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Research article

Impact of Aquatic Weeds in the Shire River on Generation of Electricity in Malawi: A Case of Nkula Falls Hydro-Electric Power Station in Mwanza District, Southern Malawi

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Abstract

Electricity plays a key role in the economic development and food security in Malawi such as agro-processing. However, the country is currently experiencing inadequate electricity production resulting in frequent blackouts and load shedding. The Electricity Supply Corporation of Malawi (ESCOM) has attributed these problems to interference by the aquatic weeds in the Shire River where the power plants are built. However, the menace caused by aquatic weeds to the generation of hydro electricity in Malawi appears to be only one among many challenges which ESCOM is currently facing. To validate this assertion, this study analysed the extent to which aquatic weeds have contributed to the problem of hydro-electricity production in Malawi in comparison to other likely problems.

Daily electricity generation data from 2007 to 2009 were collected at Nkula Falls Hydro-Electricity Power Station in Mwanza District, Malawi. Randomly selected key informants were also interviewed to obtain supporting information on causes of the current problems. Effect of aquatic weeds on production of hydro electricity was not highly significant (P>0.05) compared to "other" reasons which included inefficient machine performance and frequent shut down of machines during servicing. Variations in daily electricity generation were also observed among the machines running uninterrupted for 24 hours, indicating problems with machines. It is concluded that although aquatic weeds impede power generation which was also widely reported in the interviews and personal observations such as by choking turbines, problems of less electricity production in Malawi are many such as management and obsolete machines. Based on these findings, the study recommends that while efforts of removing the weeds from the Shire River are on-going, ESCOM should reconsider acquiring new and more efficient machines.

Keywords: Aquatic weeds, Electricity generation, Shire River

Introduction

Electricity is pivotal to economic development in Malawi. As a country that relies predominantly on agriculture, the agro-processing industry heavily depends on electricity, for example in the processing of rice, maize, tea and other crops. More than 95% of electricity in Malawi is produced from Hydro Electricity Plants found in the Shire River in southern Malawi. However, Malawi has recently been facing intermittent electricity blackouts. The Electricity Supply Corporation of Malawi (ESCOM), which provides about 98% of the electricity in the country (Millennium Challenge Corporation, 2010), is facing a great challenge to meet the demand for power. It is reported that in 2005 alone, Nkula Falls Power Station lost about 349.19 hours of electricity generation resulting in load shedding and consequently loss of revenue for ESCOM (Liabunya, 2007). It is estimated that annually, Malawi loses 215.6 million dollars due to the power outages (Millennium Challenge Account Malawi, 2012). In fact, Malawi's power outages are the highest in Africa (World Bank, 2012) and only 8% of the population in Malawi has access to electricity (Mhango, 2012). The country is one of the least electrified in the SADC region, with an average per capita consumption of 111KWh per annum, rated among the lowest in the world (Malawi Government, 2009).

ESCOM has, however, attributed the problem of persistent power outages to the weeds in the Shire River (Figure 1) where Nkula Hydro-Electricity Power Station is built. Since late 1990s, aquatic weeds which have not caused any environmental concern in the Shire River have found their way into the power generation plant at Nkula Falls HEP (Liabunya, 2007).

Figure 1: A combination of several aquatic weed species – Water hyacinth, reeds, water lettuce and others at the Nkula Falls Intake Dam (Photo: Maureen K. Mzuza)

Increase in the aquatic weeds has resulted in an increase in floating aquatic weeds and debris in addition to siltation at the intake ponds (Figure 2).

Figure 2: The Water intake dam at Nkula Falls on the Shire River (left); heavy siltation (right)

The Aquatic weeds have caused extensive damage to ESCOM's hydroelectric generation machines. With a perception that factors other than the aquatic weeds could be at play, the major objective of this study was to analyse and document the effects of aquatic weeds on the generation of hydro-electricity at Nkula Falls Hydro Electric Power Station.

Materials and Methods

A three-year daily electricity generation data between 2007 and 2009 was sourced from the power generation house at Nkula Falls Hydro Electricity Power Station in Mwanza district of southern Malawi. Nkula Falls Hydro-Electricity Power Station is the first in a series of HEPs from Liwonde Barrage, about 80kms upstream on the Shire River where most aquatic weeds are trapped and collected. The case study of the problems of aquatic weeds on production of electricity at Nkula Falls HEP Station followed a conceptual framework model (Figure 3) modified from Chapalapata (2009) and Liabunya (2006).

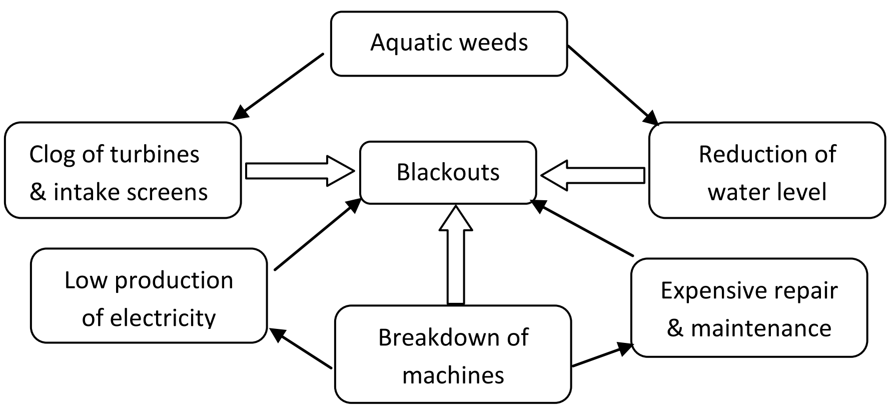

Figure 3: Theoretical model (modified from Chapalapata, 2005 and Liabunya, 2007)

The conceptualization is that blackouts are due to the fact that aquatic weeds choke the turbines but also cause reduction in water levels in the Shire River hence less water available to drive the turbines. In some extreme situations, aquatic weeds damage the machines resulting in shut-down during repairs hence low production of electricity as not all the machines are operational. A structured questionnaire was also administered to randomly selected key informants to provide a narrative background to the current problems.

Statistical data analysis

Data were entered into the computer Microsoft Excel spread sheet, then analysed using SPSS for Windows Version 15.0. Independent Sample t-Tests were computed to compare means for power generation loss caused by trash from aquatic weeds and other factors.

Results and Discussion

Results from data on energy loss in megawatts per hour (MWhr) from July 2007 to June 2009 are presented in Figure 4.

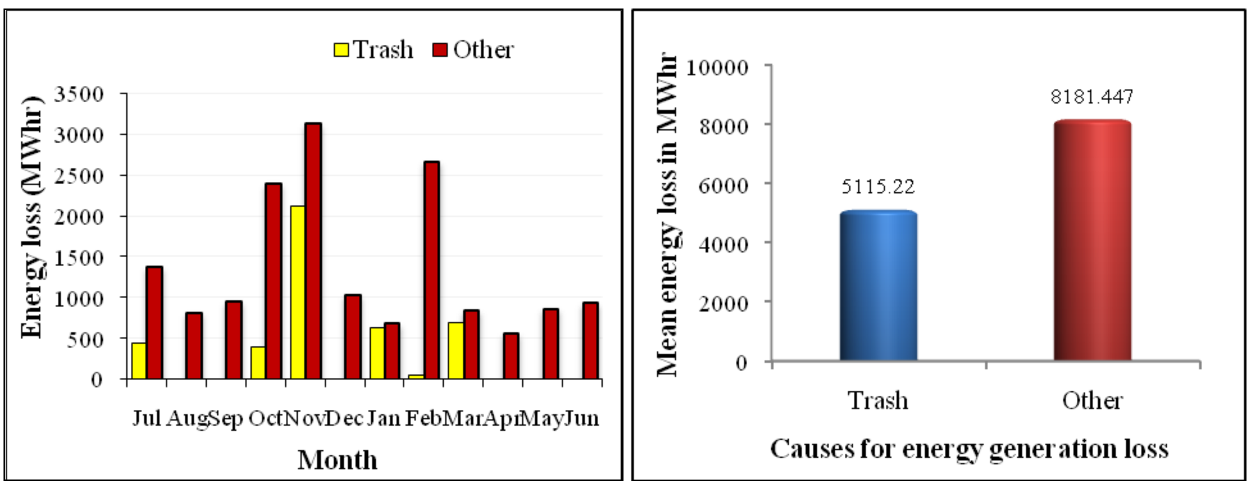

Figure 4: Energy generation losses (MWhr) due to trash and other causes for Nkula Falls A and B Hydro-Electricity Power Station between July 2007 and June 2008 (left) and summary (right) (Stdev ±721.37 trash, ±2115.99 others)

This suggests that energy generation losses that were incurred by ESCOM due to removal of aquatic weeds trash at the intake dam were far much lower compared to losses due to other problems that affected power generation. Highly significant differences ($P<0.05$) confirmed the observation that more energy was lost as a result of other factors such as repairs, silt removal, turbine breakages, temporary pausing of machines to reduce wear and tear other than effect of aquatic weeds. It was further shown that energy production loss due to trash from aquatic weeds did not even amount to half of the period thus 6 months in a year as highest energy losses were due to other reasons/causes other than trash (434.8, 1381; 397.6, 2402.7; 2121.2, 3136.5; 620.38, 6838, 54.6, 2672 and 695.8, 845.9 MWhr for trash and other reasons respectively). Some of the reasons for problems in electricity generation expressed by the engineers at the Nkula HEP Station included: removal of silt from the intake dam, low oil level in the turbine bearing basin, turbine bearing basin leaking, repairing of main oil pump, removing pump, replacing the repaired oil pump, repairing of machines such as greasing, runner repairs, brush gear sparking, breakage of pond inlet screens and clogging of the screens, damage of the turbines and general breakdown of the machines. Other minor reasons included power disruption by vandalism of ESCOM transformers and animals being short-circuited on power lines.

Summarised electricity generation data from January to June 2009 (Figure 5) supports the general perception and observations that aquatic weeds are a big menace especially during the rainy season (January, February and March) when the country receives adequate rains. Except for the situation in 2009 (Figure 5) where effect of aquatic weed trash was observed in rainy season, figure 4 shows that aquatic weed accumulation at the intake dam was not only in rainy season.

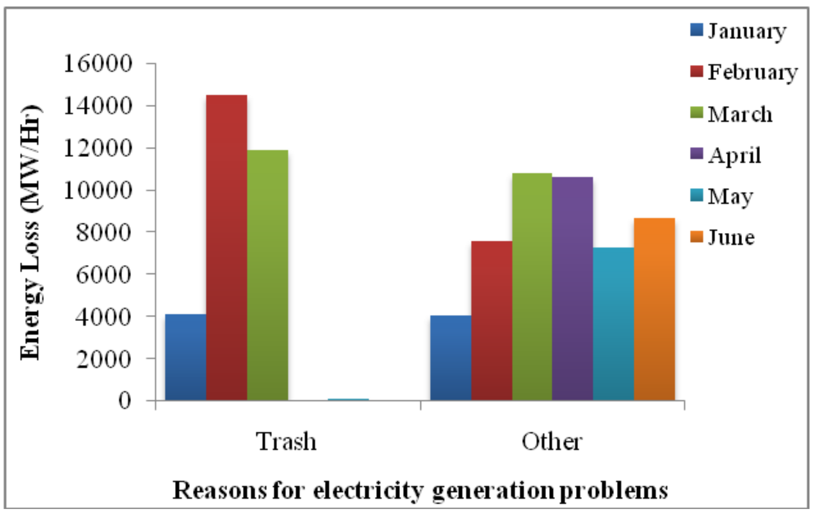

Figure 5: Energy loss (MWhr) of energy loss due to trash and other causes for Nkula Falls HEP from January to June 2009.

However, it is clear that 'other reasons' were to a greater extent responsible for power generation problems than those arising from removing of trash at the intake dam or clogging of turbines by aquatic weeds. Differences in daily machine performance were also observed as power production varied from 69,047,000 to 40,056,900 MW (59,722,728±6,714,164) while running for 24hours (Figure 6). Thus, even with an exception of the 2 days when there was no power production during repairing of leaking in the turbine basin (Figure 6), power production fluctuation continued. Most ESCOM employees interviewed at the site indicated that aquatic weeds mainly water hyacinth (*Eichhornia crassipes*), had been seen in the Shire River since the 1990s. One of the longest serving employees who started working with ESCOM in 1979 also reported to have seen water hyacinth in the Shire River in the 1990s.

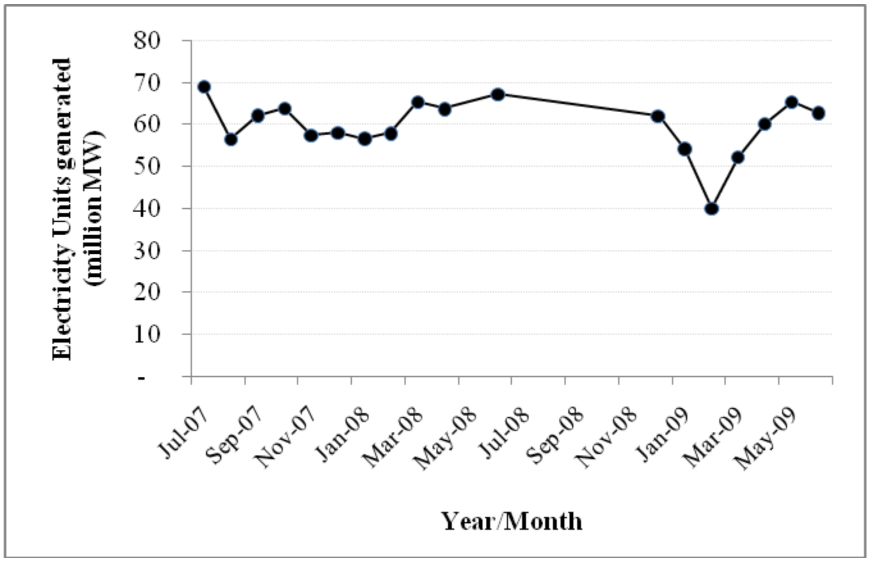

Figure 6: Amount of units (MWhr) generated per day between July 2007 and May 2009 at Nkula Falls HEP.

There was a general agreement by the interviewees that aquatic weeds in the Shire River play a role in disrupting electricity generation at the Nkula Power Station sighting breakage of pond inlet screens, clogging of the screens and damage of the turbines.

It could be most likely that Chapalapata (2009) who reported that floating aquatic weeds started becoming a problem in the Shire River and finding their way into the intake dam at Nkula Falls from the 1990s sought information from the same source as the current study. It is reported that aquatic weeds started infesting massively African freshwater bodies during the early 1950s and rapidly spread in many countries (Mitchell et al., 1990). In fact, ESCOM power stations operated without any major environmental problems until 1990s when there was an increase of floating aquatic weeds and debris in addition to silt deposition at the intake ponds (Mhango, 2012; Liabunya, 2007). In recent years, there has been a dramatic increase in the onset of floating aquatic weeds on the river so much that electricity generation has been greatly affected especially during the rainy seasons (Liabunya, 2007).

The impact of aquatic weeds on generation of hydro-electricity has been documented by several reporters (Mhango, 2012; Liabunya, 2007; Lancar and Krake, 2002). Damaging effects include pumps and turbines in super thermal power stations and hydroelectric power stations influencing electric production which consequently increases the cost of maintaining the power stations. For example, in December 2001, the intake structures at Tedzani Falls I & II (HEPs downstream after Nkula Falls HEP) were blocked by accumulated weeds and repairing the screens cost more than US$12 million (Liabunya, 2007). In 2009, weed infestation caused damage to the intake screens of the biggest power station resulting in loss of 124MW (Malawi Government, 2009). It was also reported that though staff in ESCOM's generation business unit have long experience of operating hydropower plants, problems in financing have hampered reduction in the risks to turbines and generators caused by trash and sediment (Millennium Challenge Account, 2009).

Despite the reported significant impact brought about by aquatic weeds in the Shire River, results from this study showed that generation of less power was not entirely or directly due to the effect of aquatic weeds but rather other reasons. For example, losses in electricity generation due to the removal of weeds at the intake dam were much less than those between July 2007 and June 2008. Engineers spent more time fixing problems such as low oil level in the turbine bearing basin, turbine bearing basin leaking, repairing and replacing main oil pump/removing pump. It was reported that frequent equipment breakdown contributed to losses in power generation in Malawi (World Bank, 2012). A senior ESCOM employee was quoted as saying *"during the Easter Holiday, ESCOM repairs equipment from the head-ponds. We lose revenue once we halt operations but such repair works on Easter Holidays are crucial to us as ESCOM. Just this year, we first closed Tedzani Power Station on Friday and Sunday and then Nkula Power Station later to ensure that most parts still have power"* (Mhango, 2012). It is suffice to note that by 2007, ESCOM reported that the aquatic weed problem had been put under control through a program of vegetation cutting and harvesting, combined with a system to trap floating weeds (Liabunya, 2007) suggesting that the maintenance of equipment may not have been as a result of damage by aquatic weeds.

The observation that the effect of trash weeds was also recorded in July and October, months when nearly all parts in Malawi do not receive rains - dry season, is an indication that problems of aquatic weeds occur not only during rainy season as is reported by ESCOM. This is in agreement with Liabunya (2007) that during the 2007 rainy season (January to March or April) there were virtually no plant shutdowns due to trash aquatic weeds. Probably this could be directly related to how much rain was received from the river's catchment area. The high power production losses in November due to both trash and other reasons could be attributed to the fact that the southern region of Malawi receives rains much earlier than the central and northern regions of the country. It can be suggested, therefore, that even without the effect of the aquatic weeds, significant losses in electricity generation of HEP machines would still be observed. This means, therefore, that there should be other notable reasons for the reduced electricity generation other than effect of aquatic weeds (trash) which is always believed to be the major cause. Also, the report that rising water levels dislodge roots of weeds that had grown on the river banks during the dry season, causing them to float into the water (Liabunya, 2007) was clearly observed in this study where power generation loss was recorded even in the dry months of October and July. This indicates that problems of aquatic weeds occur throughout the year and not in the rainy season only. A report by Malawi Government (2009) indicated that load shedding has become rampant following the loss of 40MW generation capacity in 2001 when one of the power stations was flooded. In 2003, another 100MW was lost as a result of flooding (Malawi Government, 2009) Though the power station was restored within 4 months, it is reported that the efficiency of the plant has been negatively affected, and the life span of some major components has been reduced drastically (Malawi Government, 2009). The Malawi Government Report (2009) further puts it that under-investment in ESCOM has resulted in acute shortages of generation capacities and deterioration in the quality of supply such that the system is operating on negative generation reserve capacity. It is reported in the Millennium Challenge Account (2009) that ESCOM has had inadequate financial resources to ensure proper maintenance of generation and transmission assets resulting into problems of poor generation availability and reliability. These have also led to low levels of investment in transmission and distribution, leading to overloaded equipment, low supply reliability and poor quality supply.

ESCOM equipment is costly hence any type of damage is significant. That is why scenarios of animals such as monkeys falling and being electrocuted over electric wires cannot be under estimated. Vandalism of ESCOM equipment also continues to be on the rise resulting in the company spending a lot of money maintaining its equipment (http://escom.mw/news-1.php).

The study also observed differences in daily machine performance as power production varied from 69,047,000 to 40,056,900 MW (59,722,728±6,714,164) while running for 24hours. For example, in June 2009, power production fluctuated even during days when machines were running for 24 hours in a day. This suggests that even in the absence of any interference like that of aquatic weeds, production of electricity would still be impaired probably due to inefficiency of the machines.

Conclusion

It is apparent from the results that not all the problems causing electricity generation losses at Nkula Falls HEP are related or caused by aquatic weeds. Rather, results show that other reasons play a key role chiefly poor efficiency of the equipment and frequent repairs. Problems of load shedding are generally due to the fact that electricity generated by ESCOM is by far below from meeting the demand. It is apparent therefore that issues of management are a greater challenge.

Recommendations

Based on results from this study, it is recommended that while efforts of removing the aquatic weeds in the Shire River are on-going, ESCOM should reconsider acquiring new and more efficient machines. On the side, Water hyacinth weeds which ESCOM is struggling to remove at the Liwonde Barrage has many important uses in other countries such as cheap fertilizer and production of biogas. With proper programmes, Malawi can benefit greatly from its use hence turning it from a menace to an important natural resource.

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