International Journal of Science, Environment and Technology, Vol. 2, No 5, 2013, 920 – 929

ISSN 2278-3687 (O)

ENERGY COST SAVINGS IN MUNICIPAL WATER PUMPING SYSTEMS-NEED FOR WEB INTERACTIVE TOOL

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Abstract: Municipal bodies are short of funds to provide effective quality services (like education, health, water and sanitation) to local communities. A major share of funds, as high as 60 -70%, goes for paying electricity bills for water pumping and street lighting services. This huge cost poses a challenge for municipal bodies to supply water in a cost effective way. Energy efficiency studies show that there is a significant scope for energy costing savings in municipal water pumping operations. However, a key barrier for carrying out energy efficiency improvement programme is the lack of knowledge and skill sets among the operational staff. To assist the municipal staff a web based interactive tool has been developed for identification of energy cost saving opportunities. The implications due to the use of such an online tool and its benefits are discussed.

Keywords: Energy conservation, Municipal water supply, Pumps, Web Interactive tool.

1.0 Introduction

The global water demand has been increasing fuelled not only by the rapid growth in population, but also by a rise in the per capita water consumption rate. Water use has been growing at more than twice the rate of population growth in the world from the last century. Around 700 million people across 43 countries presently live in a state of water stress (UNFCC, 2009). In India this problem is particularly exacerbated. We have 17% of the world's population and only 4% of the world's fresh water resources (GoI, 2012). Further, due to population growth and a rising per capita consumption, the water available per person in India has steadily decreased in the past few years. During 1992-2007, the per capita water availability in India decreased by 22% (ESCAP, 2009).It is estimated that by the year 2050, a half of India's population will be living in urban areas and will face acute water problem (Singh, 2000). Water management in urban habitats (municipalities, towns) becomes a critical issue as the world becomes an increasingly urban space. Therefore, water management in urban habitats is an extremely important area for policy makers to focus on in order to ensure sustainable development.

*Received Aug 2, 2013 * Published October 2, 2013 * www.ijset.net*

In recent years, municipalities in global scenario are finding it challenging to supply potable quality piped drinking water due to a phenomenal growth in the urban population over past five decades. The issues affecting the water sector include disparity in water supply across regions, depletion of ground water and undercapitalized municipalities. The disruption in the monsoon rainfall pattern and rising energy tariffs has also created problems in meeting additional water requirement. Municipalities are spending large portions of their revenues on purchasing energy for providing public services such as street lighting and water supply (IFC, 2007). According to a recent Electric Power Survey, the Public Water Works in India consumes more than 12000 MUs and Public Lighting consumes 5000 MUs of electricity.

The experience of energy efficiency studies conducted at water utilities have shown that there is a great potential for energy conservation and achieving better energy efficiency level in these installations without or with low / medium cost investments. Such initiatives will help water utilities, which are mostly under local bodies, to reduce their energy expenditure.

At the same time, there is also a need for creation of awareness among the operating staff of water utilities on energy issues, steps for evaluation of their operating system from energy performance view point, identification of energy efficiency opportunities and induction of energy management approaches for integrating better standards and practices in everyday operation of water utilities.

2.0 Municipal Water Pumping Systems

The integral relationship between water and energy is not widely understood or sufficiently exploited through coordinated holistic efficiency approaches. The water-energy relationship is based on the reality that treating water for human consumption and pumping treated water to the consumer is an extremely energy intensive process. Every litre of water that passes through a system represents a significant energy cost. The relative energy importance of the different municipal water systems depends on factors like the topography of the water source and its destination (especially elevation change), distance from the bulk water supply, and the integrity of the primary mains (supply pipes) and secondary mains (distribution pipes). A review of demand management techniques applicable for developing countries can be found in Vairavamoorthy and Mansoor (2005).

In developing countries energy is usually the highest cost associated with water supply. The high amount of energy consumption coupled with high maintenance costs have been a common factor for water supply utilities. Sometimes, in developing countries, water users do not have enough paying capacity. In many cases even the operating costs cannot be recovered due to social responsibilities. The contribution to capital outlays are met by domestic governments and external assistance by way of aid or loans. All these factors leave municipal water utilities with a greater challenge of meeting urban water demand in a cost effective manner. Poor power quality, especially erratic voltage and frequency, along with deficit power supply overburdens the already strained system (Halpeth M K, 2002).

One of the energy efficient methods to meet municipal water demand and flow control, particularly for systems where static head is a high proportion of the total, is to install two or more pumps and operate them in parallel. A variation in flow rate is achieved by switching on and off additional pumps to meet the demand. The combined pump curve is obtained by adding the flow rates at a specific head. The system curve is usually not affected by the number of pumps that are running. It is also apparent that the flow rate with two pumps running is not double that of a single pump. If the system head was only static, then the flow rate would be proportional to the number of pumps operating. Care must be taken when running pumps in parallel to ensure that the operating point of the pump is controlled within the region deemed as acceptable by the manufacturer (BEE, 2005).

3.0 Energy Conservation Potential Study: Methodology and Sample collection

The data collected for this study includes maximum demand, power factor, and tariff details from the operations team during the visit to various water pumping stations. The details of the installed equipment such as pumps, motors, transformers, starters, cable sizes, and capacitor bank design details are obtained from the site. Piping networks in the pump house, and transmission networks and storage tanks in the distribution network – including their capacities – are collected from the design offices of water works. The flow rate and quantity of water pumped, the number of pumps in use, the duration of operation is recorded for each station. The actual water flow rate, inlet and outlet pressures at the pump and power consumed at each installation are measured using the following instruments:

- Portable load manager to monitor and log the transformer parameters (voltage, current, power factor, kW, kVA, kvar, Hz, kWh);
- Clamp on electrical power analysers to measure and log the individual motor parameters (voltage, current, power factor, kW, kVA, kVAr, Hz, kWh);
- Ultrasonic water flow meter to measure the velocity and flow rate of water at the pump and in pipelines;
- Digital pressure sensor to measure the delivery head of the pumps.

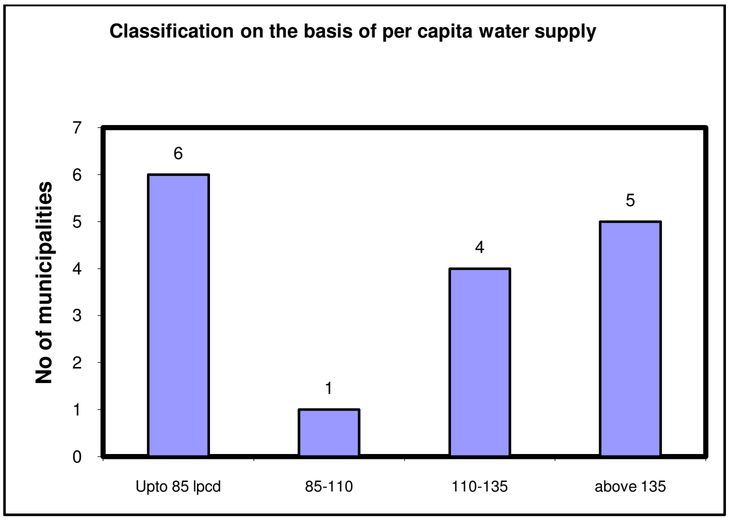
The data was collected and analysed in 75 pumps of different rating (connected motor to pumps 22 kW to 500 kW) installed across 20 pumping schemes in 16 municipalities. Since the instruments are portable, measurements were taken during the actual operations at the water works. In a few situations, the installation of pressure sensor could not be undertaken due to non-availability of measuring points near the individual pumps. In such cases, the delivery pressures have been collected from the system design curves and network diagrams. Motor efficiency figures were in the range of 88 -93% collected from manufacturer test certificates and nameplates. The following table provides the classification of the 16 towns/cities based on their population, where the audit was done.

Category	**Population slab in lakhs**	**No of towns**
A	Less than 1 lakh	5
B	Between 1-3 lakhs	4
C	Between 3-5 lakhs	4
D	Over 5 lakhs	3
	Total	16

From the table it is evident that the study has representation of water installations of all possible categories between 1 lakh and >5 lakh population.

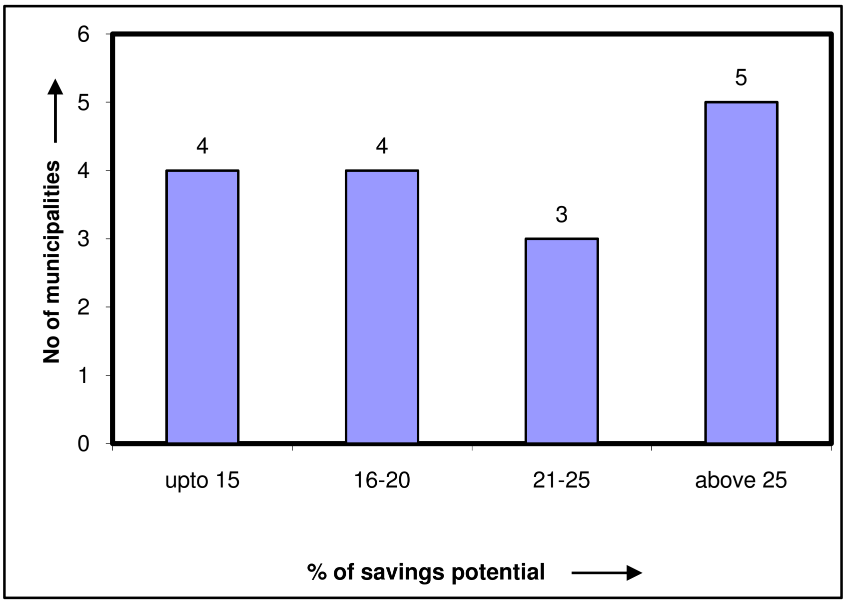
Data Analysis

The collected data was analysed based on the water availability at the source and the present installed capacity of the pumping stations. The comparison of the per capita figure against the all India norms of 135 lpcd water supply reveals the deviation from this norm at these municipal towns.



As seen from the above chart the disparity in the amount of water received varies largely from town to town, and 75% of the towns receive less than the all India norms fixed by the government. A major reason for this is the non-availability of water at the source. It is also not uncommon that the schemes with low installed capacity integrate borewell water at several locations within the municipal vicinity area. In many cases these borewells are hand operated.

The comprehensive energy audit revealed that significant potential exists in municipal water pumping installations in terms of improving the energy efficiency. The details of energy and cost savings identified, as a result of the energy audit is classified in terms of the percentage saving potential, are given in the following chart.



The consolidated benefits revealed by the municipal water studies are highlighted below:

- The total estimated energy saving potential in all these 16 municipal station was at 202 lakh kWh per annum (20 million units) amounting to an estimated cost savings of Rs. 881 lakh. Out of the 16 towns, cost savings were in more than 25% in five towns, and in seven towns it was in the range of 16-25%.In the remaining four towns it was up to 15%.
- The total equivalent potential for CO_2 emission reduction was estimated at 20,200 Mt per annum.
- In a majority of the cases, the payback period was less than one year which indicates that lucrative savings was possible even with 'low and medium' payback period investment options.

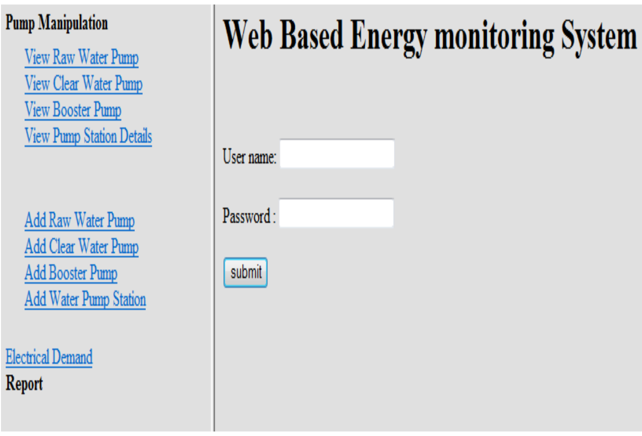
The energy efficiency studies revealed several ways to improve energy efficiency after a thorough evaluation of the pumping systems. The identified energy cost saving measures and their potential is listed in the table below.

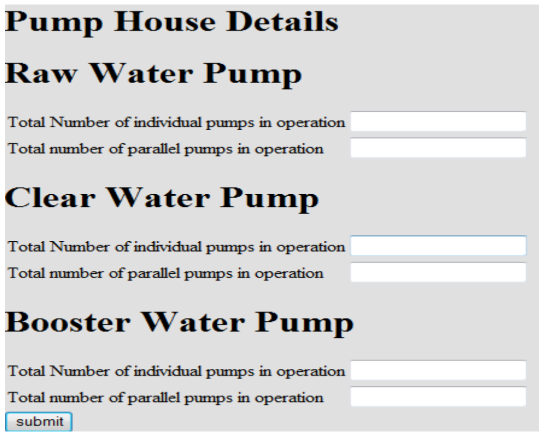
Type Energy Cost Saving Measures	**Potential, Min ~ Max (in % of overall)**
Fine tuning of contract demand	0.5 to 20
Penalties paid in lieu of maintaining low power factor	1.0 to 14
Suitable sizing of pumps	3 to 45
Replacing of pumps due to poor efficiency	10 to 45
Operating schedules/practices of pumps	12 to 70
Changes in storage tanks filling practices	1 to 3
Other measures (specific to sites)	2 to 30

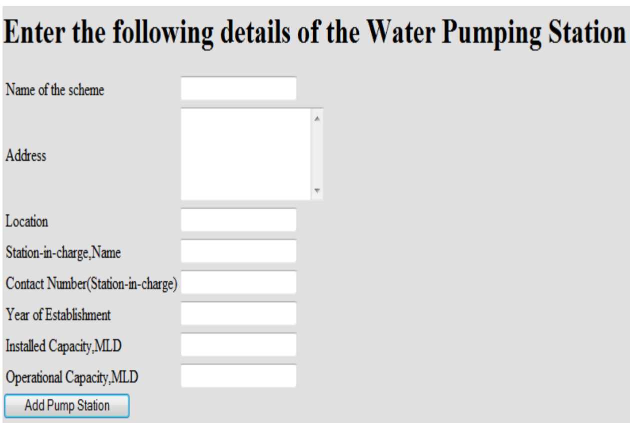
It can be seen from the above table that improper accounting / metering of water supply systems and lack of municipal water pumping system, staff commitment and trained staff, monitoring and maintenance practices is leading to large scale inefficiencies (TERI, 2008).

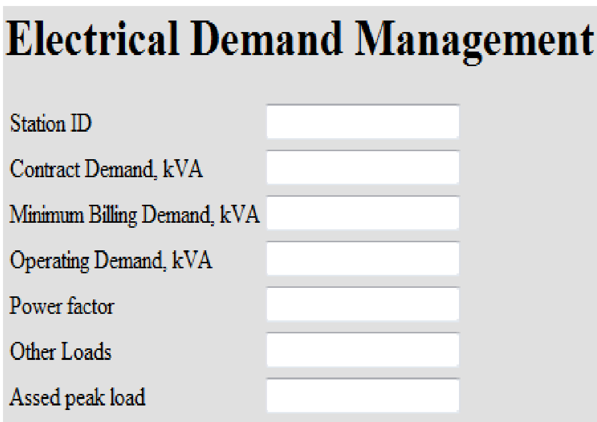
4.0 Development of a Web Interactive Monitoring Tool

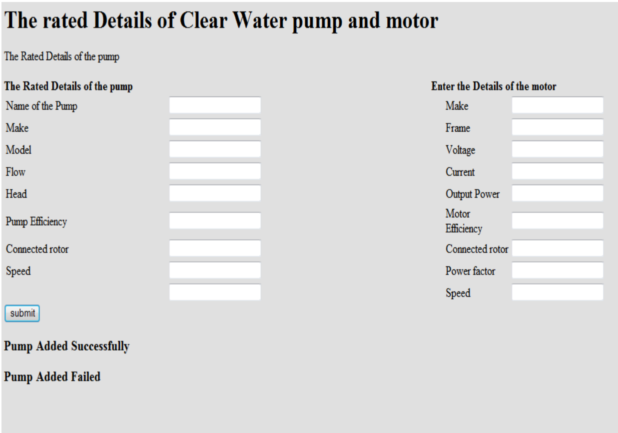
A monitoring tool has been developed to capture basic infrastructure details of municipal water pumping systems (like electrical system and its prevailed tariff structure, pumps and its configuration, specifications etc.). These details can be entered along with registration. A back end data base storage has been created which captures all the entered monthly details (billing details, operating hours, number of pumps in use etc.). A comparative analysis is carried out based on operational data versus design (or) allocated data applicable to a particular pumping station. The results are displayed in terms of graphical representation which can be viewed and understood by the operating staff (skilled or Unskilled). Depending upon the available instrumentation / information pumping station level data can be entered. It can be analysed on a monthly and daily basis. The tool is a web interactive mode of operation with availability of expert services which is optional, where municipal utility staff can pose questions to the experts based on the data furnished. The technical expert team also can view the furnished data and provide free advisory services through mail (or phone). This will help the municipal staff to take necessary steps to enhance the pumping system operating efficiency. Some of the screen shots of online interactive tool are furnished in below.

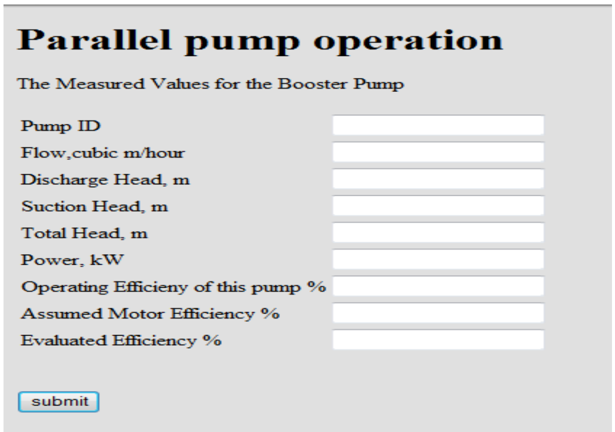












Energy conservation measures like utilisation of contract demand (including penalty), power factor management, operation of pumps (with respective to piping networks) and drop in pumps operating efficiency are analysed for corrective action using the monitoring tool.

5.0 Results and Discussions

A majority of the municipalities in India are not familiar with new concepts and technologies available in the market, due to lack of education and training. Municipalities should make it as part of their work culture to educate ground-level as well as supervisory staff on energy, water and technologies that are available to improve efficiency. Inefficiencies should be pointed out and figures should be converted into their rupee equivalents, and given in terms of hour, day, and year. Educating the staff on these figures will result in cost-effective initiatives emerging from the ground level staff members who operate the system.

Most municipal personnel follow a routine working pattern rather than going a step further. The routine working pattern can be attributed to lack of individual commitment, and most importantly and absence of motivation from seniors. A human resources team should be formed for these assignments, whereby the working personnel become aware of the bottlenecks and take necessary actions towards improving energy efficiency. Moreover, a back-up support from the top-level management can bring about miraculous results towards achieving higher efficiency.

Normally, the facilities required for estimating system parameters are absent in a municipal water supply system. An accurate metering and accounting system helps municipalities to become aware of system problems and bottlenecks, and identifying causes for these problems. Metering and accounting systems have helped many municipalities cut energy consumption by 10% (TERI, 2009).

Time series data pertaining to energy consumption, cost of energy inputs and other related data like quantity water pumped, which has a bearing on energy consumption, should be collected. Historical data available with the utilities for major equipments including billing systems needs to be studied. Information on inventory of the electrical / mechanical equipment installed and its operating parameters (like hours of operation of pumps, actual load in kW etc.) should be collected. These data should be compared with the design/operating values and margins for improvement can be found out.

The online web interactive analytical tool is a step forward towards addressing municipal staff awareness / training / skill development for energy cost savings of their respective municipal water system. Energy efficiency studies have established that energy costs account for 40 to 60% of the operating expenses for supplying water. By becoming energy efficient, each municipal water system can reap a minimum energy savings of 25 to 40%. This translates to an energy savings of at least 3000 MUs (based on the data that public water works in India consumes more than 12000 MUs), which means that one can avoid the need for an additional capacity of 500 MW for the Indian scenario.

6.0 Conclusions

Energy consumption and cost is increasing rapidly due to a reduction in the operating efficiency of the system. It is evident that energy efficiency initiatives in municipal water systems should be recognized as the first important step before any other alternatives and / or new augmentations are planned.

From the study it is clear that a tremendous energy saving potential exists in these municipal water pumping installations. One of the interventions needed is to train and create awareness among the municipal utility staff about the benefits of energy efficiency improvement. In order to help and assist these staff with available resources/information an online web interactive monitoring tools has been developed. The tool will help in better understanding of their municipal water system and changes required for realising energy cost saving opportunities. Municipalities can utilise the energy cost savings accruable as a result of implementing energy efficiency measures for any other important services like health, education which are equally important in sustainable development.

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