs | : | Analog : 4-20 Amp or 0-10 V DC (preferably 0-10V DC) |
| | : | Digital : RS – 232, RS – 485 or USB (preferably RS-485) |
| Transducers | : | Clamp-on type. Necessary set of transducers suitable to cover the whole range of pipe dia. should be quoted. |
| Transducer Cable | : | Suitable type, along-with connectors. Cable length 10m preferably |
| Power Source | : | AC: 230 V ± 10%, 50 Hz<br>Batteries: Internal / External<br>both options be available on the Instrument |
| Accessories | : | Software for Data interfacing, Data Interface cable, Power cord, Connecting cables, Carrying Case, One pair of magnetic clamping fixtures for transducers. |

Essential Features

1. Shall be suitable for different pipe materials and for both unlined and lined pipes.
2. Shall be complete with transducers as necessary for all pipe sizes in the specified range.

**6. Hand-held Global Positioning System (GPS)**

| | | | |
|---|---|---|---|
| 1. | Tracking | : | Up to 12 or more satellites |
| 2. | Waypoints | : | 1000 |

3. Track : 20, Routes: 50
4 Track log points : 10000
5. Memory : 1 GB RAM
6. Display : 256 Colors TFT
7. Accuracy : Positional: less than 10 meter
Barometric: less than 3 meter
8. Temperature range : -10$^0$C to 55 $^0$C
9 Antenna : Quad helix/built in Multidirectional patch
10. (a) Power Supply : Batteries rechargeable along with battery charger
(b) Battery Life : Up to 8 Hrs

Essential Accessories::

3. PC USB interface cable for data Transfer win Windows O/S
4. Shall be complete with Carrying case.
5. With software driver CD
6. Wrist Strap

**7. Hand-held Global Positioning System (DGPS)**

- Zeno 5 UMTS Zeno 5 UMTS version of a rugged entry level PDA with TI AM3715 Sitara 800 MHz processor, 3.7" screen, QWERTY Keyboard, SirfStartIV GPS receiver, internal 3.8G Modem (Voice and Data), IP54 and Windows Mobile Operating System incl. handstrap, stylus, battery (3.6 Ah) and display foil with accessories
- RV4001 USB SnapOn module Connector module with power jack (IP54), Micro USB cablefor Leica Zeno 5 rugged PDA.
- RV3010 RV3010 - Lithium Ion Batteries for Leica Zeno 5, 3600 mAh, rechargeable.
- Charger for Zeno rugged PDA
- RV6021 Handstrap for Zeno 5.
- GVP706 Soft bag for Zeno 5 GPS handheld for transportation and protection against dirt, including belt loop.
- **On Board Software**
  GSW1111 Leica Zeno Field on Zeno 5 is an OEM version of ArcPad 10 and provides in addition: GNSS raw data logging, RTK configurations, feature accuracy management.

**8. DISTO meter**

Handheld laser distance meter, Measuring range of 0.05 m / 0.16 ft up to 200 m / 650 ft, typ. accuracy ± 1.0 mm / ± 0.04, 360° tilt sensor, Digital Point finder with 4x zoom and high resolution color display, Error-free and quick data transfer to Pocket PC or PC via blue tooth for further processing in Excel®, Word®, AutoCAD® or other Windows-based programs

**9. Weirs Plate (Steel)** – as per ISO 1438/1

Rectangular notch in a vertical, thin steel plate which shall be plane and rigid and perpendicular to the walls and the floor of the approach channel

**10. Measuring Tapes**

30 m fiber glass in meter with 1 cm marking on one side and on other side in Feet/Inch.

**11. Total Station**

| | |
|---|---|
| Least Count Angular | 1" |
| Angle Accuracy | 3" |
| Distance Accuracy | ±(3mm +3ppm) in prism mode and ±(5mm+5ppm) in prism less (reflector less) mode |
| Compensator | 1'' |
| Distance Measurement Range Reflector less mode | 500 m or higher |
| Distance Measurement Range with Single Prism | 3000 m or higher |
| Centering | Laser or Plummet |
| Telescopic Magnification | 30X |
| Keyboard and display | Attachable/attached display screen, display real time data visualization with full graphics |
| Software (with media and license for each total station) | PC based Data transfer, processing & post processing software for contouring, perimeter, area and volume measurement |
| Power Supply | Ni MH with minimum 8 hours backup |
| Data Storage | 10000 points storage, 64 MB CF Card or Higher |
| Data download | USB port and preferably with Bluetooth connectivity |
| Accessories | Original accessories-<br>*Wooden telescopic tripod with carrying case<br>*Single prism with target plate<br>*Telescopic prism pole<br>*Traversing Kit<br>*Data Transfer Kit<br>*Battery and Battery Charger |

**12. Digital Camera**

8 Mega Pixel,
Image Size: 3072x2304
1 /2.5 `` CCD, 3 x zoom, 2.4'' TFT LCD, LCD,
23 MB Internal Memory, 1GB SDCARD , Vibration reduction
Auto focus, In built flash, video cord, USB Cable,
Ni-MH Batteries with charger,
Built in speed light, shooting modes, Brightness
Camera carrying case, wrist strap, cable, manual, CD

**13. Laser Distance Meter** to measurement range from 0.05 m to 60 m (0.16 ft to 200 ft) with accuracy of ±1.5 mm (± 0.059 in)

**14. Hand-Held Digital Multi meter -**

| | | | |
|---|---|---|---|
| 1. | Display | : | 5 digits, LCD/LED |
| 2. | DC Voltage Measuring Ranges | : | 400 mV / 4 V / 40 V / 400 V / 600 V |
| | Accuracy | : | +0.7%+ 3 digits |
| | Input Impedance | : | 10 M |

| | | | |
|---|---|---|---|
| 3. | AC Voltage Measuring Ranges | : | 4 V / 40 V / 400 V / 600 V |
| | Accuracy | : | +1.6%+ 5 digits |
| 4. | DC Current Measuring Ranges | : | 40 mA / 400 mA |
| | Accuracy | : | +2.2%+ 5 digits |
| 5. | AC Current Measuring Ranges | : | 40 mA / 400 mA |
| | Accuracy | : | +2.8%+ 5 digits |
| 6. | Resistance Measurement Ranges | : | 400 / 4k / 40k / 400k / 4M / 40MΩ |
| | Accuracy | : | +1.2%+ 5 digits |
| 7. | Capacitance Measurement Ranges | : | 50n / 500n / 5μ / 50μ / 100μF |
| | Accuracy | : | +5%+ 10 digits |
| 8. | Frequency Measurement Ranges | : | 5 Hz ~ 100 Hz |
| | Accuracy | : | +0.5%+ 3 digits |
| 9. | Duty Cycle Ranges | : | 20% ~ 80% |
| | Accuracy | : | +0.5%+ 5 digits |
| 10. | Buzzer on Continuity Check | : | Should be Available |
| 11. | Diode Test | : | Should be Available |
| 12. | Power | : | Battery Operated |
| 13. | Operating temp. | : | 0-50 °C |
| 14. | Humidity | : | 80% RH(non-conducting) |
| 15. | Sampling Rate | : | 2-3 times /second |
| 16. | Bandwidth | : | 40~400 Hz |
| 17. | Safety Voltage | : | 600 V max. |
| | Accessories | : | User's Manual, Batteries, Carrying Case |

**15. Tong Tester**

| | | | |
|---|---|---|---|
| 1. | AC Current Measuring Ranges | : | 40 / 300 A |
| | Detection | : | True RMS Preferred |
| | Band width | : | 50-500 Hz |
| | Accuracy | : | +2%+ 10 digits |
| 2. | DC Current Measuring Ranges | : | 40 / 300 A |
| | Accuracy | : | +2.5%+ 10 digits |

**16. HAND HELD GPS**

| | |
|---|---|
| Operating System | Windows 6.5 mobile |
| GPS Receiver | 20-channel GPS/SBAS receiver high sensitivity SiRFstarIII,3D compass, Pressure Altimeter and Barometer |
| Memory | 128MB RAM or more |
| Display | QVGA display (400 x 240) or better |
| Processor | 533 MHz or better |
| Key Board | Alpha-numeric virtual keyboard. |
| Camera | 3.2 megapixel or better |
| Flash Storage | 4 GB |
| GPS Accuracy | 3 to 5 meter real-time accuracy or better with internal antenna |
| Time to first fix | 30 seconds or better |
| Battery life | 8 hours or more |
| Power Supply | Rechargeable batteries along with battery charger |

| | |
|---|---|
| Communication & connectivity | Bluetooth ,Wireless LAN, USB data transfer |
| Speaker & Microphone | Integrated speaker and microphone |
| Update Rates | Min. 1 Hz or better |
| Temperature | Operating: -10°C to +50°C |
| Humidity | IPX7 |
| Carrying Case | Good Quality |

## 17. DIGITAL TACHOMETER - CONTACT TYPE

***Technical Specifications***

| | | |
|---|---|---|
| Range | : | 60-20000 rpm |
| Accuracy | : | ±1 digit |
| Display | : | 9999 (LED Display) |
| Battery | : | R6Px4 |
| Auto Power off | | |

**Accessories**

- Contact rubber tip
- Tangential speed ring
- Hexagonal wrench
- Instruction Manual
- Carrying case

## 18. DIGITAL TACHOMETER - NON CONTACT TYPE

***Technical Specifications***

| | | |
|---|---|---|
| Range | : | 60-50000 rpm |
| Accuracy | : | ±1 digit |
| Detection Distance | : | 10~150mm |
| Display | : | 9999 (LED Display) |
| Battery | : | R6Px4 |
| Auto Power off | | |

**Accessories**

- Reflective mark
- Instruction Manual
- Carrying case

## 19. ALTIMETER

Altimeter range: 500 m to 9,000 m
Weight: 55 gm
Resolution: adjustable by the user to 1 m/5m; 3 ft/10 ft.
Altitude alarm range up to 9,000 m
Temperature compensated altitude readings
Up to 20 user-definable altitude points can be stored in memory for later viewing (information stored: # of point stored, altitude, date and time)
Should give current altitude, vertical ascent and descent rate measurement, and logbook memory
Barometer with barometric pressure and temperautre measurement
Atmospheric pressure range: 300 – 1, 100 hPa; 8.90 – 32.40 in Hg

Resolution: 1 hPa; 0.05 in Hg
Temperature resolution: 1°C; 1°F
Pressure change alarm activated when pressure drops 4 hPa/0.12 in Hg or more during a 3-hour period
Water resistant
Shock-resistant elastomeric casing with rough surface to increase grip
The display is designed to offer the user maximum clarity and simplicity
Adustable for metric or imperial units
Battery life: Minimum 1 year

## 20. ECO SOUNDER

| | | |
|---|---|---|
| Application | : | Measurement of velocity and flow rate through open channel. |
| Specifications: | | |
| Transducer | : | Non-wetting type |
| Measuring range | : | 0.05 to 20 m/s |
| Accuracy | : | ±2% of full scale |
| Display | : | 4 and 1/2 digit digital or graphical display |
| Power supply | : | 230V AC, 50 Hz with storage battery |
| Resolution | : | 1 cm/s or better |

Features:
1. Shall be complete with probe, flow sensor carrying case and display unit etc.
2. Suitable for Channel depth up to 20 m and width up to 200 m.

The eco sounder should be able to meet the needs of hydrographic surveyors working on medium to large survey vessels for surveying in shallow water, lakes, rivers, harbors, waterways, and for offshore and dredging applications.

It should support / dual, triple or quad channel sounding operations with individual frequencies making it convenient as a four channel mini – multi channel system (mcs). It should have internal data storage with playback capability and unique tamper resistant data set encryption that can offer a verifiable back-up alternative to paper recorder. The equipment should be complete with integrated software systems survey software, user friendly user interface ideal for hydrographic surveys.

- The equipment should support dual channel simultaneous operation and be compact, light weight, and easy to operate single beam sonars.
- Single beam equipment should spans the range from standard models for routine depth data collection to high-end systems for a variety of demanding hydrographic survey operations.
- Be dedicated for connection to a standard PC system. Compatible with software
- High ping rate, up to 20Hz
- Resolution 1cm
- Frequency range from 15 –600 kHz should measure upto. four independent frequencies in simultaneous operation mode
- Should measure depths up to 1200m
- Capable of Printing on standard Windows Printer
- Should have interface for Heave, AUX (DGPS) and Repeater output
- Should have Sound Velocity Profile compensation

TECHNICAL SPECIFICATIONS

- Frequency: 28-35 kHz and 190-225 kHz; optional 15-600 kHz
- Accuracy1 cm at 210 kHz; 7 cm at 33 kHz
- Output resolution1 cm
- Pulse length: Manual or automatic; 20µs to 4ms
- Internal recorder Available with play back capability
- Interface I/O: 4 x serial RS-232C for Com, Heave, GPS and Loop-Through/-1010 Interface I/O: 4 x serial RS-232C for Com, Heave, GPS and Loop-Through
- Max transmit power: 450W
- Depth range: 0.2 – 600 m (support up to 1200m with 15KHz frequency)
- Channels/ Transducers:2/2
- Max Ping Rate(PRF) 20 Hz
- Power consumption60 W
- Supply voltage: 24VDC
- Cable: 100 m

* The rate of any other spares should be quoted separately

## 21. TORQUE METER -

**A Braking Dynamometer (Eddy currents)**

| | | |
|---|---|---|
| Braking Power | : | 30 kW |
| Braking Torque | : | 200 N-m max. |
| Speed | : | 75 to 3000 rpm |
| Residual Torque | : | Less than 20% |
| Accuracy of torque measurement | : | ± 0.5% or better |
| Accuracy of speed measurement | : | ± 0.5% or better |

Speed and torque outputs should be available for data acquisition

**B Digital Indicator for Torque sensor 5 digit display**

Supply: 230 V AC with Couplings

**Test Bench equipment for Speed Governors, Turbines and synchronous generators, including an islanded operation real-time simulator**

Hardware components

• Voltage and current sensors to adapt the high-current and high-voltage signals to signals in the range of +- 10V;
• AD and DA input/output boards;
• LAB QNX computer with Intel Dual-Core processor for real-time computing;
• 3-way switch (2 for input, 1 for output) for connection between input voltage, test bench and input port of speed governor;
• A laptop computer to control test bench and signal monitoring;
• An additional flat screen;
• An emergency UPS power supply;
• Two robust carrying cases;
• Required cables and accessories.

Software Components

The basic software consists of the following:

- LAB QNX real-time operating system;
- Test Drive system to control and monitor the test bench;
- Speed Regulator Test Software including the following modules
    - Digital calculators for frequency and electric power;
    - Modules to estimate the speed and mechanical power;
    - Real-time simulator of islanded power system operation;
    - Adjustable PID controller;
    - Signal generator for speed errors;
    - Signal converter for speed errors into AC modulated voltage;
    - Speed governor and turbine adjustable linear models for comparison with real values.

Complete training and commissioning including travel

## 22. A WORKING MODEL FOR PELTON TURBINE

### (A) Circuit Pelton Wheel Turbine

1. Pelton turbine for 1.5 kW output consisting of a Perspex (transparent) casing, stainless steel nozzle assembly and runner with stainless steel buckets.
2. Working model should consist of the following;
    - Service pump-motor set for supply of water to the turbine for rated turbine output 1.5 kW along with suitable loads and stainless steel piping system (pipes, control valve, bends etc.)
    - Mild Steel Sump/tank for water circulation.
3. A set of precision instruments for flow, head and power output measurement

Special Conditions

- Offer should include necessary installation accessories and tools.
- Manufacturer's original catalogue must be submitted with the offer.
- A statement of item-wise compliance to the above specifications & features must be submitted with the offer.
- Charges for AMC beyond the warranty period must be quoted separately

### (B) Closed Circuit Francis Turbine

1. Francis turbine for 1.5 kW output, consisting of casing and draft tube of Perspex (transparent) material, stainless steel Francis runner, stainless steel guide vanes with suitable link mechanism through a hand wheel for operating and to control the flow.
2. Working model should consist of the following;
    - Service pump-motor set for supply of water to the turbine for rated turbine output 1.5 kW along with suitable loads and stainless steel piping system (pipes, control valve, bends etc.)
    - Mild Steel Sump/tank for water circulation.
3. A set of precision instruments for flow, head and power output measurement.

**(C) Francis Turbine** 2 HP Capacity Closed Circuit Francis Turbine Test Rig with M.S. Unit with FRP Lining S.S. Unit having following Components.

| | | |
|---|---|---|
| **FRANCIS TURBINE** | | |
| Type | : | Inward flow reaction turbine |
| Capacity | : | 2 HP |
| Rated speed | : | 1000 RPM |
| Discharge capacity | : | 900 Litres / minute |
| Supply head | : | 25 Meters |
| Guide vanes | : | Gun Metal vanes (aerofoil blade shaped) |
| **LOADING** | : | Rope brake |
| Material | : | Cast iron |
| Drum size | : | 200MM diameter |
| **SUPPLY PUMP SET** | | |
| Size | : | $3' \times 2\frac{1}{2}''$ |
| Discharge | : | 900 Litres/Minute |
| Total head | : | 28 Meters |
| Motor capacity | : | 7.5 HP |
| Starter for motor | : | DOL |
| **FLOW MEASUREMENT** | | |
| Venturimeter | : | |
| Material | : | C.I. body with brass lining |
| **PRESSURE MEASUREMENT** | : | Double column<br>Differential manometer |
| Manometer fluid | : | Mercury |
| **RPM INDICATOR** | : | Digital |
| **SUMP TANK** | | |
| Material of construction | : | M.S.unit with FRP Lining/ S.S.Unit |
| **SERVICE REQUIRED** | : | Electrical Supply- 7.5 HP, 3 Phase, 440 volts, 50 Hz, AC Supply |

## 23. INFRARED THERMOMETER

Specifications:

| | | |
|---|---|---|
| Temperature Range | : | -18 to 538 °C |
| Accuracy | : | ±1% reading. |
| Emissivity | : | Adjustable from 0.1 to 1.0 |
| Distance to Spot Size Ratio | : | 10:1 |
| Response Time | : | 1 sec or less |
| Resolution | : | 1 °C |
| Grip | : | Pistol Grip |
| Readings | : | MIN /MAX /AVG /DIF : |
| Alarm | : | High |
| Laser Sight Configuration | : | dot/circle |
| Power | : | Battery Operated |

Other Essential Features
(a) Backlight
(b) Trigger Lock
(c) Carrying Case

## 24. THREE-PHASE CLAMP-ON PORTABLE POWER AND ENERGY

*Technical Specifications*

| | | |
|---|---|---|
| Measurement Modes | : | Single-Phase, 3P3W and 3P4W, Selectable |
| Measurement Functions | : | All Voltages, all Currents, active power, reactive Power, apparent power, power factor, frequency and energy. |
| Response | : | True RMS |
| Voltage Range | : | Up to 600 V in 3 or more appropriate ranges |
| Currant Range | : | Up to 20 A in 3 or more appropriate ranges |
| Frequency Range | : | 45 to 55 Hz |
| Basic Accuracy | : | 0.1% |
| Ranging | : | Automatic and Manual (both modes are essential) |
| Display | : | LED or LCD , alphanumeric |
| Analog Output | : | D/A output for recording current, voltage and power |
| Interface Port | : | RS-232/RS-485/USB( preferable USB) |
| Power Supply | : | A.C. mains, 200 V to 250 V, 50 Hz |

## 25. (A) DIFFERENTIAL PRESSURE TRANSDUCER

Range : -2 to + 2 kPa,
Span : 0.5-8 kPa
Range : -20 to + 20 kPa,
Span : 2-80 kPa

Technical Specification:

| | | |
|---|---|---|
| - Basic Accuracy | : | +0.075% |
| - Characteristic | : | Square root output |
| - Output Signal | : | 4-20 mA with HART FSK protocol superimposed |
| - Integral Display | : | LCD, Alphanumeric |
| - Power Supply | : | 12V/24V dc |
| - Operating Temp. | : | -10 to 50 C |
| - Humidity | : | 95% condensing |
| - Processes connection | : | 12.5mm (1/2 inch)NPT/Stainless Steel |
| - Sensor Housing | : | Stainless Steel |
| - Protection Class | : | IP 67 |

Special Conditions:
The Calibration certificate shall be submitted with each smart pressure

### (B) IMMERSIBLE PRESSURE TRANSDUCER

Technical Specifications

| | | |
|---|---|---|
| Part Number | : | CTEM8000…CSSERIES |
| Pressure Range | : | 0-1 bar |
| Output signal | : | 4-20 mA |

Power Supply : 12-30 VDC
Accuracy : ± 0.1%
Operating Temperature : -25 deg C to + 70 deg C
Electrical Connection : Polyurethane cable of 20 mtrs length

**(C) GAUGE PRESSURE TRANSMITTER**

Range : 0-1MPa

*Technical Specification*

| | | |
|---|---|---|
| Basic Accuracy | : | +0.075% |
| Characteristic | : | Square root output |
| Output Signal | : | 4-20 mA with HART FSK protocol superimposed |
| Integral Display | : | LCD, Alphanumeric |
| Power Supply | : | 12V/24V dc |
| Operating Temp. | : | -10 to 50 C |
| Humidity | : | 95% condensing |
| Processes connection | : | 12.5mm (1/2 inch) NPT/Stainless Steel |
| Sensor Housing | : | Stainless Steel |
| Protection Class | : | IP 67 |

Special Conditions:
1. The Calibration certificate shall be submitted
2. Manufacture's original catalogue must be submitted with the offer.

**PART B: Equipment Required For Manufacturing Of Turbines**

A list of required equipments for manufacturing of small hydro turbines and valves is listed below depending on the progress made in the subject the equipment may be procured. However in the beginning the equipment required/proposed by COET for its TDTC may be procured and renovated/over hauled. There are given in Annexure VII.

List of a Plant & Equipment required for a typical turbine manufacturing plant

➢ Fabrication + Welding Shop

- Plate Bending Machine (3000mm wide x 35mm thick) 1 No.
- CNC Flame Cutting (3000mm x 8000mm x 200mm thick) 1 No.
- Welding equipment
  - Manual Arc Welding Rectifiers (400 Amps) 4 Nos.
  - TIG Welding Machines (TIG 3000) 2 Nos.
  - MIG Welding Machine (MIG 5000) 2 Nos.
  - SAW Welding Machine (1000 Amps) 2 Nos.
- Floor plates & Beams
  - Floor plates (Size 4M x 2 M) 9 Nos.
  - Beams Fabricated 1 Lot
- Miscellaneous equipment 1 Lot
  - Grinding tools
  - Chipping tools
  - Temperature recorders
  - Cutting & heating torches
  - Electrode Backing Ovens

- Plate storage racks
- Pug cutting machine

- Heavy Machine Shop
  - CNC Horizontal Boring & Milling Machine (Spindle Dia 135mm) 1 No.
  - CNC Horizontal Boring & Milling Machine (Spindle Dia 110mm) 1 No.
  - Large Lathe (Dia 2000mm x 6000mm) 1 No.
  - Double Column Vertical Lathe (Dia 3500mm) 1 No.
  - Single Column Vertical Lathe (Dia 1600mm) 1 No.
  - Radial Drilling Machine (Dia 100 x 3150mm x 4000mm) 1 No.
  - Tool & Cutter Grinder (Dia 280mm) 1 No.
  - Cylinderical Grinding Machine (Dia 550mm x 2000mm) 1 No.

- Small Machine Shop
  - Shaping Machine (Stroke 915mm) 1 No.
  - Centre Lathe (Dia 660mm x 1500mm) 2 Nos.
  - Centre Lathe (Dia 800mm x 3000mm) 1 No.
  - Universal Milling Machine (Table size 1320mm x 320mm) 1 No.
  - Radial Drill Machine (Drilling capacity 50mm dia) 1 No.

- Assembly Shop
  - Floor plates & beams
    - Floor plates (Size 4 M x 2 M) 5 Nos.
    - Beams fabricated 1 Set
  - Assembly Tools (Hand tools, spanners etc.) 1 Set

- Grinding Section for Runner
  - Grinding tools 1 Lot
  - Air Tools 1 Lot
  - Exhaust & Ventilation System & Work Tables etc. 1 Lot

- Surface Preparation & Painting
  - Shot Blasting System (6.5M x 6.5M x 6.5M size Job) 1 No.
  - Painting Equipment 1 Lot

- Material Handling Equipment
  - Jib Crane (3T capacity) for Assembly & Grinding Shop 2 Nos.
  - Jib Crane (2T capacity) for Fabrication Shop 1 No.
  - Lifting Tools & Tackles 1 Set
- Auxiliaries
  - Gas supply system 1 Lot
  - Compressed Air system 1 Set
  - Water system (Pumping, treatment and supply) 1 Set
  - Electrical Distribution system 1 Set
  - Diesel Generating Sets (50 kVA) 2 Sets
- Measuring Instruments & NDT Equipment
  - Measuring instruments 1 Lot
  - NDT equipment 1 Lot