Malawi Aquatic Weeds Management at Hydro Power Plants

William Willoughby Liabunya¹
ESCOM LTD, Generation Business Unit, P.O. Box 2047, BLANTYRE, MALAWI.
E-mail: wliabunya@escommw.com

ABSTRACT

The Electricity Supply Corporation of Malawi Ltd (ESCOM LTD) has all its major Hydro Power stations along the Shire River which is the biggest river in Malawi. It is the outlet of Lake Malawi which is the third largest lake in Africa. In recent years there has been a dramatic increase in the onset of floating aquatic weeds on the river so much so that electricity generation has been greatly affected especially during the rainy seasons. In 2005 ESCOM launched a project at Liwonde Barrage to manage the Aquatic Weeds at Liwonde and the project was called Liwonde Aquatic Weeds Management.

This paper looks at the project set up and its impact on the electricity generation during the time the project has been in existence.

1 INTRODUCTION

Malawi is a land locked country in the South Eastern part of Africa. It borders with Mozambique in the east and south, Zambia in the west and Tanzania in the North and eastern side. Lake Malawi which is the third largest lake in Africa constitutes the largest border line between Malawi and Tanzania and partly with Mozambique. Lake Malawi is a fresh water body that lies in the Great Rift Valley and its outlet the Shire River which is the biggest river in Malawi continues to run in the Rift Valley until it connect into Zambezi River. The Lake Malawi and the Shire River are the major sources of water for hydro power generation in Malawi and supplies domestic water for the commercial city of Blantyre and for irrigation at the sugar plantations in the lower Shire and at the Lake among others. The Shire River drops a total of 380meters in a distance of 184kilometers in what is known as the Murchison Falls.

Electricity generation in Malawi is almost wholly obtained from hydro and is generated and supplied by the Electricity Supply Corporation of Malawi (ESCOM) Ltd. It is a wholly government utility and is responsible for generation, transmission and distribution of power in the country and in certain cases to cities across the borders in Mozambique and Zambia. The three major power stations in the country lie in the middle Shire River making use of the falls in the Murchison Falls. These hydro electric schemes are of run off the river type. The first Power station was the Nkula Falls A which was commissioned in 1966 and has 3 units each rated at 8MW. As part of the Hydro electric scheme a barrage was constructed at Liwonde and was commissioned in 1965 to control and regulate the flow of the Shire River. The second scheme to be constructed and commissioned was the Tedzani I&II which has 4 generators and was commissioned in 1972 (two units) and 1977 (two units also) each rated at 10MW. Nkula B Power station was the third scheme which has 5 units rated at 20MW each and were commissioned in 1981 (3 units), 1986 (1 unit) and 1992 (1 Unit). The forth scheme was constructed at Tedzani III with two units each rated at 26.35MW and was commissioned in 1995. The Last one is Kapichira Falls which has two units each rated at 32.4 MW and was commissioned in 2000 (as phase 1 of the Project). The second phase is yet to be constructed with another two sets and ESCOM Ltd with assistance of the Malawi Government is looking for funding.
The power stations used to operate without any major environmental problems until in the late 1990s when there had been an increase of floating aquatic weeds and debris in addition to silt deposition at the intake ponds.

2 THE AQUATIC WEEDS

Since the early days of hydrogenation in Malawi there had never been as big a problem of aquatic weeds at the Power Stations intakes as the case has been of late. Due to population growth and the pressures associated with it most of the hills have been laid bare in most of the river catchments areas of the rivers. People have been opening up gardens to compensate for low yields and in addition the use of firewood and charcoal both as a household energy source and for business has depleted our forests. This has loosened up our soil covers and making the soils being prone to erosion. During the rains therefore a lot of soils are eroded into the river tributaries and later to the shire river itself which is the biggest river. Since these soils that are being eroded are full of soil nutrients and in addition to this almost all farmers nowadays use artificial fertilizers which are together eroded together with the top soils.

When these soils and their nutrients are deposited into the river they provide necessary nutrients to the aquatic plants and they then grow and multiply. The occurrence of these aquatic weeds is very prevalent in the rainy season in the months of December to March or April. Masses of floating weeds are seen coming from up stream of The Shire River and are caught at the barrage where they form a mat like carpet covering the water surface. The problem is prevalent in the rainy season because this time around the water levels of...
the river have risen thereby causing the weeds that had grown on the banks during the dry season to float off. As the aquatic weeds float, the river currents then cut them off from the main firm grounds of the river banks and they are carried away down stream.

In recent years exceptionally big islands of aquatic weeds have been seen floating coming towards the barrage and then accumulate upstream of the barrage. The islands had at times covered all the water surfaces because they had been stopped at the barrage so as to achieve controlled trash floatation to the power stations. The weeds among others comprise of water hyacinth (eichhornia crassipes), locally known as Namasupuni, Red water fern (Salvinia molesta), water lettuce (Pistia stratiotes) and elephant grass.

To clear the weeds accumulating at the barrage operators used to open the barrage gates and flush the weeds down stream and a day or two later the weeds would reach the power stations at Nkula Falls, Tedzani Falls and Kapichira Falls. The weeds have been a source of serious operation problems at the Power stations and have at instances caused damage at the power stations. At the intakes the weeds would choke the intake screens more especially those weeds that have submerged. The screens are cleaned by trash rakes but at certain instances the trash rakes have been overcome by the inflow of the weeds so much so that the whole power station could be shut down to allow for the weeds to be cleared out at the intake screens.

3 LIWONDE BARRAGE AS A TRASH BARRIER

The Liwonde Barrage was constructed as part of the Nkula A Hydroelectric scheme and was commissioned in 1965. It is a concrete structure 156m long with 14 radial steel gates and it carries a 6.6m carriageway providing a bridge across the river. The barrage was constructed to control the water flow down the Shire River so as to ensure adequate water supply to the power station down stream even in situations where the water levels at the Lake Malawi would be fluctuating.

As the weeds accumulate at the upstream of the barrage a temporary relief is provided to the power stations for them to generate electricity. However there comes a point that you cannot hold the weeds any longer at the barrage and they therefore have to be flushed out. When the weeds are flushed out there has been extensive damage to the power station structures and ESCOM has been losing millions of Dollars to carry out such repairs. In addition to the damages ESCOM is forced to shut down the generating stations bringing in inadequate generation capacity and therefore load shedding exercises take place. ESCOM therefore looses revenue and in the process the national economy is affected since production of the industries is also affected. It is estimated that ESCOM looses about 27,000USD in a day of load shedding and the industry’s shutdown loss is 10times more.

4 DAMAGE CAUSED BY AQUATIC WEEDS AT THE HYDROPOWER STATIONS

As has been noted aquatic weeds have been of major concern to the operations at the power stations. Apart from the usual plant shut downs when the weeds have accumulated at the intake screens there has been substantial damage that has been caused to civil and hydraulic structures at the intakes. In December 2001 the intake structures at Tedzani I&II Power station were completely demolished due to weeds that had accumulated at the intake screens so much so that adequate
water could not pass through. This created a vacuum in the tunnel and as a result collapsed the intake screens since the machines were running.

The Tedzani Falls intake was provided with a course screen that runs across the pond to catch and divert any oncoming trash and weeds before they reach the fine screens. These screens had suffered extensive damage at its base foundations and cross structures that some screens got washed away during the 2001 season and had to be replaced with new fabricated ones. The damaged structures both at the fine screens and at the coarse screens require over 12mUSD for them to be repaired and have the station back in operation. Further to this there had also been so many instances in which screens at the intake at Nkula had been dislodged due to trash and necessitated divers to go into the water and fix the screens.

Plate 3: Damaged coarse screens (Tedzani Falls)

5 MITIGATING MEASURES TO MINIMIZE IMPACT

Considering the big loses that were being incurred by ESCOM and other stakeholders due to the weeds problems, ESCOM had been putting effort to put in place measured to mitigate these effect and where possible to do away with the weeds all together and have our intakes free of trash. Through the years since 2002 when the aquatic weeds were considered to be at the peak, a number of actions had been done.

5.1 Manual Weeds Harvesting

In January 2002 a group of men were employed to manually remove the weeds from the waters using machetes, nylon ropes and dug-out canoes. After almost a month of operation it was noted that the weeds being harvested were far much lower than that which was coming from upstream. Weeds continued to accumulate more and more upstream of the barrage as if nothing was being done to them. Flushing of the weeds continued on a daily basis and the power stations were experiencing shut-downs as if nothing was being done upstream to mitigate the weeds effects. This was therefore abandoned in late 2003.

In 2005 the same mode was also employed this time using the Malawi Defense Force soldiers that came on site and were using motorized boats, ropes and machetes.

This time around they complimented very well since ESCOM had partially deployed mechanical vegetation chopper which had no harvester as yet. Therefore the soldiers were like a harvesting mechanism of the chopped weeds by an Aquatic Vegetation Cutter.
5.2 Manual and Mechanized Harvesting

In 2003 the Malawi Government went into contract with a local shipping company that operates ships on the lake to be removing the weeds from the barrage area. This contractor was using a hired grab crane and some manual laborers as well as tipper truck and a lorry to dump the weeds to depository sites. The contractor mobilized to site in August 2003 and worked through until in February 2004 it was observed that the contractor was not delivering as expected. His rate of harvesting was still very low as compared to the weeds that were coming from upstream and this still necessitated that the weeds be flushed going back to the same problem that was to be solved. The crane broke down often and so too were the trucks. A bigger percentage of the time was spent in repairing breakdowns.

Plate 3 & 4: Mechanized Weed harvesting using Grab crane

In April 2004 the contract was terminated and ESCOM took over the operations as its own internal operation. ESCOM hired the same crane and deployed five trucks in addition to manual laborers. ESCOM was spending USD 50000 mainly for the hire of the crane and diesel fuels. This operation brought a significant improvement in reducing the weeds being flushed down stream and the operations at the hydroelectric power stations improved too. However not all aquatic weeds would be cleared from the waters. This crane was stationed right on the motorway for it to be able to access the weeds in the water. It was therefore a traffic hazard and in addition it was giving a persistent loading to the barrage when it was designed to only have passing load. This also created some fears over the load bearing capacity of the barrage at its age. Therefore ESCOM was still looking at ways of having a better and more effective and efficient means of clearing the aquatic weeds.

6 THE LIWONDE AQUATIC WEED MANAGEMENT PROJECT

The whole range of efforts to manage the weeds from the Barrage became an established project after having noted that all the small scale efforts that were being done were not bearing the results to the desired level. The Liwonde Aquatic Weed project aims at minimizing the effect of aquatic weeds to the hydroelectric power generation at the power stations and to also bring back the beauty of the Shire River at Liwonde Barrage. The Project was designed to employ mechanical means of combating the weeds and was to use an aquatic weed cutter/chopper, a mechanical harvester and a shore conveyor. A floating boom was incorporated to be laid across the river at a point it can catch any weeds that may not have been harvested by the harvester upstream or had come during the night when there was no operations. On 29th September 2004 ESCOM signed a contract with Aquarius Systems Inc. of the United States of America to supply equipment and train ESCOM staff on the operation of the equipment worth
USD799,950.00. The supply of equipment and 3 months training included 1x aquatic vegetation cutter (AVC 101), 1x mechanical weed harvester, 1x shore conveyor, 1x conveyor trailer, 1x workboat, 1x set of floating boom.

The first consignment comprised of an AVC and a workboat which arrived in April 2005. The second consignment and a final one was delivered to site on 28th June 2005. The contractor had his engineer on site that was responsible for the training, a site set up and assembly of the equipment as it arrived.

6.1 Project Operations

The project employed marine engineering staffs who are responsible for the operation and maintenance of the equipment.

The AVC was first put into operation on 6th April 2005. The AVC attacks masses of aquatic weeds and chops them into small pieces of 15mm lengths. It has two blades in the front which are both used for propulsion and at the same time are used as cutters. When it arrived all the floating masses were being attacked before reaching the barrage and since there was no harvester most of these chopped weeds were left to float down stream to the power stations. The Malawi Defense Force soldiers used to harvest some of it manually. Although the weeds were left to get to the power stations the aquatic weeds did not give many problems as such. Because of their sizes in the chopped condition, they would either easily pass through the screens or had floated off to the banks of the river before reaching the power station intakes due to their sizes.

Plate 5: The Aquatic Vegetation Cutter (AVC) in operation

The Harvester was first launched on the 5th July 2005, three months after the launch of the AVC. The harvester collects or harvests the weeds that have been chopped or cut by the AVC. It can also collect weeds that may not have been chopped. After collecting the weeds to its capacity, the harvester off loads the trash through a shore conveyor into trucks. The trucks take the trash to the depository sites that have been designated for such.
6.2 The Boom Material

The boom material that came was not the desired boom material due to breakdown in communication between the client and the contractor. Instead of a heavy duty material boom we were supplied with a light water surface trash boom with a depth of about 30cm. After it was installed across the river some 130m upstream of the barrage it was noted that aquatic weeds were just diving underneath the boom and went past to the barrage. If at all any was being caught then it was that sort of weeds that were light. If the weeds would stay longer that 5 hours without being harvested at the boom then when it begins to absorb water it gets heavier and later would sink and passes through the boom. The boom was therefore not as effective as was desired. The contractor however on the other hand said the boom material he delivered was what he had quoted and could therefore not do otherwise.

6.2.1 Boom Modification

Having noted the shortfall in the design of the boom and at having no immediate alternative for another boom the project team decided to make the best with what was already available. It was therefore decided that the boom be redesigned and modified. Materials were procured for the modification and in essence the modification design aimed to achieve increased depth of the boom and increased strength of the span length tension wire rope. Galvanized wire and rectangular metal plates were used together with aluminum wire for meshing the extension depth.

6.2.2 Depository Sites

During the project set up consultative meetings were being held with a number of stake holders. The forestry Department allowed us to deposit the aquatic weeds into their forest area where after depositing they dry off and in the ensuing year they decompose and become composite manure. It was due to this fact that after some time of operation when the villagers observed the process they began to request ESCOM to be damping the chopped weeds into their gardens for processing as composite manure. The project has therefore won support from the villagers around the operation site.
7 PERFORMANCE ASSESSMENT

The project has been in full operation for one year and four months as of August 2006. The real test of its performance was in the past rainy season in which Malawi received a very high rainfall especially in the Lake Malawi and upper Shire River catchments areas. In March there were floods in the Mangochi district which is a district at the southern tip of Lake Malawi. These floods brought with them weeds and trash that were even not all aquatic. As the weeds came towards the Liwonde barrage they were being attacked with the AVC and later harvested with the mechanical harvester. On one or two occasions while at night there were a heavy accumulation of such weeds on the boom and as morning came there was a larger area covered but being held by the boom. However the loading was too much so much so that as we started to chop and harvest the weeds the boom snapped. All the weeds that were being held at the boom therefore was discharged from the boom and later went past the barrages to the power stations but little reached the power station that the impact was not felt. This prompted us to increase the size of the anchoring wire rope of the boom and it was replaced with a bigger diameter wire rope of 14mm instead of the 12mm which was there before. Since then there had not been such an incident again.

In the past rainy season during which the project was in full operation there had been virtually no power plant shut down due to trash. In the past years there had been so many frequent power generating machines shutdown due to aquatic weeds chocking the intake screens. In 2005 alone Nkula Power Station lost 349.19 hours which translates to some customers being load shaded and thereby inconveniencing them while at the same time ESCOM losing some revenue and the Malawi economy as a whole being affected. This trend was the norm in each and every station and at the end of the day ESCOM’s performance was poorly rated by the customers and stakeholders.

The project so far has tremendously improved the performance of ESCOM and its image has tremendously been improved and is very successful despite some launch problems.

8 PROBLEMS AND WAY FORWARD

After a year of Operation as a project team we sat down and analyzed some bottlenecks that we had experienced in the project. These problems were overcome in one way or the other but there is need to come up with lasting solutions.

1. The Boom material: As has already been highlighted above there is needed to replace the boom with a proper tough boom material which is designed to catch heavy loads and at a much bigger depth as opposed to the current boom. Plans have already been put in place to procure the right boom.

2. The harvester size has been another area of concern. The rate at which the AVC chops the weeds is well about 3 times that of the harvester harvesting the same. This has left the operational staff to be under strain in order to overcome the limitation of the size of the harvester. In this regard an additional harvester is planned for procurement

3. Transportation to depository site has been a problem because we have been using the normal conventional Lories instead of tippers. Offloading has been time consuming and has ended up using a lot of laborers. In this regard tipper trucks have been planned to replace the conventional Lorries currently being used.

9 SOCIAL BENEFITS OF THE PROJECT

The project has provided some social benefits to the society around the project are as here below outlined:

1. Job Opportunities

Since the project started a lot of people in the area have benefited a lot to have found some job opportunities. At first it was only local unskilled laborers but slowly the project has grown. At the moment there is now a marine engineer on site and other marine technicians.
2. **Farm Manure**

The depository sites were at first being difficult to find since people were refusing to grant land for the same. They were always being afraid that the water hyacinth would grow in their fields. Our first depository was therefore in a forest. However after a short observation the village farmers observed that the weeds once deposited they began to decompose. Trials in maize fields showed tremendous improvement of fertility enrichment. From this time on the villagers were actually requesting ESCOM team to be depositing the weeds into their fields. In the urban dwellers have preferred to use these organic manure in the home grass gardens because they are odorless as opposed to tobacco stems manure.

3. **Briquettes Manufacture**

The Project provides opportunities for setting up an industry for manufacture of briquettes for heating and energy. This although has not been explored yet provides an avenue through which forests can be preserved since the population in Malawi especially in the urban areas depends on charcoal for their heating energy requirements.

**10 CONCLUSIONS**

The Liwonde aquatic weed management problem has successfully enabled ESCOM operate her hydro power generating machines in an almost debris free environment. This has achieved improved efficiency of power generation at the hydro-power stations. The image of ESCOM to her customers and her stakeholders has improved by the end of the day.

It is a fact however that the problem being addressed is an environmental problem but is being tackled mechanically. It therefore must be appreciated that you cannot solve an environmental problem by other means other than environmental solutions. The thing that is desired to achieve a debris free operating environment is to completely do away with the weeds permanently from the source and not to be guarding against them on the waters. While we earnestly work hard in this project and seek avenues to perfect the shortfalls in this project, all heads be it in government, NGOs, the academician and ESCOM herself must put heads together to find a lasting solution to aquatic weeds problem.

**REFERENCES**