

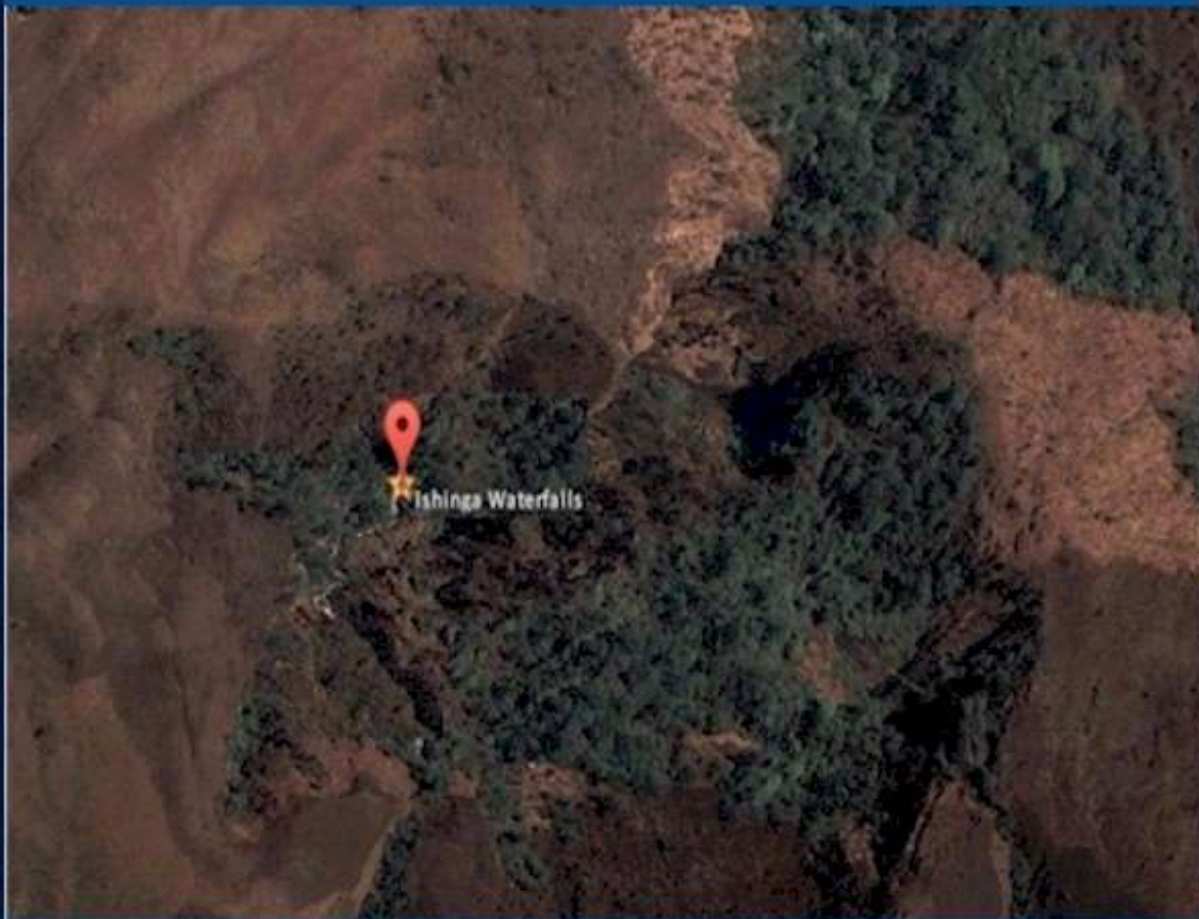


Texpol Development Company Ltd

# Mwela Mini-Hydro-Power Development Project

Ishinga Waterfall, Ishinga River

## FEASIBILITY STUDY



Sept 2015

*Texpol Dev. Co. Ltd, P. O. Box 77279,  
Plot No 2202, Tabata, Kisukuru,  
Dar es Salaam, Tanzania*

*Tel: [+255-766-326727](tel:+255-766-326727),  
Email: [texpol5@wp.pl](mailto:texpol5@wp.pl),  
Website: [www.texpoldev.com](http://www.texpoldev.com)*



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## **ACKNOWLEDGMENTS**

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## **EXECUTIVE SUMMARY**

*Mwela village is one of the seven (7) villages of Ilungu ward of Mbeya Rural District, Mbeya Region. Other villages are Mashese, Ifupa, Shango, Kikondo, Ngole and Nyalwela. The ward has seven (7) river deltas with waterfalls which are potential for small hydro power generation. One of these waterfalls is river delta of Ishinga located near to Mwela Village. The delta has potential of generating electricity for supplying to the national electricity grid. Currently, there is no any other source of electrical power in the area, implying that all households, businesses and institutions will get access to modern energy services and some of these people will become potential customers for electricity from TANESCO. This implies that the generated electricity will be supplied to TANESCO through the national grid and TANESCO will distribute it to the village community.*

*The feasibility study was conducted for Texpol Company with aim to analyse issues related to technical and hydrological potentials in order to find possibilities of establishing small hydro power generation at Ishinga Waterfalls. The feasibility study report will be used as initial document for making decision to invest in the proposed project in a Public-Private- Partnership mode.*

*The Mini Hydro Plant will be decentralized electricity generation system that will use waterfalls along Rivers Basins to run the turbine. The project will provide access to affordable electricity by developing mini hydropower plant which will supply electricity to TANESCO. Customers in Mwela and neighbouring villages will benefit from electricity supplied from the grid by improving productive initiatives and livelihoods of the people living in the rural Communities and serve social institutions, small and medium scale enterprises and households in rural areas.*

*The selected village has potential for developing biomass, solar and hydro energy resources. The grid has recently been extended to the nearby village of Ifupa but this will enable the company to supply generated electricity to both village and the national grid. The investment costs of solar PV is high, its operation is lower compared to Mini-Hydro Plant and Biomass Gasification. Biomass energy technologies have additional costs of buying fuels while mini-hydro plant does not require fuels. It is operated by water-flow from the river and requires minimum periodic maintenance, mini-grid can be expanded and generate no waste products. The least cost power option for Mwela Village is Mini-Hydro Power Plants.*

*The feasibility recommends starting with development of mini-hydro plant of 5,000kW along Ishinga River. This plant will supply electricity to the national grid. To determine the power potential of the water flowing in a river or stream it is necessary to determine both the flow rate of the water and the head through which the water will drop (hydraulic drop).*

*In order to create the stable management and institutional set up for this project, Texpol through its office will lead implementation and post-management of the project. Texpol will use its professional staff and external consultation to develop the mini-hydro plants and initially maintain small work force of five staff (two (2) field staff stationed at Mwela Village and three staff at the head office) for operation and maintaining the plant during post project duration.*

*The project developer through matching grant has applied for legal certificates from relevant ministries to acquire land for the project site and rights for getting water from the Ishinga River at Ishinga waterfalls.*

*The reality for people in the proposed village is that life after sunset slows right down due to the lack of electricity resulting in children not being able to do their homework, productivity being restricted and quality of life being impaired. The environment and Social Assessment will be conducted by undertaking a study on Social and Environment Impact Assessment (SEIA).*

*Feasibility study conducted in the Mwela Village revealed that the Ishinga river fall has sufficient water flow throughout the year. The river fall surveyed for feasibility study had sufficient heads to generate electricity estimated to 5.0 MW from identified river falls. As a roadmap of developing this project, the Texpol will continue with preparatory activities and implementation of the project for the scheme of Ishinga Waterfalls at Mwela Village.*

*The project profitability was assessed based on acquired costs of investments, operations, recurrent (management) and revenue from different potential sources. The annual cash-flow of costs and benefits at 10% discount rate were analyzed for financial viability of the project. The cost and benefits analysis at 10% discount rate and came up with NPV of USD 306,133 and IRR of 20.18%, respectively. The NPV was tested again at 18% discount rate. The NPV was still positive (USD 20,073). The positive NPV implies that based on the costs and revenue transactions obtained the proposed project is financially viable and according to its assessment. The IRR above the discount rate implies that the investment, if will be well managed should return the capital invested in relation to discount rate or interest rates for funds obtained from the bank credits.*

## **ABBREVIATIONS**

<i>DED</i>	<i>District Executive Director</i>
<i>EPP</i>	<i>Emergency Power Producers</i>
<i>GHG</i>	<i>Green House Gases</i>
<i>GoT</i>	<i>Government of Tanzania</i>
<i>GPS</i>	<i>Global Positioning System</i>
<i>IRR</i>	<i>Internal Rate of Return</i>
<i>IPP</i>	<i>Independent Power Producers</i>
<i>MWL</i>	<i>Ministry of Water and Livestock</i>
<i>NBS</i>	<i>national Bureau of Standards</i>
<i>NPV</i>	<i>Net Present Value</i>
<i>O&amp;M</i>	<i>Operation and Maintenance</i>
<i>PV</i>	<i>Photo-Voltaics</i>
<i>REA</i>	<i>Rural Energy agency</i>
<i>SEIA</i>	<i>Social and Environment Impact Assessment</i>
<i>SMEs</i>	<i>Small Medium Enterprises</i>
<i>TANESCO</i>	<i>Tanzania Electric Supply Company</i>
<i>TDC</i>	<i>Texpol Development Company. Ltd</i>

## **SECTION 1: BACKGROUND AND INTRODUCTION**

### **1.1 Background of the Project**

Energy is a crucial component in doing business and investment and Tanzania has been facing key challenges in the Energy Sector. Tanzania is richly endowed with many alternative power sources which, if fully utilized, could produce enough energy for local consumption and regional export. But, all the hydro-power generated at the Mtera, Kidatu, Hale and Nyumba ya Mungu dams, as well as the power from natural gas at Ubungo, IPTL and elsewhere, is far below demand. To-date only about 24% of the country's population has gained access to electricity. Extending the National Grid to many parts of the country including rural areas is not financially and economically feasible.

More than 90% of energy delivered from biomass is consumed in rural areas; heavy dependence on biomass as the main energy source contributes to deforestation, while the importation of oil costs about 25% to 35% of the nation's foreign currency earnings. Majority of the people, especially those in rural areas have lower purchasing power and thus depend mainly on woodfuels (charcoal, firewood and bio-residues) for cooking, kerosene for lighting and human energy for agriculture and transport activities. The use of traditional and low quality energy technologies and services has negative consequences on poverty reduction and sustainable development efforts in the country.

### **1.2 Electricity Situation in Tanzania**

Tanzania is endowed with diverse forms of energy resources which are at different stages of development. These resources include natural gas, hydro, coal, biomass, geothermal, solar, wind and uranium. However, the country is still facing the low electrification ratio which is a barrier to economic development.

Tanzania's installed electricity generation capacity is 1,550 MW of which 1,466 MW is available on the grid. Installed capacity consist of 553 MW of large hydropower, 501 MW of thermal generation with natural gas, 456 MW with oil; 27 MW with biomass, and 13 MW of small hydropower . TANESCO supplied 59% of the total electricity generation capacity; IPPs 26%; emergency power producers (EPPs) 13%; and small power producers (SPPs) 2%. It is estimated that there is an additional 300 MW of distributed generation capacity, mainly composed of diesel engines that are not connected to the grid. In addition, to face demand from cross border urban centres, Tanzania imports electricity from neighbouring countries.

In 2012, the demand was 851 MW of on-grid power. In terms of electricity consumption per capita, Tanzania has very low levels: about 97 kWh/year in 2012. Efforts have been put forward in order to achieve the PSMP 2012 target of 200 kWh/year electricity consumption per capita by 2015/16.

Through the implementation of the different policies and strategies currently in place in Tanzania, electricity demand is expected to increase at a rate of 12%-15% annually from what it is today to 7,400 MW by 2035. Generation capacity is expected to increase at a rate of 6% annually, from around 1,550 MW in 2012 to at least 8,990 MW by 2035. A recent revision of the power sector strategy expects capacity to increase to 10,000 MW in 2025.

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Therefore, in the medium- to the long-term, a transition to cheap electricity from local sources is vital for both the rural economy and for efforts to expand energy access in the country.

The opportunities that exist in the Illungu ward, Rural Mbeya District include the available potential for the utilization of hydropower along Ishinga River. This study being carried out to harness mini-hydro potential at Ishinga Mwela for setting up a decentralised mini-hydro unit with local implementation and management.

### **1.3 Executing Organisation**

Texpol Development Co. Ltd (Tanzania) is a private company based in Dar es Salaam, Tanzania with experiences in development of renewable energy technologies and services. The company was registered with Brella in 30 November 2012 with number 95567 and TIC number 10771. The company's office is located at Tabata, Kisukuru, Plot number 2202, Dar es Salaam, Tanzania. The company operates in rural areas of Mbeya Region. The company is owned by shareholders who are committed to development of rural communities in Tanzania. The company is owned by Mr. Julius Zellah (Managing Director).

#### **Vision**

Rural Communities with increased access to renewable energy services for enhanced livelihoods, economic growth and social development while conserving environment

#### **Mission**

To plan and develop cost-effective, safe and environmentally responsible renewable energy initiatives (solar, small-hydro, biomass, etc.) to serve existing and new energy requirements for rural grid and off-grid areas

#### **Goals**

- To be profitable and financially strong and capable of generating wealth for the shareholder, partners and communities in the rural areas.
- To pursue opportunities and development that is consistent with an integrated renewable energy in rural areas
- To be proactive in embracing and developing renewable energy technologies and services
- To develop renewable energy business models suitable for different rural settings.

### **Activities**

- Promote the use of renewable energy for consumptive, productive and institutional uses
- Implement renewable energy programmes and projects in rural areas
- Support renewable energy enterprises and business development services
- Develop technical, institutional and business capacity for developing renewable energy services
- Develop and manage marketing network for customers

The country is having a lot of rivers and waterfalls which are potential for electricity generation but it is unfortunately that the country production of electricity does not exceed 18%. The most suffering part of the country is rural area where the population is more than 30 million. Under this acute problem a Tanzanian company Texpol Development Co. Ltd immerged to invest and develop hydro-power energy from existing water falls to serve the demand of this people and the country as whole.

The proposed activities are among the fundamental business of Texpol Company since the company is planning to expand services to all rural areas of Tanzania. Other basic activities are capacity building to local people on how to 1) produce power using renewable and available energy, 2) Use electricity for the productive activities and development of their community, 3) Avoid using diesel grind-mills 4) Avoid using charcoal as source of energy. 5) Limitation of carbon dioxide emission.

## **SECTION 2: FEASIBILITY STUDY**

The study intends to identify mini hydropower potentials at Mwela Village in Ilungu Ward, Mbeya Region by collecting data related to mini-hydro development through stakeholder

consultations, field site visits and other assessments, data analysis, preliminary power market surveys and finally produce a feasibility study report

## **2.1 Feasibility Study Objective**

The overall objective of this consulting assignment is to analyse issues related to technical and hydrological potentials in order to find possibilities of establishing small hydro power generation at Mwela village. The feasibility study report will be used as an important document for making decision to invest in the proposed project in a Public-Private- Partnership mode.

## **2.2 Types of Activities**

The main economic activities in this village are agriculture and cattle keeping. The main crops grown in the area include potatoes, vegetables and maize, potatoes being the leading. Agriculture is the leading economic activity and is done through both small and large scale farming. Annual rainfall varies between 650 to 2600mm. The crop growing season begin in November and continues to May. Other economic activities include businesses by small shops, transport, and timber harvesting using local methods and diesel engines.

## **2.3 Scope of Work**

This report covers the feasibility study of the proposed mini hydropower project for the area located at Mwela Village. The study also considered preliminary design of the project components including selection of site and control system as well as power distribution network, the design also includes initial site locations and hydraulic structures/civil works.

## **SECTION 3: METHODOLOGY**

The study is based on the agreed standards, approach and methodology in undertaking assessing feasibility of implementing the mini-hydro development projects. The study was undertaken in line with the established guidelines and legal framework. Stakeholder's consultations were carried out throughout the study process.

### **3.1 Desk Literature Review**

The methodology of assessing the following project has been commenced and approached primarily by literature review. The literature review included the reading of a range of textbooks along with credible internet sources and journals. Relevant aspects of these sources were then used to formulate notes, which were then used in their relevant section of the report. The knowledge gained from the literature review was then applied to the particular situation of the chosen site. The most suitable applications of different technology were analysed before being selected and recommended in this project.

### **3.2 Data Collection**

Quantitative and qualitative primary and secondary data were collected from different literature and project area and analysed for mini hydro planning including technical and economic analysis of the project. The technical analysis involved water resources assessment as well as hydropower potentials. Hydrologic study was carried out using existing discharge and rainfall data recorded at the gauging stations available for the sub-basin in or nearby the area. Even though there is significant missing data in rainfall and runoff, as well as poor matching of recorded periods, monthly rainfall and concurrent runoff data were used. In this study, filling of the missed data was conducted by finding the secondary data from Mbeya District Council and relevant sources at the national levels (NBS and MWL).

### **3.3 Technical Design**

The technical design addresses both run-of-river and reservoir development and wide variety of hydro turbines. The Small Hydro Project Model has been developed primarily to determine whether work on the small hydro project should proceed further or be dropped in favour of other alternatives. The selection criteria used among others were hydraulic head for mini hydro development, shorter water ways, information on river discharge and accessibility.

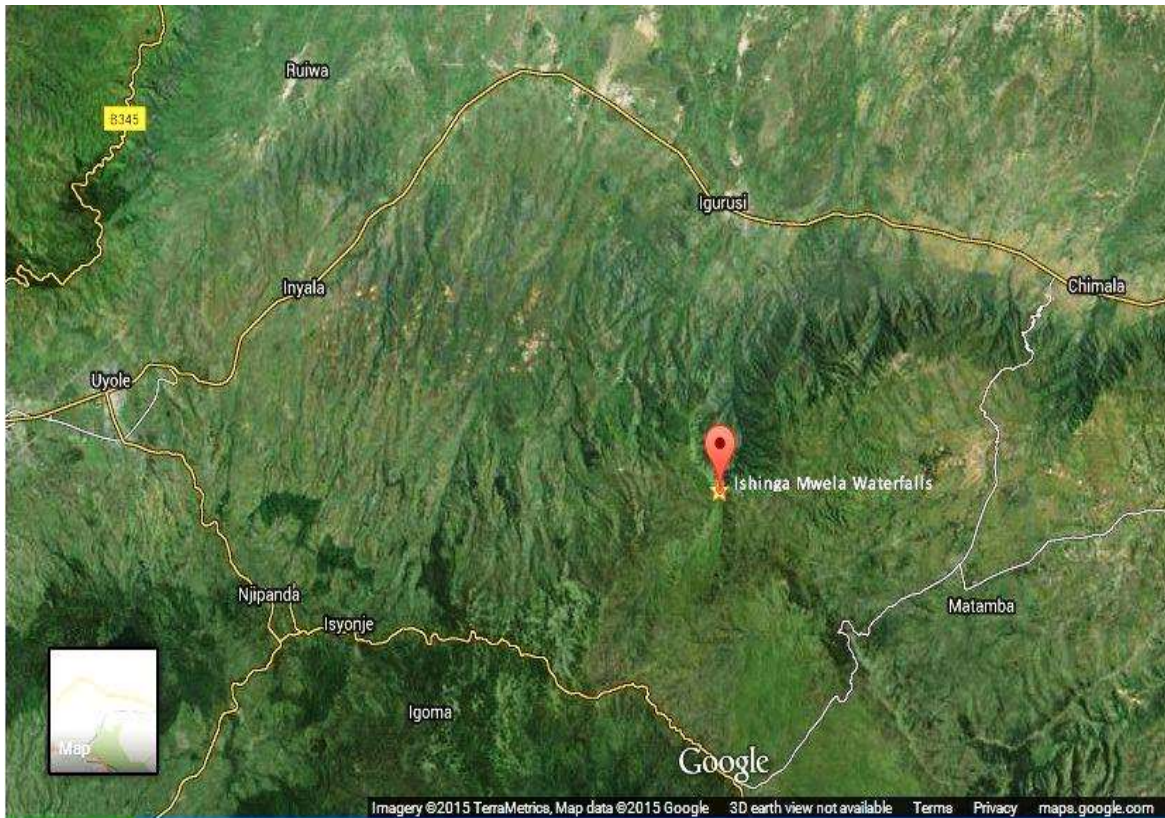
### **3.4 Project Economical Analysis**

The project profitability was assessed based on acquired costs for investments, operations, recurrent (management) and revenue from different potential sources. The annual project cash-flow of costs and benefits at 10% discount rate were analysed for financial viability. The viability coefficients were determined to assess profitability of the project.

## **SECTION 4: DESCRIPTION OF THE PROJECT AREA**

Mwela village is one of the seven (7) villages of Illungu ward of Mbeya Rural District, Mbeya Region. Other villages are Mashese, Ifupa, Shango, Kikondo, Ngole and Nyalwela. Geographically, the Mwela village is located according to GPS reading at S = 0,8°56'26.1", E = 0,33°50'27.9". The village has one Primary Schools, 2 churches, 2 welding machines, 20 shops, 4 restaurants and 4 diesel grind mills. Mwela village has a total of 1,000 modern residential houses and hundreds acres of cultivated land.

The ward has seven (7) river deltas with waterfalls which are potential for small hydro power generation. One of these waterfalls is river delta of Ishinga located near to Mwela Village. The delta has potential of generating electricity for supplying to the village community and feeding in the grid.



Map 1: Location of the Project Area (Google Map)

Currently, the national grid electricity connected is to the nearby village of Ifupa. The mini-hydro plant will generate electricity for feeding into the grid and use for those who have not been reached by electricity, implying that all households, businesses and institutions in the village will have access to modern energy services and some of these people will become potential customers of electricity by virtual of extending the grid to the project areas. The customer for surplus electricity is TANESCO which will be facilitated by connecting mini-hydro plant to the National Electricity Grid.

#### **SECTION 4: TOPOGRAPHY AND HYDROLOGY**

The assessment is based on analysis performed by Texpol (Abroad) through pre-feasibility study conducted in the project. The activity enabled to design small hydroelectric plants according to feasibility decisions. The activity analysed the hydro-geographical characteristics for a wide range of sites and a model that involves significant physical parameters was developed. An appropriate technical parameters or design model describing hydro-turbine efficiency was

developed and optimized. The technical drawings and model entailed details of the design and layout of the small hydro plant at Ishinga Falls showing proposed structures of intake, weir, settling basin, main canal, fore-bay tank, penstock and power house including turbine and its accessories. The optimization covered a range of site characteristics and commercially available hydro-turbines. An overall plant model was introduced by taking into account their construction characteristics and operational performance.

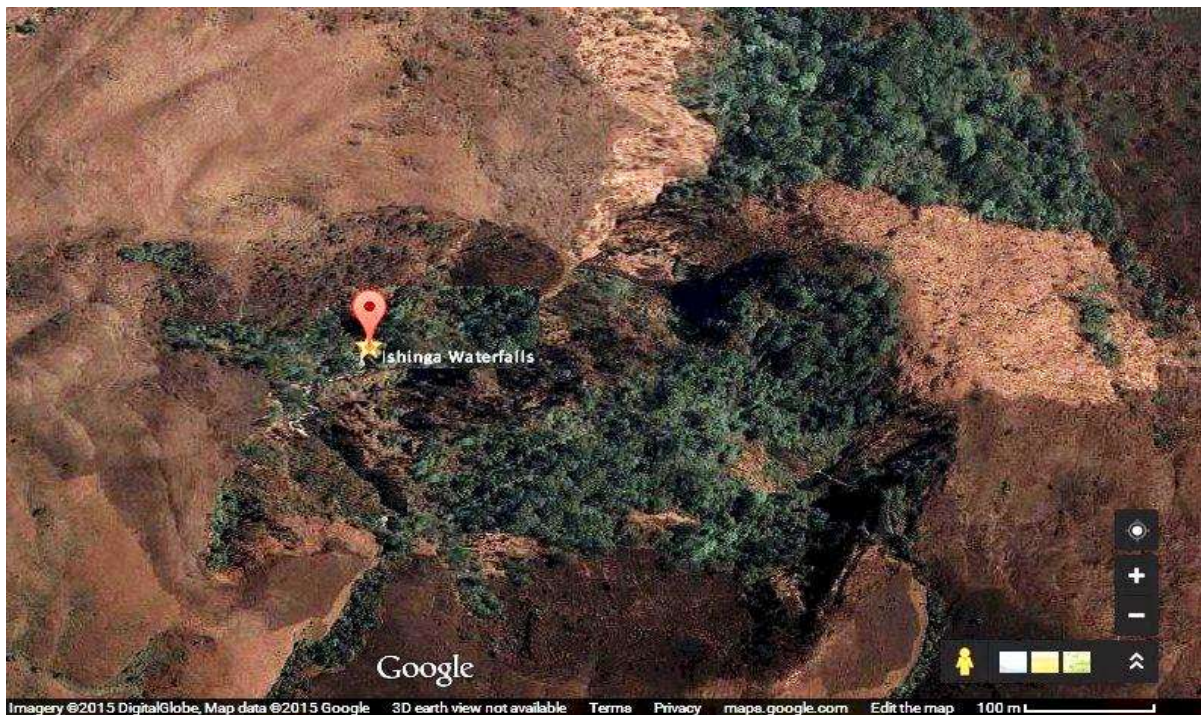
#### **4.1 Topographic Survey**

The topographic features of the areas were assessed by using aerial photos and physical reconnaissance visits to the project area. The scope of topographical mapping was decided following the field reconnaissance when locations of major structures were decided through pre-feasibility study. In general, the extent of mapping was not sufficient to cover all alternatives envisaged and to allow for reasonable realignments of structures, waterways, access roads and transmission lines. There is a need for detailed survey by performing land topographical survey for engineering design before implementation of the mini-hydro plant in the field.

It is recommended that the first activity in the topographic survey should be the establishment of a control network of reference points and benchmarks. The network should provide coverage of the complete hydro scheme from intake to tailrace channel including related switchyards, laydown (stockpile) areas and site roads. While the initial use of this network is for control of topographic surveying, the same benchmarks will eventually be needed for control of construction. Much difficulty and expense can be avoided later, in the construction phase, if these benchmarks are solidly installed so that they will be available whenever construction starts up: within months or years, as the case may be. Once the benchmarks have been installed a first order survey should be carried out to establish elevations and coordinates at each control point.

#### **4.2 Hydro Electric Resource Assessment**

Apart from proposed river delta at Ishinga, the ward has other six (6) river deltas with waterfalls which are potential for small hydro power generation. Some of these waterfalls are found in river deltas of Kwaharaka, Mbogolo, Hale, Iswi, and Ipwisi. The potential area for Mwela Mini Hydro Development project is as shown in the map 2 hereunder:



Map2: Location of Ishinga Waterfalls (Google Map)

The rivers in the project area are perennial and not seasonal. Construction of water reservoir at the weir site is one of the pre-requisite for mini hydro. The reservoir will continue to maintain the flow of water for mini-hydro plant and electricity generation from this site. The water rights will be sought form the regional and district water authorities and only a small amount of water will be drawn from the river. Therefore, there are high chances that drawn water from these rivers for power generation through this mini-hydro plant will not affect other marine and terrestrial activities.

**Table 2: Hydro Power Potential and Estimated Production Capacity (in KW)**

Location (HPST)	Name (SPP)	GPS Reading	Measured Flow	Base Flow Factor	Mean Flow	Rated Flow	Head (m)	Eff.	Production Unit (Turbine)	Power Production in dry season (kW)	Production in wet season
1	Kwaharaka	S = 0,8°59'29.4", E = 0,33°45'39.9"	0.04	0.12	0.333	0.300	90	80%	Francis /Pelton	212	370

2	Mbogolo	S = 0,8°58'32.4", E = 0,33°44'55.7"	0.06	0.13	0.462	0.420	100	81%	Pelton	334	500
3	Iswi		0.006	0.1	0.060	0.050	50	78%	Crossflow	19	22
4	Ipwisi	S = 0,8°57'05.7", E = 0,33°45'09.3"	0.06	0.13	0.462	0.420	17	78%	Crossflow	55	90
5	Ikula	S = 0,8°55'47.3", E = 0,33°45'57.4"	0.04	0.12	0.333	0.300	65	80%	Francis	153	250
6	Ishinga -Mwela	S = 0,8°56'26.1", E = 0,33°50'27.9"	0.3	0.18	1.667	1.600	350	83%	Pelton	4560	5000
	Total kW									5,333	6,232

### 4.3 Hydrological Investigation

#### 4.3.1 Measurement of Head

Often this task is assumed to require a surveyor for head measurement; however, this was not necessary because the head was determined and measured during pre-feasibility study of river deltas in Ilungu Ward. However, during Engineering Design much quicker and more cost effective methods could be employed. Of these methods, the level is preferred not only due to its simplicity but also due to its relatively low cost. A carpenter's level was the cheapest option but a Locke hand level was also used. Accuracy will generally be around 5%, but this is dependent on the steepness of the slope. This was to check the head as stipulated in the pre-feasibility study. The head for water falls at Ishinga (Mwela) waterfall is 350 metres. This method provides a relatively accurate, quick and effective way of measuring the grosshead of a site. It must be taken into account, however, that the available power from a turbine will be proportional to  $H^{3/2}$ , and so the measurements will have a severe effect on any inaccuracies.

#### 4.3.2 River Flow Measurement

Although river flow gauging would be useful, it may not prove necessary due to the amount of flow consistently available in the Ishinga River. The river water flow was measured during pre-feasibility study and finds that the river has flow of 0.3 m/s, base flow of 0.18 and mean flow of 1.667 (which was rated at 1.6m/s). The hydrological parameters estimated from the feasibility study shows electricity generation of 5 MW from Ishinga waterfalls which can be used to tape hydropower energy. Feasibility study conducted in the Mwela Village revealed that the river-fall has sufficient water flow throughout the year.

The feasibility study has explored the mini-hydro potential of the SPP 6 for Ilungu Ward to be Ishinga Waterfalls along Ishinga River. The feasibility study has assessed this site and found that it could generate electricity which will suffice requirements of feeding into the national grid.

#### 4.3.3 Distance to Utility Connection

The connection to the grid requires the company to transfer electricity generated to the local electric grid, either directly or through installed meter with an adjacent on-site electrical load which can be served by the new hydro plant. The distance to the national grid is 15 km at Ifupa Village where three phase transmission line will be required to feed electricity to the grid.

#### 4.3.4 Access Road

The project site is located in remote areas where an access road is important in order to transport construction materials and equipment to the site. The distance from Mwela village to the proposed plant is 6 Km. It is observed that it is necessary to understand how all aspects of the project will be accessed by road, including materials for constructing the intake, penstock and powerhouse. This will be a public road therefore permission and access to the site is granted. The area reserved for the road will be of 6 metres width which means the road is large enough for the passage of necessary construction equipment.

According to the pre-feasibility study, the site which will be installed and constructed with a mini-hydro plant is shown in the map3 hereunder.



Map3: Hydro Power Station 6: Ishinga Waterfalls, Mwela Village

## SECTION 5: ENERGY RESOURCE AVAILABILITY

The study also considered the project's energy resource availability and sustainability in the project area. These include the major energy source such as hydro, solar and biomass. There are different options in the project of energy resources which can be developed for power generation. These among other include mini-hydro, biomass energy and solar energy systems. The assessment of these energy systems are as explained hereunder:

### **5.1 Mini Hydro Systems**

The project area has all hydrological features for supporting production of electricity from mini – hydro power plant. The potential in the project sites can produce up to 5 MW which could be supplied to the community at Mwela Village or supplied to the national grid. The management and maintenance costs of these systems are relatively high because of skills required for their construction and management but this is possible since the company has capacity of maintaining and managing the plant.

### **5.2 Biomass Energy**

Project area has large amount of biomass energy resources. Biomass fuel is a primary source of energy for cooking and heating purposes. Solid biomass energy resources are mainly from both public and private forests but have for a long time been affected by uncontrolled harvesting. There is a possibility of getting cow dung which is potential feedstock for biogas plants. Wind being one of the energy resources with low to zero-emissions is a proven technology for rural areas but there is no potential of using this resource in the project area.

The biomass energy resources are the main fuels used in the proposed village for cooking. The main problems associated with biomass resources are high costs, unavailability and long distance to the source. The region is under biomass conservation initiatives. Afforestation programmes have always been encouraged in the project area. The aim is to control land degradation, deforestation, soil erosion and floods as well as protection of catchment areas of river sources. Therefore, use of these resources may compete with other uses. Some technologies such as gasifiers could be used for power generation. The area has high potential of developing biogas for supporting cooking in households (especially for livestock keepers). The selected villages have limited resource potential of operating biomass technologies for electricity generation. Management of such technologies and biomass fuels could pose difficult of running them in the selected project area.

### **5.3 Solar PV Systems**

There is high potential of converting solar energy into electricity at Mwela Village due to solar isolation. Solar PVs are promising renewable energy technologies for selected Mwela village community. The solar PV system could also be designed easily and does not require fuel. The solar PV system does not require fuels, it operates unattended and requires minimum periodic maintenance, it can be expanded and generate no waste products. The only constraints within this technologies is related high investment costs and inadequacy of electricity generated from solar PV systems compared to mini-hydro Although the option of grid extension has higher costs

compared to decentralized mini hydro system, the project management is advised to mix both of these systems by generating electricity from mini-hydro plant at Mwela-Ishinga and supply to the village community and surplus will be supplied to the grid. Project area has biomass energy resources and their applicability for electricity generation is limited by the high installation and operation costs of technologies and energy conversion.

**Table 4: Ranking of Least Cost Power Generation**

S. No.	Energy Technology	Feasibility	Investment Costs (Tshs)	Ranking
1	Biomass Gasification (30 -500 kW)	The biomass resources are scarce in the project areas and technology itself requires close technical maintenance and capacity building. Its operation requires buying biomass resources.	15-552 million	3
2	Mini Hydro Power Plant (5,000 kW)	The project area has potential of generating electricity by using water flow identified river deltas with waterfalls which are potential for small hydro power generation. Electricity generation capacity is high compared to power generation from other sources	200 million to 4.8 billion	1
3	Solar PV farm (20-25kW)	The solar Isolation is ranging from 5.4 - 6.17 kWh/m <sup>2</sup> /day. There is high potential of harvesting solar energy and convert it to the electricity through solar PV systems. The investment costs are high but operational costs are low and easier for expansion	500-950 million	2

The options above were ranked according to their feasibility and investment costs. The investment costs of solar PV is high, its operation is lower compared to Mini-Hydro Plant and Biomass Gasification. Biomass energy technologies have additional costs of buying fuels while mini-hydro plant does not require fuels, it is operated by water-flow from the river and requires minimum periodic maintenance, it can be expanded and generate no waste products. The feasible power option for Mwela Village is Mini-Hydro Plant. The project is opting for this technology in order to generate electricity for village community and supply electricity to the national grid.

#### **5.4 Recommended Technology and Proposed Site for Power Generation**

This option of generating electricity by mini-hydro plants is more appropriate and recommended for selected rural settings of Mwela Village. This technology is recommended due to existing

potential of high capacity of power production from Mwela -Ishinga water-falls. To determine the power potential of the water flowing in a river or stream it is necessary to determine both the flow rate of the water and the head through which the water can be made to fall. The flow rate is the quantity of water flowing past a point in a given time. Typical flow rate units are litres per second.

The waterfalls found at Ishinga, has high potentials for power generation. The feasibility study recommends piloting the development of mini-hydro plant of 5000 kW at Ishinga waterfalls along Ishinga River. This is attributed to accessibility to the site, in-kind community willingness to support the project activities and potential demand of energy is high.

## **SECTION 6: DEMAND AND POTENTIAL STUDY**

### **6.1 Demographics and Socio-Economic Issues**

Texpol Development Co. Ltd (Tanzania) intends to invest and develop hydro-power energy from existing water falls to serve the energy demand of the people in the village. The company is planning to start production and distribution of energy in Mbeya Rural District, Ilungu Ward at Mwela Village in which people have been living for many years without electricity. Mini-hydropower stations are interventions which the company is intending to develop in Tanzania.

The Mini Hydro Plant will be electricity generation system that will use waterfalls along Rivers Basins to run the turbine. The project will provide access to affordable electricity by developing mini hydropower plant which will supply electricity to TANESCO through the national grid. The village community will benefit from extension of grid to the project area, which will enable them to get access and connected to the grid. This will enable to improve productive initiatives and livelihoods of the people living in the rural communities and serve social institutions, small and medium scale enterprises and households in rural areas.

The targeted customers of electricity are households, institutions, businesses and Small Medium Enterprises (SMEs) and will access electricity as a result of this project. Based on interviews conducted with villagers, village leaders and other participating stakeholders during feasibility study it was revealed that 60% of households are willing and able to pay their monthly electricity

bills at a cost of USD 4 per month and 40% of households are willing and able to pay USD 5 per month. Businesses and SMEs were willing and ready to pay for electricity services charges up to USD 8 per month. Other potential customers are earmarked to come for the neighbouring villages of Mshese, Mwela, Shango, Kikondo, Ngole and Nyalwela. Successful implementation of this project will benefit more than a thousand households. Presence of electricity to these villages will result into income generating small enterprises like hair cutting and beauty salons; saw milling machines, etc., thus creating jobs and income to the villagers. The potential of agro-processing industries is high since the area is endowed with a lot of fruits, vegetables and other agricultural crops. Consequently, the situation will create jobs for the villagers and for the nearby villages.

## **6.2 Major Load Centres**

Currently there is no any source of electrical power in the area and the mini-grids through mini-hydro plant will be the only source of electricity, implying that all the village households, businesses; institutions are potential customers of electricity from this source. However, in the near future, there are efforts for extending grid electricity to the village. The costs of energy solutions currently in use are high when compared to cost of the service this project will be offering its customers.

The major load centres for this investment will be the national grid and customers in the Mwela Village (surrounding households and business entities). The local customers are categorized into residential houses, commercial enterprises, small industries and public lighting. The residential houses are further sub-categorized into high load households, medium load households and low load households

## **6.3 Specific Growth Assumptions and Load Forecast**

The project will initially change the livelihoods of customers in the village by enabling them to connect to the grid electricity but the generated electricity will be fed into the national grid (selling electricity to TANESCO). Therefore the major load centre in the future will be the national grid in which electricity will be sold to the power utility. Additional customers for future connection will be businesses and households due to increase in future demand, market of electricity in the project areas. Therefore, it is anticipated that in the future demand of electricity and trend will be growing in the village and surrounding communities.

Load forecast has been estimated for the period of 20 years. Due to the economic situation it is anticipated that in the first few years the load served by the generated electricity will be much smaller than the generated power. The future annual peak demand was estimated using the historical growth of other similar electrified areas by the public electric power company. In the

first four years after commissioning of the project, load is expected to grow by 25% annually to the initial full load. From the fifth year onwards the load growth rate will grow differently with regards to the type of consumers as follows:

**Table 1: Growth Rates for Different Customers of Mini Hydro Project**

<b>S. No</b>	<b>Type of Households</b>	<b>Growth Rate</b>
<b>1</b>	Residential houses	4%
<b>2</b>	Commercial	3%
<b>3</b>	Small Industries	2%
<b>4</b>	Public lighting	2%

A load factor of 0.5 was assumed for the project area. The forecast of power and energy demand for the twentieth year for the project area was estimated to be 145.24 kW and 650,734.45 KWh

#### **6.4 Willingness and Capability to Pay**

The people in the villages in the proposed project area agreed to participate directly and physically in all construction works during implementation of this project with Texpol Dev Co. Ltd. This offer will be valid for domestic use only and people who will be connected for commercial activities will have different arrangement and different tariffs depending on specifications of TANESCO.

The villagers have ability to demand and pay for the electricity service at approximately USD 15 (equivalent to Tshs. 30,000 per month). The project will find possibility of reducing this amount of costs during operation of the plants by connecting to more customers. There are high chances that trend in the future for customers will increase due to awareness increase and demand from more households, SMEs and institutions and future expansion of project to other customers.

#### **6.5 Estimated Load in the Project Area**

Energy load for Mwela and especially Mini-Hydro Plant, which will start compared to others in Mwela, was estimated for 20 years. This is initial time determined by Texpol and experts during feasibility study, this period could be extended to 25 years as recommended planning period by TANESCO for areas to be supplied through grid extension, owing to the time lag for house wiring and extension of service lines to customers. Future annual peak demand and energy was estimated using historical growth rates used for similar electrified areas as follows;

- In the first four years after commissioning of the project, load will be expected to grow by 25% annually to the initial full load.
- From the fifth year onwards, the loads for each tariff category will grow according to the following rates:

- 5% for the residential consumers
- 3% for commercial consumers
- 2% for light industrial and
- 2% for public lighting

A load factor of 0.5 was assumed for the project area. These are measures of divergence of spreading over time of the peak loads. Three selected diversity factors are unit diversity factor (g1), Group diversity factor (g2) and overall diversity factor (g3). The load and energy demand forecast for Ishinga waterfalls for exploiting hydro potential at Mwela Village which is going to be the first river delta and village which will receive support for mini-hydro development was determined for 20 years and its forecast is as shown hereunder:

**Table 3: Load and Energy Demand Forecast**

Onwards	5%	3%	2%	2%		
1st 4 Yrs	25%	25%	25%	25%		
Year	Residential (kW)	Light Commercial (kW)	Small Industries (kW)	Public Lighting (kW)	Total Demand (kW)	Energy (kWh)
1	18	9	25	1.1	53.1	237,907.91
2	22.5	11.25	31.25	1.38	66.38	297,407.29
3	28.13	14.06	39.06	1.72	82.97	371,736.71
4	35.16	17.58	48.83	2.15	103.72	464,704.50
5	36.92	6.04	49.8	2.19	94.95	425,411.61
6	38.76	6.22	50.8	2.24	98.02	439,166.36
7	40.7	6.41	51.82	2.28	101.21	453,458.75
8	42.74	6.6	52.85	2.33	104.52	468,288.80
9	44.87	6.8	53.91	2.37	107.95	483,656.48
10	47.11	7	54.99	2.42	111.52	499,651.42
11	49.47	7.21	56.09	2.47	115.24	516,318.42
12	51.94	7.43	57.21	2.52	119.1	533,612.66
13	54.54	7.65	58.35	2.57	123.11	551,578.97
14	57.27	7.88	59.52	2.62	127.29	570,306.93
15	60.13	8.12	60.71	2.67	131.63	589,751.76
16	63.14	8.36	61.93	2.72	136.15	610,003.06
17	66.3	8.61	63.16	2.78	140.85	631,060.82
18	69.61	8.87	64.43	2.83	145.74	652,969.85
19	73.09	9.14	65.72	2.89	150.84	675,819.77

20	76.74	9.41	67.03	2.95	156.13	699,520.95
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The forecast of power and energy demand for each year is as shown in the table above. The energy demand in the twentieth year for the project area is 156.13kW and 699,520.92 KWh respectively as shown in table 3 above.

## **SECTION 6: DESIGN OF CIVIL WORKS**

Based on the pre-feasibility study results, the preliminary design was estimated at this feasibility study to determine the magnitudes of civil works. This includes hydraulic structure required for mini-hydro such as dam structure, conveyance canal, fore-bay, penstock powerhouse and tailrace. The design is based on the specifications/requirements and necessary assumptions for future use of the mini hydro plant

### **6.1 Reservoir and Intake Design**

The sites will not require a large reservoir for water collection and diversion because of its head. Intake Structures involved a weir to direct the appropriate flow into the penstock and provide for adequate screening. There are several general configurations that can be used in a natural stream or a canal; a lateral, side or bottom intake. The higher the head on the turbine, the more important is to have water free from sediment. The side intake is desirable for this project because most of the debris and bed loads can completely bypass the screens. All diversion weir or any other hydraulic structures should include a gate to sluice the sediments that will accumulate from the river or at the intake. Adding a movable gate to the diversion structure allows for more control of both the intake and bypass flow. The turbine should also have screen for sediment and trash control. Screening the water before it enters the turbine will prevent accelerated wear of runners and other components of the turbine. Floating debris may also cause significant damage if allowed to enter the turbine. The assessment will be made to understand the type of debris and sediment during rainy season in order to understand type of screen will be procured.

### **6.2 Water Conveyance Canal**

The mini hydro-plant at Mwela-Ishinga waterfalls will be supported by two water canals (200m length of concrete and 1000m of clay earth canal). The clay soil does not allow percolation of water and is the best materials for water canals. The intake water retaining walls with intake weir and settling basin will be constructed with height of 5 metres. Water from the intake will pass through the water canal to the fore bay-tank. The fore-bay will be connected to the Pelton turbine at the Power Station through the water pipes (penstock) of cross section of 1000mm and 90 metres long. There will access gravel road to the plant from Mwela village of 11 Km. (PushiparChitrakar, 2010)

### **6.3 Forebay**

The position of the water tank, selected from the level survey of the intake was decided so that the head for power generation is maximised and the route of the penstock is constructed to the power house on a straight line. The water tank capacity is such that the widely used 60 second capacity is maintained. The inflow earth and sand are discharged to the river from the silt- flushing gate.

### **6.4 Penstock**

The penstock of cross section of 1000mm and 90 metres long has been proposed for Ishinga – Mwela Mini Hydro Plant. Based on the results of the pre-feasibility surveys, the penstock route is chosen along a narrow ridge having the shortest possible distance, small risk of landslide damage and representing a minimal amount of excavation. In the vertical bend section, the penstock is fixed by anchor blocks and installed with concrete support at 6–8m internals for straight stretch and at each point where there is a change of direction. Additionally, reinforced concrete structures are utilised for the anchor blocks and concrete blocks. Note that the penstock is fixed in place with a thrust block just before entering the turbine.

### **6.5 Powerhouse and Tailrace**

In order to maximise the head for power generation, the power house will be located on flat land close to the Ishinga River. The installation altitude of the generation plant was determined in accordance with the highest ever level recorded in the river in order to prevent flood damage to the mini-hydro facilities. The generation capacity of this plant will be about 5000 kW.

The top vegetable soil was observed to be weak soil which will require cutting of the top layer and fill with selected material which is expected to be Gravel/Sand where this weak layer seems to extend. The foundation of the powerhouse and forebay will be founded in Cohesion less soils.

For the design of office block, the strip foundation has been adopted. The strip foundation in this case will support the load bearing walls in the proposed building. The architectural drawings will be prepared to ensure safety and put assumption that the total force from a proposed wall will not exceed 50kN/ meter as with a house of the same construction, not exceeding 30kN/m. Since the powerhouse has no storey, the same loading from the wall has been assumed. The general bearing factor will be determined based on the soil investigation, the internal angle of friction of 30° and soil cohesion of  $C=0$  has been considered. The engineering design of all features required for power house will be re-assessed including bearing factor for power house before construction of power house and other structure in the project area.

## **SECTION 7: ELECROMECHANICAL EQUIPMENT**

### **7.1 Hydraulic Turbine**

The power potential from the water flowing in Ishinga River or stream was determined during pre-feasibility study. The flow rate of the water and the head through which the water can be made to fall were determined as stated in items 4.3.1 and 4.3.2. The flow rate is the quantity of water flowing past a point in a given time. Typical flow rate units are litres per second or cubic metres per second. The head is the vertical height, in metres, from the turbine up to the point where the water enters the intake pipe or penstock. Either Francis or Pelton Turbines could be installed at Ishinga waterfalls to generate 5.0 MW.

The Francis turbine is an inward-flow reaction turbine that combines radial and axial flow concepts. They operate in a water head from 10 to 650 meters and are primarily used for electrical power production. The speed range of the turbine is from 83 to 1000 rpm. Wicket gates around the outside of the turbine's rotating runner adjust the water flow rate through the turbine for different water flow rates and power production rates. Francis turbines are almost always mounted with the shaft vertical to keep water away from the attached generator and to facilitate installation and maintenance access to it and the turbine (Pushipar Chitrakar,2010).

The Pelton wheel is a water impulse turbine with wheel that extracts energy from the impulse of moving water, as opposed to its weight like traditional overshot water wheel. Although many variations of impulse turbines existed prior to Pelton's design, they were less efficient than Pelton's design; the water leaving these wheels typically still had high speed, and carried away much of the energy. Pelton's paddle geometry was designed so that when the rim runs at  $\frac{1}{2}$  the speed of the water jet, the water leaves the wheel with very little speed, extracting almost all of its energy, and allowing for a very efficient turbine.

The selection of turbine type and number of parallel unit is governed by the available head and flow conditions of the site, operational and reliability requirements, accessibility of the site and future maintenance plan of the plant.

### **7.2 Electronic Load Controller**

For the case of grid isolated mini hydro system as the one under consideration, proper control of frequency and voltage is an important design consideration. Since the input to the mini-grid is essentially constant, any excess in power generated resulted from the decrease in the load must be removed so as to maintain power balance. Electronics load controller (ELC) is an electronic governor that functions as a frequency and voltage regulator on the generator. The ELC prevents speed variations by continuously adding or subtracting the excess load thus maintaining the

turbine operation under full load condition permanently. This report proposes ELC due to the following advantages:

- The use of ELC avoids expensive mechanical and electrical governors.
- ELCs are relatively more simple and cheaper.
- ELC offer very wide range of load variations.
- They require simple maintenance and hence ensure high reliability.

### **7.3 Control Equipment**

To simplify the design and reduce the cost of the control and auxiliary equipment, the hydraulic turbine will be designed for manual start and stop. In the event of the protective device being activated (in order to prevent damage to the generator and to avoid human accidents, etc.), the main circuit breaker of the generator will be opened to stop power generation, but the hydraulic turbine and generator will continue operating

### **7.4 Transmission and Distribution Line**

Assessment of the tentative route of 33kV transmission line revealed that the length of the proposed line is about 16km to Ifupa Village. Overhead transmission line is preferred due to the complicated terrains from the proposed mini- hydroelectric power station near river Ishinga to Village Centre. The electricity will be connected to Mwela village by 33KV supply line with two power transformers – one at the plant and the second at the Village and later on to the 33KV National Grid.

The distribution network will also adopt the overhead technology to enable future expansion. The three phase transmission line shall use bare conductors of 100mm<sup>2</sup> core Aluminium Conductors Steel Reinforced (ACSR) type for 33kV power transmission. Wood poles are proposed as economical line supporting structure for this power network. This will go concurrently with construction of 0.4 kv ABC 50mm<sup>2</sup> LV distribution line and distribution substation 33kv/0,4kv (200kw) at Mwela Village Community from electricity supplied to the Grid.

## **SECTION 8: IMPLEMENTATION, MANAGEMENT AND INSTITUTIONAL ASPECTS**

### **8.1 Proposed Project Components**

At the beginning of the project, the developer will acquire basic requirements for implementation of this kind of project such as relevant sector clearances and licenses. The core components for the proposed project will include:-

- Construction of Access road from Ishinga Site to Mwela Village
- Construction of SPP Power Building
- Excavation and Construction of Water intake
- Excavation and Construction of 1200 Water canal
- Install Power turbines, generators and power unit
- Install Penstock 2 x 600mm
- Install Step up transformers 400kVA
- Layout 33kv from power house to Mwela substation
- Layout 33 kv ACSR 100mm<sup>2</sup> HT from Mwela substation to National Grid
- Layout 0.4 kv ABC 50mm<sup>2</sup> LV distribution line from the national grid to in Mwela settlement
- Construct Distribution substation 33kv/0,4kv 200kw at Mwela settlement
- Core Support of the Project Implementation and Management

The project will also procure equipment and construction of different hydraulic structure during project implementation. These will include Switchgear, de-Silting chamber, headrace canal, Diversion Weir, Flood Control, Power Station, Generators and access roads.

### **8.2 Ownership and Management Model**

According to experiences from different areas, the ownership of similar energy systems by village community is a little bit difficult because it requires thorough organization of user associations and high degree of social organization and local governance. Alternatively, in order to create the stable management and institutional set up for this project, Texpol through its office will lead implementation and post-management of the project. Texpol will use its professional staff and external consultation to develop the mini-hydro plants and initially maintain small work force of five staff (two (2) field staff stationed at Mwela Village and three staff at the head office) for operation and maintaining the plant during post project duration. However, the mini-hydro plant is large enough to justify for independent field staff who will among others upkeep the plants, mini-grids, users' connections and collect tariffs from users. This model is usually

used in mini-hydro plant of 2,000-6,000 kW connected to 1400 to 1900 users in Asian Countries (India, Vietnam, etc.) (ADB, 2013)

Although ownership per se by village community is not encouraged, ideally a “village electrification committee” would be put in place for regulatory activities. TEXPOL and TANESCO will enter into agreement on type of management required for supply of electricity to the grid and ensure supply of electricity from the grid to the Mwela Village Community.

This external influence would, however, need to take great care to respect the requirements, wishes and customs of the local community. The villagers will always know best what they need and in what shape they need it and so it is important to work very closely with village leaders and to maintain a good relationship with them. All decisions must be made with the best interest of the community in mind and ensure electricity connection to the villagers.

### **8.3 Regulations and Legislations**

The project developer through this project should have all legal certificates from relevant ministries to acquire land for the project site and rights for getting water from the Ishinga River at Ilungu ward. The certificates required are the Title Deed/ Offer for Land and Water Rights. Other certificate may include NEMC certificate and certificate for investment from Tanzania Investment Centre (TIC).

### **8.4 Institutional Framework**

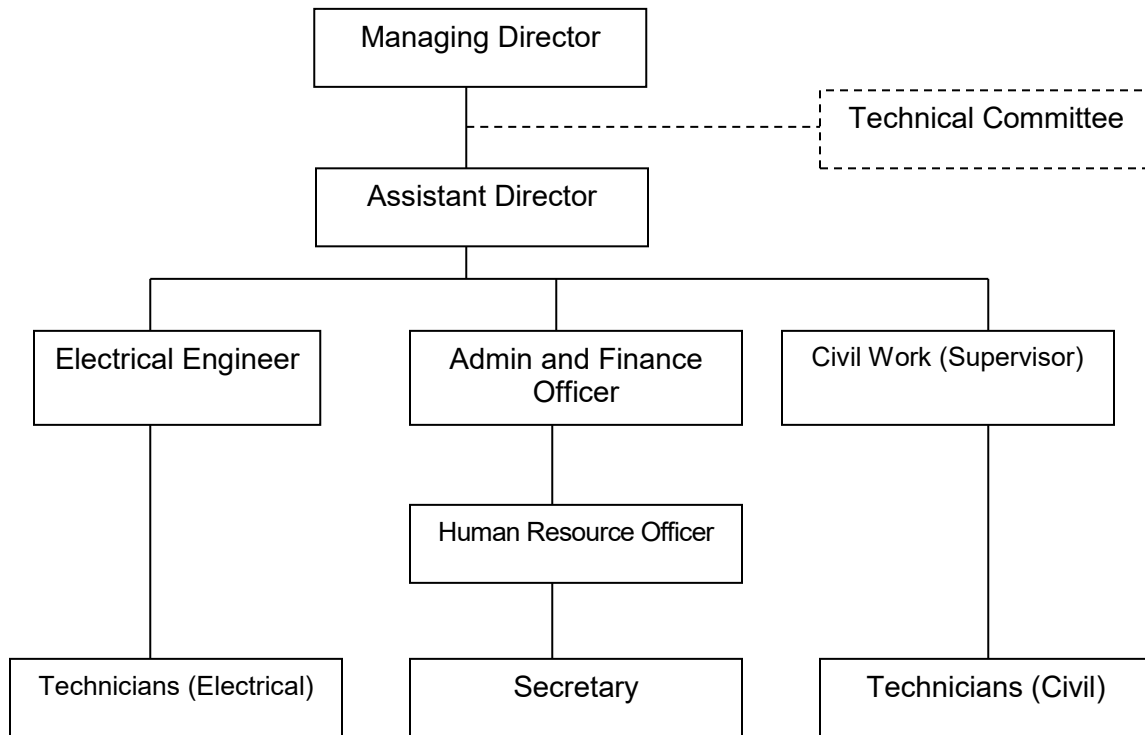
Texpol Development Company is the sole owner and the main project developer, with room of other participating stakeholders to connect with the electricity services which will be provided by the project. The Texpol Development Co. Ltd (Tanzania) is a private company based in Dar es Salaam, Tanzania with experiences in development of renewable energy technologies and services in rural areas of Mbeya Region.

Texpol will provide technical expertise, overall management and also monitor development and performance of the project during its lifetime. Texpol has strong capability of mini hydropower designing and installation and other civil and mini-hydro development projects. The contact person for Texpol is Mr. Julius Zellah, who is also the founder of the company.

The project at local level will be managed by technical committee. The technical committee will draw members from Mwela Village Community, Ilungu ward, DED and Texpol Dev. Co. Ltd (TDC). The company will require when necessary, expertise from TANESCO.

The project is planned to have area-based collaborative type of management. It will be managed by Texpol Development Company in collaboration with technical Committee. The centre of project activities is Texpol Head Office. The institutional organisation chart 3 for this project is as shown hereunder:

**Chart3: Institutional Framework for Project implementation**



Texpol Dev. Co Ltd will take the lead responsibility for implementing the project through its established organizational set-up. The company will collaborate with relevant stakeholders in the private sectors, government institutions, donors and individuals in implementing the project. The main emphasis will be to intensify active involvement of all stakeholders in the whole business cycle.

**8.5 Environment and Social Assessment**

The reality for people in the proposed villages is that life after sunset slows right down due to the lack of electricity resulting in children not being able to do their homework, productivity being restricted and quality of life being impaired. The clean technology which will be used for energy generation and this has minimal negative effect to the environment. The system will replace the current use of kerosene lanterns, as they have health and fire hazards and are also expensive and of poor quality. The environment and Social Assessment will be conducted through the component of Social and Environment Impact Assessment (SEIA).

**SECTION 9: RISK ANALYSIS**

Risk factors may affect the implementation, timely completion and sustainability of the proposed project. In this regard, few risks have been identified alongside with mitigation strategies (mitigation measures). However, none of the risks are considered serious enough to prevent smooth execution and attainment of the expected outputs and impacts. Table 5 summarize risks and mitigation measures:

**Table 5: Possible Risks and Mitigation Measures**

S. No	Risks	Mitigation Measures
1	Lack of technical and insufficient managerial capacities at local level – village level	Texpol experience will be used to mitigate this risk by undertaking local level capacity building on management, O&M of project
2	Competition arising from other water uses	Rationing water use to suit the situation will be agreed by both project management and village government authority.
3	Level of poverty, may at initial stages affect smooth take off and sustainability of the project	The customers will be provided with business trainings to use the generated electricity for income generation
4	Most of equipment are not available locally, this may increase the cost and delay of the project completion	Need to undertake transactions process as early as possible to avoid delays of the project
5	Increasing inflation rates may increase installation, operation and maintenance costs of the project	All necessary equipment for installation, operation and maintenance costs will be transacted using Euro to avoid loses. Goods will be bought immediately after securing funds
6	This project construction work may impact the environment negatively	There will be careful planning so as to avoid unnecessary practices that may affect the environment.
7	Increase of exchange rate	Currency will be discounted to take care of future value of money.

There are other financial related risks such as affordability issue may hinder beneficiaries to pay for their connections and low acceptability of the energy services to be offered by the project. There is a need for beneficiaries to repay investment costs for equipment and support for installation costs by paying through instalments.

## **SECTION 10: SUSTAINABILITY MEASURES**

The proposed project activities are expected to continue even after completing project development phase. The installation of mini-hydro plants will be required for even all potential waterfalls in River Deltas. Operation of these mini-hydro plants will in the short run continue to supply electricity to households, the social centres and business enterprises not only in Mwela

Village but also in the Ilungu Ward as a result these services may serve and expand to the neighbouring communities. However, due to extension of grid electricity to the rural areas of Ilungu ward, electricity will be fed into the national grid. Some of the most important issues that would contribute to sustainability of the proposed project are as highlighted in the following aspects:

### **10.1 Financial and Economic Sustainability**

Experiences show that commercial approaches tend to be more sustainable in the long run, because the driving force and self-interest of making profit through business ventures. The benefits such as income generation, employment and improved health and education improvement will create demand of these services in the project areas and neighbouring places in order to get these opportunities. Furthermore, the business skills acquired by the technicians, TEXPOL, availability of reliable sources of raw materials with increased access to sources of funds would definitely contribute to an expanded business and market base that would lead to both financial and economic sustainability.

### **10.2 Social Sustainability**

Social sustainability can be achieved when social exclusion is minimized and social equity maximized. It is anticipated that there will be continuity for availability of social benefits of mini-hydro plant for the benefit of the community to the institutions and enterprises even beyond the life of the proposed project. Social and cultural benefits include knowledge and skills gained increased family relationships, behaviour and attitude change (modernization), reduced gender differences and roles, etc. Institutions and enterprises will use the increased income due to use of electricity for other social needs like education and health services. This will therefore create sustainability since beneficiaries will always opt to maintain and install additional ones in their institutions.

### **10.3 Environmental Sustainability**

The mini-hydro plants will generate electricity (which is clean energy) and will continue to use of clean energy technologies to contribute to the efforts of cleaning environment and its sustainability. Improved livelihood assets through increased income and improved clean energy services in households, institutions and enterprises have direct impact on the improvement of environment (through reduced deforestation and GHG emissions). The benefits to be accrued

from implementation of the proposed project can be assessed by comparing situation during and after implementation of the proposed project. It is assumed that during post-project period, rural entrepreneurs, social centres will continue to use electricity and will continue to contribute to the efforts of deducing environmental effects. All these growing demands signify sustainability of the on-going initiatives and beyond project duration.

The water flow will not cause any soil erosion and will as well minimize endangering rare species. Water drawn from the river for power generation will later return to the same river downstream. This will not affect other activities downstream. Ecosystems in the project areas will be improved due to construction of reservoir which will enable marine and terrestrial life of different species in the project areas.

## **SECTION 11: FINANCIAL AND ECONOMIC VIABILITY**

### **11.1 Project Costs**

Break down of total project cost is in the table below.

<b>Description</b>	<b>Unit</b>	<b>Equity(USD)</b>	<b>Loan(USD)</b>	<b>Total (USD)</b>
Feasibility study	CPL	41895.65		41,895.65
ESIA (Environment and Social Impact Assessment) report	CPL	28,547.65		28,547.65
Business Plan	cpl	26,547		26,547
Survey work	24 months	30,000	30,000	60,000
Administration	24 Months	442,800		442,800
Logistics	24 Months		311,040	311,040
Access Road	7 Kms		248,828	248,828
SPP Power building	1 Unit		206,894.56	206,894.56

Water Intake	Metre square 126 @1560		196,500	196,500
Water Canal	MB 26@ 1455		75,660	75,660
Power turbines, generators and power unit	CPL 2 @2,376,894		4,753,788	4,753,788
Penstock 2 x600 mm	Mb 750@2,825		2,118,750	2,118,750
Step up transformers 400KvA	2 CPL@89,975.54		179,951.08	179,951.08
33 kv From power house to Mwela substation	6 KMS@47,678.96		286,073.78	286,073.76
33 kv ACSR 100mm2 HT from Mwela substation to National Grid	12 Kms@48,678.96		584,147.52	584,147.52
0,4 kv ABC 50mm2 LV distribution line in Mwela settlement	9 Kms@36,976		332,784	332,784
Distribution substation 33kv/0,4kv 200kw at Mwela settlement	CPL 2@19,640.70		39,281.40	39,281.40
<b>Total project costs</b>		<b>569,970.30</b>	<b>9,363,697.94</b>	<b>1,600,000</b>

During the operational phase of the project, the company would require additional funds for purchase of transformers, road construction, turbines, generators and buildings distribution lines. The amount required would cover initial operating expenditures, and will thus be reflected in the projections of income statements.

#### 11.2 financing plan

The project will be financed by both equity and loan. The project promoters, who are the directors and shareholders of the company, will inject equity into the project in the form of cash and assets. Equity injection amounts to USD 126,218.

The debt to equity ratio given the estimated amounts of equity of loan will be as follows:

**Amount (USD)**

**Percentage**

Equity	126,218	3
Loan	4,758,709	97
Total	4,884,927	100

## 12.0 ECONOMIC AND FINANCIAL ANALYSIS

*This section gives economic and financial analysis. This includes detailed analysis of cash flows and income projections for a reasonably foreseeable period, loan repayment schedule, and feasibility valuations based on results of valuation methods such as discounted Cash Flow methods and the Payback period.*

### 12. Economic and Financial Statement

#### 12.1 Projected financial statements

The projected financial statements for ten year period are attached as Appendix i-xi. These statements include the projected balance sheets, income statements, and the statement of cash flows.

The projected balance sheets indicate a healthy trend, with a total equity position. The projected current assets will remain substantially above current liabilities, thus posing no liquidity problems. The projected income statement shows a steady increase in net income starting from the first year of project implementation

The projected cash flows indicate a strong cash position enough to support loan repayment and interest payments at the due dates. The projected interest calculation and loan amortization is attached as annex XI.

## **7.1 Analysis of Financial and Economic Viability**

The analysis of financial viability of the project was done using the Discounted cash flow approach (DCF) and the payback method. On the basis of the results of the analysis, the project is financially viable as it has a positive net present value. The Internal Rate of return (IRR) of 16% is also above the cost of capital.

The project's payback period is 10 years.

Economically, the project is also viable for it will contribute significantly to the development in the following measurable ways:

- The project will create about 52 employment opportunities.
- The project will contribute to government revenue in the form of taxes. It is projected that, the project will have generated about USD 2,192,308 sales alone by the end of year ten
- The project will result into significant positive multiplier effects through various stages of manufacturing corrugate boxes and distribution chain

## **7.2 Contribution of the Project to Economic Development**

The project will serve as an additional source of supply of corrugated boxes to the economy. It will also contribute to the supply of foreign exchange, since a significant portion of products will be exported. The project will also contribute to the growth of the economy through generation of new employment, increase in government revenue through payment of taxes, and through a multiplier effect that would arise through various points in the value chain of manufacturing corrugated boxes distribution, and export.

## **11.1 Capital Costs**

The capital costs of Mwela Mini-Hydro Development Project were determined and most of these costs are associated with development of the project as indicated in the annex 2. The investment costs that project will incur during development phase of mini-hydro plant construction and mini-grid are mainly associated with construction of these structures. The rehabilitation costs which will be occurred in the future may be considered as a separate project. The investment costs will involve land clearing, grading, layout and civil works during project development. The investment costs of this project are shown as annex 2

## **11.2 Operating and Maintenance Costs**

These are fixed and variable costs related to project implementation and operations during and after development phase. The operational costs will be mandatory for communication, electricity which is used in the plant and project office, security, sanitation and operation and maintenance

of the plant. Other costs are related to management, purchase of spares, accounting and casual labourers. (Annex 3).

Maintenance of mini hydro assets is critical to achieve reliability of electricity supply required by users and to comply with current regulations. With the goal of improving efficiencies and downtimes while lowering costs, mini-hydro plants have to get the most out of their equipment over the long term. Lack or absence of maintenance can generate deterioration or severe failures.

The operational costs will be mandatory for communication, electricity which is used for constructing the plant and project office, security, sanitation and operation and maintenance of the plant. Other costs are related to management, purchase of spares, accounting and casual labourers.

Considering the project plant power output, such a mini hydropower station may likely have a fairly high operational cost per produced unit. However, close assumption is that the project will have an estimated operational cost of 1 cent USD/kWh. This gives a total cost of \$ 4,700 a year. Operational costs will also include salary for operational personnel, long time and short time maintenance and cleaning.

### **11.3 Projected Revenue from the Proposed Project**

The recovery of investments would be from selling of electricity to the national grid and some customers who are interested to get electricity form the local mini-hydro plant. The electricity in the short run will be used by Local Customers, New Enterprises and Users (Productively) but as well feed into the National Grid.

### **11.4 Financial Analysis**

The project profitability was assessed based on acquired costs for investments, operations, recurrent (management) and revenue from different potential sources. The annual cash-flow of costs and benefits at 10% discount rate were analyzed for financial viability of the project. The cost and benefits analysis at 10% discount rate and came up with NPV of USD 306,133 and IRR of 20.18%, respectively. The NPV was tested again at 18% discount rate. The NPV was still positive (USD 20,073) (Annex 4). The positive NPV implies that based on the costs and revenue transactions obtained the proposed project is financially viable and according to its assessment. The IRR above the discount rate implies that the investment, if will be well managed should return the capital invested in relation to discount rate or interest rates for funds obtained from the bank credits. This implies opportunity cost of investment is positive if all conditions will be managed according to the feasibility study assessment.

## **SECTION 12: CONCLUSIONS AND ROAD MAP**

### **12.1 Conclusion**

This section draws together the conclusions from the analysis and criteria made throughout the study report. The available information shows that the area of study has high technical potential of generating electricity to feed in the grid and use it for electrifying Mwela Village Community. Electricity will be of great support to the community and productive activities for the rural people in the project areas. However, the electricity affordability should be increased by investing in the profitable business enterprises (which implies use of electricity productively).

However, a critical factor behind the project implementation is to ensure that enough funds are made available for development or construction activities and this will make the promising avenue for future benefits expected from this project. Another critical factor is to ensure that expected outputs are achieved. Every effort should be made to ensure that targets have been achieved and that quality of work is maintained in order to get required project impacts.

### **12.2 Road Map**

Feasibility study conducted at Mwela Village Community revealed that the waterfall in the area have sufficient water flow throughout the year. The waterfalls surveyed for feasibility study were Ishinga delta had sufficient heads to generate electricity estimated to 5.5 MW from identified river falls. The proposed project will focus on provision of electricity for consumptive and productive uses for villages in Mwela Village. Moreover, the project will also contribute to the country's efforts on rural electrification. The Texpol will continue with the following preparatory activities:

#### **12.2.1 Undertake Engineering Design**

The activity will enable to design small hydroelectric plants according to feasibility and social and environmental decisions proposed in the previous activities. The design will base on analysis made through this feasibility study and hydro-geographical characteristics for a wide range of sites and a model that involves significant physical parameters will be developed. An appropriate technical drawing or design model describing hydro-turbine efficiency will be developed and optimized. The technical drawings and model will entails details of the design and layout of the small hydro plant at Ishinga Falls showing specifications of intake, weir, settling basin, main canal, fore-bay tank, penstock and power house including turbine and its accessories. The optimization will cover a wide range of site characteristics and commercially available hydro-turbines. An overall plant model will be introduced by taking into account their construction characteristics and operational performance.

#### **12.2.3 Implementation of the Project**

It is proposed that once financing has been secured, the project implementation should start immediately beginning with implementation planning and promotion activities, procurement of equipment and construction materials. These will be followed by installation of mini hydro plants according to requirements of the Mwela scheme. Some of these activities will continue throughout the project duration. At the beginning of the project, the developer will acquire basic requirements for implementation of this kind of project such as relevant sector clearances and licenses. The project will continue with installation of the mini-hydro plant in the field, access road construction and distribution of electricity to the users.

- **Layout and Situation of the Weir and other hydraulic Structures**

The weir which is hydraulic structure with water intake will be constructed for directing water to the main canal. The specifications for tower structure at intake, the water supply pipeline, stilling basin, apron and distributary point will be determined during engineering design of the mini-hydro plant. There will be no need of a large dam since the water flow is perennial and due to height of water flame which is sufficient and have potential energy for enabling water flow in the main canal and power generation.

- **Construction of Power Conduit (main canal)**

The power conduit's purpose is to transport water from the intake to the penstock inlet with minimum head loss at a minimum cost. In most cases this means that a canal will be excavated in soil – and sometimes lined with concrete to prevent loss of water and to increase its flow. In other cases, a pipe can be used as a low-pressure power conduit to the penstock inlet

- **Construction of Forebay**

The Forebay tank is the connection between the power conduit and the penstock, serving and will be constructed in order to allow particles to settle down before the water enters the penstock. It can also be used as storage for water in the case of increased power consumption at peak times of the day.

- **Construction of Penstock**

The penstock is the pipe which transports water under pressure from the Forebay tank directly to the turbine. The penstock of 450 metres will be installed either above or below the ground. It will prove more costly to excavate an area for the pipe rather than design for the added difficulties placing the penstock pipe over ground causes. These difficulties vary from temperature variations (and hence expansions) to the secure fitting of the pipe. Gates or valves can be incorporated into the penstock to either control the flow of water or to enable

the isolation of the turbine from the water flow. This is especially useful in the case of maintenance.

- **Layout of the Hydropower Station System**

The powerhouse will be constructed to protect the turbine, generator and other electrical and mechanical equipment. Since this is micro-hydro, the power house should be kept to a minimum size in order to minimise costs. However, sufficient space must be kept to allow for repairs and maintenance. Perhaps the most important aspect of building a powerhouse is its location, rather than its design.

The powerhouse requires to be arranged at the existing stilling base and apron, with 5,500 kW or more shaft-extension type tubular turbines installed inside. The channel will be connected to the distributary point. All power house equipment will be procured and installed, according layout of the power house as will be proposed during the engineering design. Turbines for power generation will be selected and may contain energy which can be captured by a turbine in two ways:

- (i) Pressure can exert a force directly on the surface of the turbine blades which transfers energy to the turbine and causes a corresponding pressure drop in the water as it goes through the turbine. This type of turbine is called a reaction turbine.
- (ii) The pressure can first be converted into kinetic energy in the form of a jet of water blades, transferring its momentum to the turbine blade surface before dropping to the tail-water with little remaining pressure. These turbines are called impulse turbines.

- **Construction of Tailrace**

The tailrace will be installed leading away from the powerhouse and turbine. The water will be discharged into the tailrace after it has been used for power generation. The canal then will lead the discharged water back to re-join the original river. Less effort has to be put into the tailrace design as it does not serve the same vital role as the power conduit, and does not seriously affect the power generation capabilities of the project.

- **Supply of Electricity to the Village Community**

Power transmission, or distribution, will be quite significant for the Mwela micro-hydro project due to the distances between the national grid and the potential beneficiaries. The grid will be extended and used to distribute electricity to the users in 1,000 households, 4 institutions and 30 commercial units. The arrangement will be to sell generated electricity to the TANESCO which will take care of households, institutions and SMEs in the village community. Power will need to be transmitted in two directions, 15 km in the direction of the national grid and 11 km from the grid to community users. Alternating Current (AC)

system will be employed, with a transformer at the end users. Two (2) transformers 400kVA will be used to step up electricity connected to HT 33kV power lines to the grid and mini-grid.

#### **12.2.4 Participatory Involvement of Local People**

In order to maximize the chances of success when implementing a micro-hydro development project it is extremely important to involve the local community from day one. If this is done the community will take pride in their project and work to maintain it operational. This community involvement means that local labour will be used – giving the Texpol staff an insight and understanding into the functioning of the project and hence they will be able to maintain the plant without excessive external assistance. In addition the use of local staff and labour will significantly decrease costs in many areas. This does require flexible design of sensitive parts, such as the turbine, to allow for inaccuracies during construction.

In order to fully involve the community a certain amount of training would be necessary. This will range from the basics of micro-hydro, to involve and gain the approval of the entire community to the more technical knowledge necessary in installing and maintaining the turbine. Detailed maintenance procedures will be necessary to ensure that the turbine life is maximized and electrical knowledge will need to be passed on for installation.

This was observed during consultation of different stakeholders. The perception of stakeholders on mini-hydro project in their areas was assessed during the feasibility study. Adequate public consultations and participation was performed during feasibility study. Stakeholders asked included staff from government departments, target groups, SMEs, and all other groups related to the project. Consultations with communities were conducted through meetings and focus group discussions while other stakeholders were conducted through meetings them in their offices.

#### **12.2.5: Establishment of a Project on Productive Use of Electricity**

The development or extension of electricity to the rural areas should be link with efforts of accelerated electricity access and enterprise-led rural non-farm income generation in order to increase affordability of energy services introduced in the rural areas. The rural communities in Mwela will be faced with multiple barriers to increasing the use of electricity for production. The constraints on promoting demand for electricity from productive units included (i) limited technical and management skills of rural producers, (ii) inadequate access to capital and financing, and (iii) poor quality perception of grid supplied electricity, which may reduce interest in using some electrical equipment.

According to the experiences of Mini-hydro systems developed on a large scale in suitable environments in other countries. They all show a potential for powering a broad range of productive uses, including small industrial units (common ones are tools for carpentry, welding

and auto repair), battery charging, small scale agricultural grinding, milling and drying and ice-making for different uses.

The project may be established and implemented through an approach based on business development services (BDS) techniques. The BDS approach has been applied in rural programs targeting income generating activities in other sectors by working, often in collaboration with other institutions, to assist enterprises improve and start small businesses by addressing technical skills, markets, finance, technology and other constraints.

13.0

**Site**

**Drawings**

**ANNEXES**

**Annex 1: Photo of Site in the Proposed Project Areas**



*Ishinga Waterfalls at Mwela Village and Data Collection*

## Annex 2: Investment Costs (CAPEX) (USD)

S.No.	Activities	Costs			
		Units	Quantity	Unit Costs	Line total
<b>1</b>	<b>Matching Grant</b>				
1.1	Undertake Feasibility study of Mwela-Ishinga Project	cpl	1	33,895.65	33,896
1.2	Undertake ESIA Study	cpl	1	23,547.65	23,548
1.3	Sketch Technical drawing	cpl	1	45,879.00	45,879
1.4	Prepare Business Plan for Mwela-Ishinga Project	cpl	1	22,895.02	22,895
<b>2</b>	<b>Preliminary Surveys, Logistics and Administration</b>				
2.1	Survey work	months	24	2,500	60,000
2.2	Administration	months	24	15,450	370,800
2.3	Logistics	months	24	8,960	215,040
<b>3</b>	<b>Conduct Civil Works and Installation at Mwela -Ishinga Site</b>				
3.1	Construction of Access road	km	7	32,547	227,828
3.2	Construction of SPP Power Building	pc	1	156,895	156,895
3.3	Excavation and Construction of Water intake	m2	116	1,560	180,960
3.4	Excavation and Construction of Water canal	mb	52	1,455	75,660
3.5	Install Power turbines, generators and power unit	cpl	2	770,894	1,541,788
3.6	Install Penstock 2 x 600mm	mb	700	725	507,500
3.7	Install Step up transformers 400kVA	cpl	2	89,976	179,951
3.8	Layout 33kv from power house to Mwela substation	km	6	47,679	286,074
3.9	Layout 33 kv ACSR 100mm2 HT from Mwela substation to National Grid	km	12	48,679	584,148
3.10	Layout 0,4 kv ABC 50mm2 LV distribution line from grid to Mwela settlement	km	9	36,976	332,784
3.11	Construct Distribution substation 33kv/0,4kv 200kw at Mwela settlement	cpl	2	19,641	39,281
	Grand Total				4,884,926
	Minimum Cost per 1 KW				977

### Annex 3: Operational Costs (OPEX) (USD)

	Item	Year 1-2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
		0	0.5	0.75	1.00	1.00	1.20	1.50	2.50	3.50
1	<b>Fixed Costs</b>									
	Electricity		510	540	720	720	864	1,080	1,800	2,520
	Communications		475	470	485	485	497	515	575	635
	Security Expenses		140	120	120	120	144	180	300	420
	Sanitation		200	225	300	300	360	450	750	1,050
	O&M Costs		1,083	1,625	2,166	2,166	2,599	3,249	5,415	7,581
	<b>Subtotal</b>	-	<b>2,408</b>	<b>2,980</b>	<b>3,791</b>	<b>3,791</b>	<b>4,464</b>	<b>5,474</b>	<b>8,840</b>	<b>12,206</b>
2	<b>Variable Costs</b>									
	Management Charges	-	24,000	36,000	48,000	48,000	57,600	72,000	120,000	168,000
	Maintenance and Repair	-	-	6,000		6,000		6,000	6,001	6,002
	Accounting Charges	-	1,650	3,713	6,600	6,600	9,504	14,850	41,250	80,850
	Casual Labourers	-	325	488	650	650	780	975	1,625	2,275
	<b>Subtotal</b>	-	<b>25,975</b>	<b>46,200</b>	<b>55,250</b>	<b>61,250</b>	<b>67,884</b>	<b>93,825</b>	<b>168,876</b>	<b>257,127</b>
	<b>Total</b>	-	<b>28,383</b>	<b>49,180</b>	<b>59,041</b>	<b>65,041</b>	<b>72,348</b>	<b>99,299</b>	<b>177,716</b>	<b>269,333</b>

#### Annex 4: Projected Cash- flow for Ishinga Mwela Mini Hydro Electric Scheme (USD)

S. No	Components	Project Years									
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
<b>1.0</b>	<b>Projection Ratio</b>		0.3	0.8	1	1.1	1.2	1.3	1.4	1.5	1.6
1.1	Investment Costs	2,930,955	1,953,970								
1.2	Operational Costs			37,200	191,683	196,218	211,915	228,868	247,178	266,952	288,308
	Sub-Total (Costs)	2,930,955	1,953,970	37,200	191,683	196,218	211,915	228,668	247,178	266,952	288,308
<b>2.0</b>	<b>Revenue</b>										
2.1	Electricity to the National Grid		39,400	39,400	43,439	47,783	52,561	57,817	63,599	69,959	76,955
2.2	Revenue from New Enterprises		5,000	5,000	5,500	6,050	6,655	7,321	8,053	8,858	9,744
2.3	Revenue for Users (Productively)		1,800	1,800	1,980	2,178	2,396	2,635	2,899	3,189	3,508
	Sub-Total (Revenue)		46,290	46,290	50,919	56,011	61,612	67,773	74,551	82,006	90,206
	<b>Net Revenue</b>	<b>(2,930,955)</b>		<b>-9090</b>	<b>-140,763</b>	<b>-139,299</b>	<b>-150,303</b>	<b>-161,095</b>	<b>-172,627</b>	<b>-184,926</b>	<b>-198,206</b>

NPV (DR 10%)                      **306,133**

NPV (DR 18%)                      **20,073**

IRR                                      **20.18**

## REFERENCES

- ADB (2013): Cost-Benefit Analysis for Development (Practical Guide), Asian Development Bank
- CEO (1973) Small Hydropower Handbook, the Colorado Energy Office
- Energy Utilization Management Bureau (2009): Manuals and Guidelines for Micro-hydropower Development in Rural Electrification, JICA
- ISMAP (2002) Tanzania- Mini Hydro Development Case Studies on Malagarasi, Muhuwesi and Kikuletwa Rivers, Energy and Water, World Bank
- Kato T. Kabaka<sup>1</sup>) and Florence Gwang'ombe: Challenges in Small Hydropower Development in Tanzania: Rural Electrification Perspective, TANESCO,
- Mini-Grid Support Programme (2003): Preliminary Feasibility Studies of Prospective Micro-hydro Projects, Alternative Energy Promotion Centre, Kathmandu, Nepal
- PushiparChitrakar (2010): Micro Hydro Power Design Aids, SHPP/GIZ
- TANESCO (2006) Selected Mini-Hydropower Potential Sites in Tanzania, Research and Investigations Section
- TANESCO (2006): Reconnaissance Study for Mini-hydropower Potential Sites Iringa Region, MEM
- TaTEDO (2007) 70 kW Micro hydroelectric Plant in Zege Village (Business Plan), TTD Resource Centre, Dar es Salaam
- UNEP (2006): Micro Hydro Power for Productive use in Eastern Africa, ITDG, TaTEDO, AfDB,