PUMP STATIONS: NON-REVENUE POWER IN WATER.

27TH IEK INTERNATIONAL CONFERENCE PAPER

NOVEMBER 2020

DICK NDIEWO

DITECH ENGINEERING LIMITED

ndiewo@ditech.co.ke

KEY WORDS: EFFICIENCY, LIFE CYCLE COST, ENERGY AUDIT

ABSTRACT

No water utility operates a self-sustaining business in Africa. This is due to many factors like high non-revenue water, incompetence, high energy bills and poor choice of equipment. While Non-Revenue Water Projects have received a lot of attention and rightly so, energy audit has not. The life cycle cost of a pump consists of 20% and 80% capital and operational costs, respectively. Operational and maintenance costs can be divided as staff, parts, and energy. In rational environment little can be done to reduce staff and parts costs, but energy can be managed by installing high efficiency equipment. Unfortunately, Africa happens to have the highest energy charges in the world making the situation worse.

Towards this end scientists and engineers have come up with many solutions including solar power plants, power factor correction capacitors, better pump designs, soft starters, variable frequency drives, permanent magnet motors, IEE motor classification. These are aimed at delivering more reliable, cost effective, highly efficient, and longer lasting equipment.

Despite the progress practitioners, to date grapple with challenges such as diversity of the field, high energy costs, outdated technology, poor understanding of equipment, inexperience, language barriers, corruption, and poor knowledge of Contract Management.

This paper explores the various scenarios that can be employed to address the energy challenge in the water and sewage pumping industry.

INTRODUCTION.

United Nations member states adopted Sustainable Development goals in 2015 to end poverty, protect the planet and ensure peace and prosperity for all by 2030. Key among them is goal number 3, 6 and 9 that are all related to water. No. 6 specifically requires all governments, private sector, civil society to work together to achieve safe and affordable drinking water for all.

In May 2018, the Government of Kenya announced plans that would see 9 million people have access to clean piped water by 2022. This plan would cost 1.2 Trillion to execute. Achieving universal and equitable access to safe and affordable drinking water by 2030 according to WASREB would cost 1.3 Trillion and Kenya Government would only afford 44% of this amount.

The SDG Kenya forum in its Second Progress Report on Implementation of SDGs in Kenya in 2019, listed the following challenges

a. Finances
b. Kenya has shortage of water resources
c. In urban areas water is unaccounted for through leaks and illegal connections. (Commonly known as Non-Revenue Water)

Many water supply schemes involving some pumping of water. And water utilities continue to grapple with managing cost of providing and maintaining clean water supply. Many projects have been formulated to arrest the non-revenue water challenge, but none is ever conceptualised to address the huge energy bills. As will be seen from the selected tabulated results the monetary losses due to low efficiency sometimes is as high as 40-50% of the recoverable non-revenue water losses hence the need to place more emphasis on addressing the low efficiencies and other pump station related problems.

Power Consumption in Pump Stations

For many water and sewerage supply utilities, especially the ones that require pumping to deliver water, all the revenue is used for paying electricity bills. The reasons for this situation are varied but key among them are non-revenue water, high electricity bills, poorly installed and maintained equipment, and poor management. Non-Revenue Water and high-power bills constitute over 90% to the problem. Non-revenue water has been extensively researched and many projects initiated to solve the problem or mitigate the consequences. In most cases as soon as the non-revenue project team leaves site, it takes less than 6 months for the status to go back to pre-project state. This may be due to corruption and incompetence.

For high electricity bills, utilities experience the challenge but lack the know how to deal with it. It is generally assumed the wastage because of equipment inefficiency and power leakages are insignificant compared to the non-revenue water hence the emphasis is always laid on non-revenue water projects. In some cases, electricity supply utilities have been accused of malpractices. Some of the reasons for high power bills are listed and discussed briefly below.

Poor Designs

Most designers of pumping equipment do not take into consideration important factors such as Net Positive Suction Head available and required, Starting system and protection, cable sizes, fluid properties, system and pump curves, water hammer, running hours, energy sources and bills, operating spaces, controls, operation and maintenance capacities, capital and operation costs.

Operation

Use of more equipment to satisfy immediate demands after an outage causes high maximum KVA demand charges which cannot be justified with the extra revenue received.

Maintenance

Because utilities lack money, they cannot maintain their equipment well. Sadly, the resulting poor state results in higher energy consumption and thus higher bills.

METHODOLOGY

This paper compares the monetised value of losses resulting from the extremely low efficiencies obtaining in the pumping stations and the non-revenue water monetary losses. Bearing in mind that it is generally agreed that the best of non-revenue water project can never reduce the losses to below 15%, this has been used as the reference point in the tabulations. The pumping equipment maximum efficiency as well has been capped at 75% but a few exceptional cases have been allowed based on reality.

FINDINGS AND RESULTS

Selected Pump Station Test Results and Analysis

Pump Station	Country	Efficiency (%)	Power Factor	% of Recoverable NRW
Kamenga	Kenya	43	0.85	49
Utonga	Kenya	27	0.85	28
Teyateyaneng	Lesotho	13	0.64	700
Old High Lift	Lesotho	85	0.61	7
Hlotse 1	Lesotho	75	0.58	13
Hlotse 3	Lesotho	55	0.87	25
Peka 1	Lesotho	59	0.59	25
Peka 2	Lesotho	41	0.84	46
Mafeteng 1	Lesotho	81	0.63	8
Mafeteng 2	Lesotho	78	0.63	8
Kabete Uthiru	Kenya	45	0.88	24
Kabete Uthiru	Kenya	49	0.85	24

Kabete Uthiru	Kenya	42	0.85	32
Kabete Dagoretti	Kenya	51	0.85	30
Kabete Dagoretti	Kenya	51	0.89	32
Kabete Dagoretti	Kenya	47	0.89	45
Kabete Dagoretti	Kenya	58	0.87	27

Table 1: Table showing actual tested figures, extrapolated life cycle power cost and a comparison with non-revenue water losses.

DISCUSSION/IMPLICATIONS

We have assumed that pump stations utilise the power utility company off peak regime 100%. This is never the case either due to demand curves, size of reservoirs/tanks and lack of knowledge of off-peak pumping. The implication is that the losses are higher than the figures presented in the tables above.

Although further financial implications would have to be considered, the design team should consider increasing the tanks/reservoirs sizes to accommodate full off-peak pumping where possible.

It is worth noting that at 50% efficiency the energy bill increases as a % of NRW doubles. Obviously, no pump should be allowed to operate at less than the maximum efficiency or best duty point.

It is obvious from the foregoing that a well-designed pump station can give utilities assured long lasting returns as opposed to any project done later as some of them the benefits are not long lasting.

Since water prices is controlled the government, water utilities must propose to the governments a pricing regime that reflect the actual cost of production or find a way of asking the government to provide subsidies to the cost of production to make water available to many. This should be done in practical ways that allows the utilities to access the subsidy. Cost of production should also include an amount for maintenance and future development.

In case pumping using renewable energy is chosen, analysis should be done and incorporate bigger reservoirs to accommodate pumping when the renewable energy is available. To this end Siaya Bondo Water and Sanitation Company is implementing ambitious programs to utilise hydro turbine pumping. If this technology is successfully implemented, it would go a long way in making energy costs in many other utilities manageable.

Energy Management Regulations of 2012 stipulated that energy audits be made compulsory. These were to be done after every 3 years. This if implemented strictly would go along way in addressing the challenges bedevilling the sector today. Results of investment grade energy audit analysis can be used to effectively decide when to dispose an equipment.

Finally, the Kenya water design manual although produced just in year 2005 needs serious review to reinforce and stress the emerging trends and technologies. Whereas good guidelines were given in the present document, not much emphasis was placed on energy efficiency. The manual does not give recommendations on new technologies like soft starters and variable speed drives. It is worth noting that the Water Policy and Advocacy committee of Institute of Engineers of Kenya has identified this as an area in need of review.

CONCLUSION/RECOMMENDATIONS

a. Include energy audit as a component of all non-revenue water projects and enforce energy management regulations of 2012.
b. Life cycle cost analysis to be made compulsory part of design presentation.
c. Include a penalty for reduction of efficiency of pumping equipment. Along with this the Institution and Government can train engineers on tender document preparation and evaluation with emphasis on equipment selection. The Government can also give incentives to water utilities that operate efficient equipment and also encourage them to enrol for carbon credit facility (Clean Development Mechanism) which has more incentives.
d. Train all water utilities staff on basic techniques for energy audit and equip them with the tools to carry out the same. The training should also include energy cost management.
e. Utilities to consider using renewable energy for pumping where possible and to try to use their own resources as much as possible to sustain services.
f. Rainwater harvesting is another measure that needs to be introduced and made compulsory the same way solar was made compulsory in urban centres. This would help reduce the cost of pumping. Along with this the government can encourage or enforce the two-pipe system as used to be done in the past. This would allow recycling of wastewater to be used for all other purposes except drinking and cooking. This helps to both reduce the energy cost of long-distance pumping while at the same time reducing water usage in the premises.

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