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Water System Audit -a Tool for Improvement in Energy and Environmental Performance in Municipal Corporation of Gujarat

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Abstract

For the people of India, natural resources are not available sufficient in comparison at global level, in particular for water and land. Climate change and increasing size of cities in India are main aspects unbalancing supply and demand of energy and water Under such circumstances, to combat the burning issue of water deficit, other than development of utilizable water resources, no stone to be kept unturned to conserve water and improve water efficiency which indirectly helps to save power, population and reduce pollution.

Municipal corporations of Gujarat are facing huge problems on energy consumption and growing water consumption. Present water system and equipments in Municipal Corporation are required to be studied for their performance evaluation. The scope for improvement and accordingly implementation of actions help to improve energy and environmental performance. In the context, the water system audit performs as unavoidable and important tool in India and at global level. Benefits of implementation of actions on water conservation and energy efficiency improvement helps to meet challenges of rapidly growing demand of natural resources and their protection, environmental protection and also mitigate climate change issues.

Keywords: Water System Audit, Energy and Environment, Efficiency, Water flow

Introduction

From 1980 onwards Water Audit concept was introduced to solve problems on various water losses, mitigate leakages and find solutions on shortage of water. Holmes Matthew (2007).

The sole purpose is to find solution based on work done and express suggestion or opinion for

organization or any system. Water audit provides a systematic and balanced framework that classifies various types of water use in any system Rathi Dinesh (2005). Hence it becomes a tool to combat problems on water drought, find solutions on increasing subsystem efficiency.

Water audit is not a novel concept and specific guidelines or Indian standards are not available at present.

Water System Audit is a part of Water Audit and it was conceptualized for one of the major municipal corporations of Gujarat two years ago and based on observations, measurement and analysis of data collection; performance evaluation of various utility systems was done. This evolution helped to find suggestions for improvement in Energy Practices and optimum utilization of water supplied to city. Conservation measures were taken to improve upon water supply and distribution system. All round action on Energy Conservation and water conservation resulted into substantial amount of savings in energy including utilities and hence reduction in demand of energy resulted in to reduction in environmental impacts.

The city in which water system audit was done had population of 2.86 lakh two years ago and demand of water was 32 mld. Water distribution network has 25,000 tap connections and three sources of water mainly Hasanapur, Anantpur, & Wellingdon.

This corporation increased facility to meet demand still there was a gap between supply and demand. Per capita water supply was 110 lpcd which could cover only 70% and also on alternate day water was supplied of 21 mld. This scarcity created need to improve the water system conditions.

In this paper, relationship between energy management and environment management practices is discussed. Integrated framework that includes water system audit, energy performance, environmental performance and sustainable development and growth is presented. In the subsequent section, method, scope, hypothesis, data collection, data analysis, results and conclusion is discussed. It concludes with a summary of limitations.

Objectives of Water System Audit

Objectives of water system audit is to find out energy performance of utility system installed, water distribution system, actual water flow supplied against rated capacity of the system and hence improve upon the system, study the pipe line network ,help to prepare mitigation plan for expansion or increase in demand of water in municipal corporation. (General Guidelines for Water Audit & Water Conservation, 2005)

Benefits of Water System Audit

Water system audit improves (a) performance of utilities installed for water supply system, (b) Stop leakages of water hence reduce water losses, (c) Reduction in energy consumption hence improved financial performance, (d) Reduction in energy consumption hence improved Environmental performance,(e) Improved distribution system (f) improved relations with Citizens and improving level of service to customers (g) Improved planning to meet future demand and combat during increase in population of the city or drought conditions. (Halcrow Water Services and Bristol Water Services Report, 2003)

Hypotheses

Water system audit covers observations of operational practices and measurements of installations consuming energy, pipe line network, water flow from sources. Data collection and analysis helps to find suggestions for energy efficiency improvement. Implementations of suggestions lead to

achievement of energy savings and further plan to conserve energy and efficiency improvement. Thus we hypothesize,

H1. Water System Audit will be positively associated with energy performance.

Due to improvement in energy efficiency, energy conservation and energy savings, demand of energy reduces from energy supplying company hence energy generation is required to be reduced proportional to reduction in energy demand. Also, equivalent carbon emission reduction takes place leading to reduction in environmental impacts. Thus we hypothesize, H2: Energy performance will be positively associated with environmental performance

Research Methodology

Problem Statements

Historically, energy as an input factor within the Municipal Corporation had low or even zero priority for management, as energy costs were only a small part of total budget since energy prices were low and relatively stable at that point of time. Therefore, energy costs were in most cases only treated as overhead rather than as a cost category in India within the last decade. (Amol A.Kulkarni, Avinash A. Patil, 2014)

Increase in population of cities in Gujarat and rapid development of cities in last decade resulted into higher demand of water and energy where as water supply system had gone through very little improvements or addition of equipments and pipe lines to cater the growing demand of water. Also, climate change during last decade has shown uneven rainfall in Gujarat areas resulting into drought conditions. Also, cost of energy is increasing rapidly in Gujarat. These all impacts has created awareness amongst municipal corporations where in it became immediate requirements to serve the people and society efficiently and effectively.

Also as energy and environment both goes together, issues on reducing environmental hazards have also been growing drastically since last one decade.

By correct solutions and implementation of energy and environment management through water system audit, water demand can be mitigated a along with reduction in environmental hazards which can be proved as one of the best tool.

Research Objectives

Objectives behind the study was as follow.

1. To find the impact of water system audit on energy performance of Municipal Corporation.

2. To find the impact of water energy performance on environmental performance of Municipal Corporation.

Methodology of Water System Audit

Theoretical Frame Work:

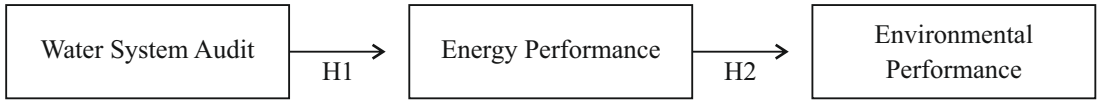
Step No.	Plan Of Action	Purpose / Results
Phase I -Pre Audit Phase		
Step 1	Plan and organize	Resource planning
	Walk through Audit	Organize Instruments & time frame

	Informal Interview with Chief Engineer , Municipal Corporation Engineers	Macro Data collection
		Familiarization of water supply activities
		First hand observation & Assessment of current activities
Step 2	Conduct of brief meeting / awareness programme with all municipal corporation staff in water department	Orientation, awareness creation
Phase II - Audit Phase		
Step 3	Primary data gathering, Water Flow Diagram & Energy Utility Diagram, Environmental status	Baseline data collection
		Prepare water flow charts
		ll service utilities system distribution (Example: Single line power distribution diagram, water distribution.)
		Design, operating data and schedule of operation
		Annual energy bill and energy consumption pattern (Refer manual, log sheet, name plate, interview), environmental status
Step 4	Conduct survey and monitoring	Measurements: water distribution survey, insulation, water, soil pollution with portable instruments for collection of more and accurate data.
Step 5	Conduct of detailed trials / experiments for selected energy guzzlers, environmental significance	Trials/Experiments:
		24 hours power monitoring (MD, PF, kWh etc.)
		load variations trends in pumps etc.
Step 6	Analysis of energy use and pollution	energy loss/waste analysis
Step 7	Identification and development of energy conservation (ENCON) opportunities and reducing environmental impacts	Identification & consolidation ENCON measures
		Conceive, develop, and refine ideas.
		Use brainstorming and value analysis technique
		Control vendors for new/efficient technology
Step 8	Cost benefit analysis and environmental impacts reduction analysis	Assess technical feasibility, economic viability and prioritization of ENCON options for implementation
		Priorities by low, medium, long term measurement

Step 9	Reporting & Presentation to the Top Management	Documentation, Report Presentation to the Top Management
Phase III – Post Audit phase		
Step 10	Implementation and Follow-Up	Assist and Implement ENCON recommendation measures and Monitor the performance
		Action plan, Schedule for implementation
		Follow – up and periodic review

Integrated research model for water system audit, energy performance, environmental performance and sustainable development and growth is as per Figure1.

Figure: 1 Research Model



Data Collection Methods and Data Analysis Plan

Data Sources:

1. Last 12 months' Electricity bills of electricity supply company and carbon emission level.
2. Cost of water and energy year wise from water department.
3. Energy conservation activities from engineering department.
4. Base line energy consumption level and pollution level.
5. Base line efficiency of all Energy consuming equipments.
6. Water pumping stations.
7. HT and LT pumping stations.

Tools and Techniques:

1. Identification of water system audit skills in employees of municipal corporation.
2. Preparation of Energy Efficiency Improvement strategy.
3. Water System Audit Study – planning at water department of municipalcorporation for (a) equipments at sources such as motors, pumps, storage tanks, reservoirs which operate to supply water and store for certain duration (b) various sources where water supply is given through pipe lines hence layout of pipe lines and identification of locations where water flow is to be measured (c) identify leakages at this system which are accessible and identification of accessories such as valves which are to be studies.
4. Based on analysis of measurements and observations, recommendations supported by calculations.
5. Savings in terms of energy and environment achieved by implementing recommendation.
6. Observation and measurement of energy parameters by ultrasonic flow meters, energy analyzer

cum harmonics analyzer, clip on meter, lux meter, pressure gauges. (Liemberger R., Brothers K., Lambert A., et al 2006).

7. Preparation of water flow chart, control process parameters for understanding at all levels of department in municipal corporation..
8. Understanding and calculation of energy cost – And its presentation by graphs.
9. Carbon emission reduction performance.
10. Efficiency improvement performance.

Following Fig 2 is schematic diagram of water system network.

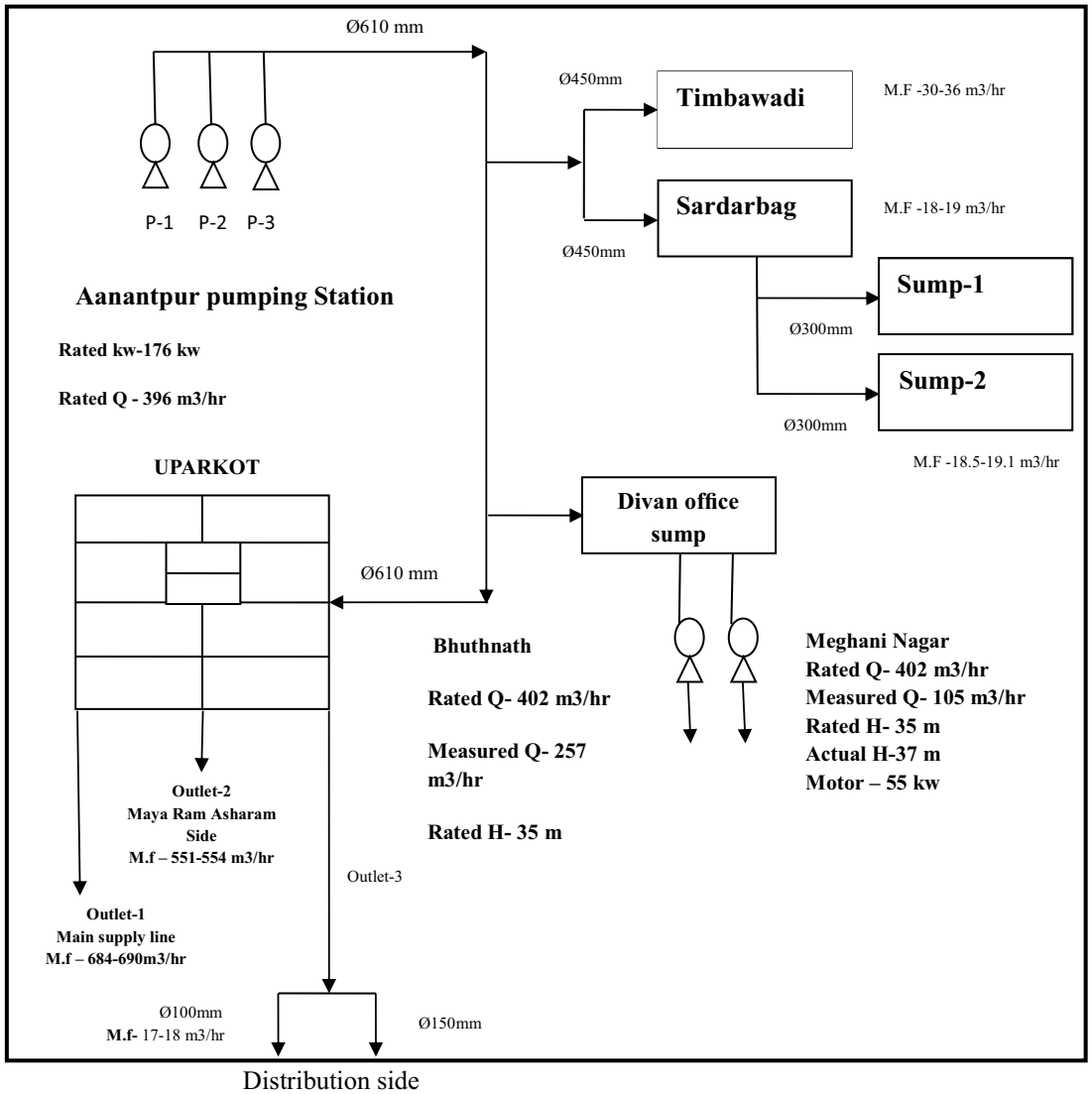


Fig 2: Schematic diagram of water system network.

Data Collection and Measurements:

1. Base line establishment of energy cost for all locations which contribute for energy consumption which includes motors, pumps and transformers and carbon emission level.
2. Base line establishment of all equipments for 1 HT and 6 No. LT Connections and their electrical measurements.
3. Water flow measurements for 23 No. locations.
4. Total 17 No. pumps were studied for measurements of flow and electrical parameters of their connected motors.
5. Establishment of energy cost equipment wise.
6. Identification of areas for energy wastage, pollution impacts, leakages.New technology adoption, retrofits, efficiency improvement projects (C.G. Shruthi, N.S. Sathisha,2013)
7. Compliance to state electricity boards, electricity bills .
8. Budgetary planning data.
9. Energy and Environment efficiency improvement data.
10. Reduction level of carbon emission and find CER (Carbon Emission Reduction)
11. Reports submitted to designate body on Carbon Emission reduction.

Data Analysis:

Following methodology was considered for data analysis.

1. Comparison of present loading and energy consumption against rated capacity of equipments installed.
2. Comparison of Actual flow which is rated flow versus measured flow to find utilization of pumps and evaluate performance of pumps along with motors.
3. Comparison of pump efficiency versus system efficiency because system efficiency takes care of motor efficiency, pumps efficiency and pipe line efficiency.
4. Based on suggestions, find amount of savings anticipated and savings achieved. To achieve identified savings, find investment required and simple pay back period which is attractive for the benefits of municipal corporations and hence society which become sustainable and gives growth in savings .
5. Find Carbon emission reduction form amount of energy demand reduction achieved.
6. Energy bills analysis for reducing demand and find specific energy consumption.
7. Identify areas of improvement.

Following graphs helped to identify performance of pumps for their utilization. In centrifugal pumping stations, pumps were found inefficient and supplying less quantity of water than their rated capacity. They were targeted for improvement.

Fig:3 Flow of V.T.Pumps

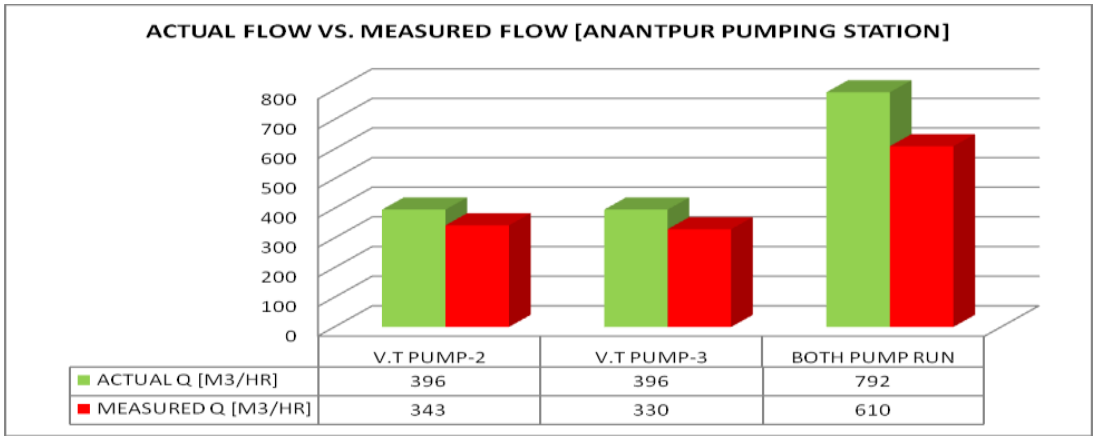


Fig:4 Efficiency of V.T.Pumps and System

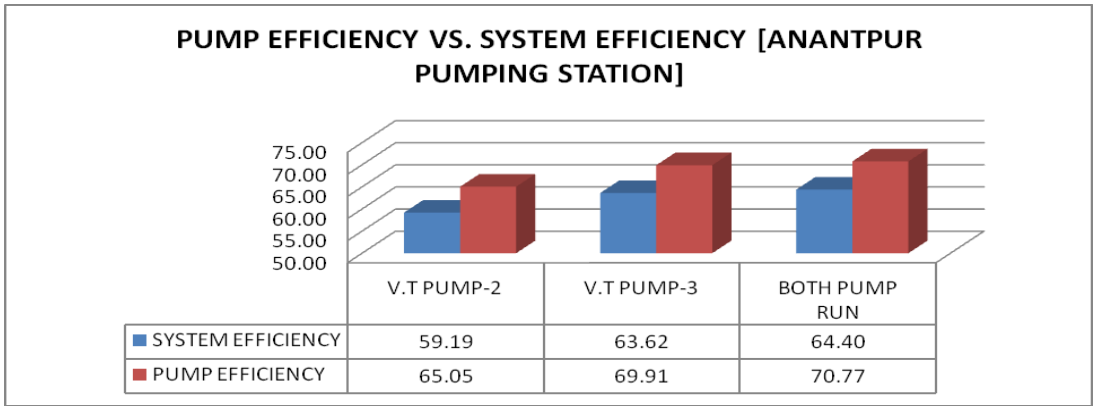


Fig:5 Flow of Centrifugal Pumps

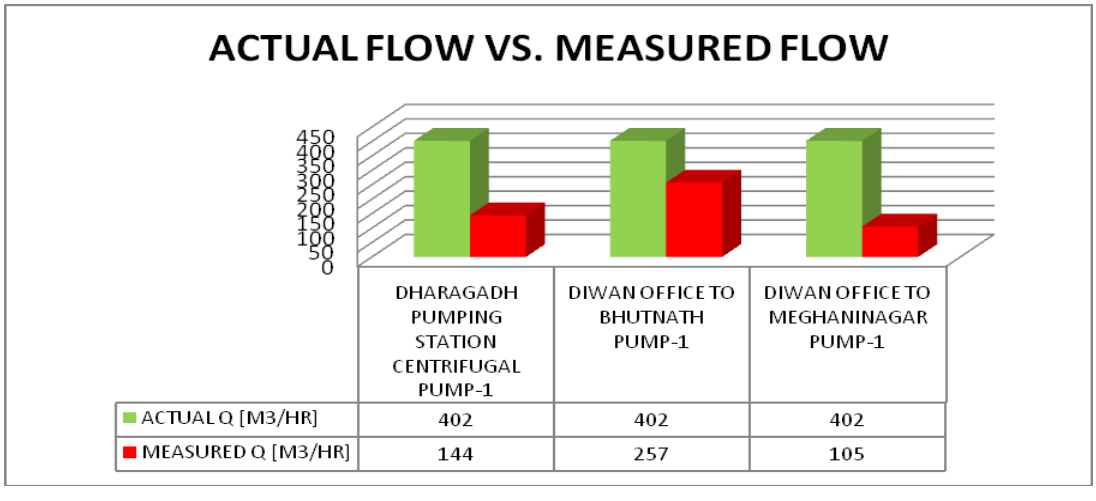
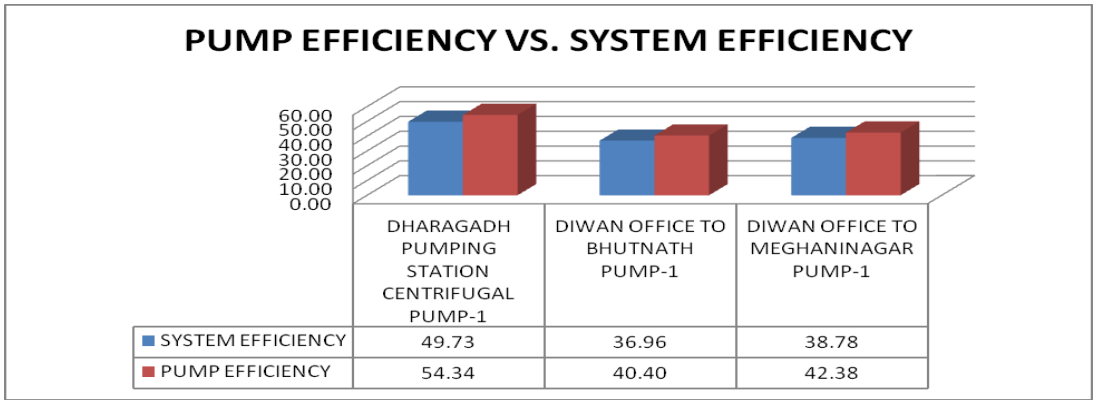


Fig:6 Efficiency of Centrifugal Pumps and System



Based on data analysis, following were major recommendations given for improvement and savings anticipated, investment planned and payback period. Table:1

Table: 1 Details of recommendations, anticipated savings, investment and payback period.

Sr. No.	Details of Recommendation	Savings (KWH)	Savings (Rs.)lacs	Investment (Rs.)lacs	Payback period (months)
1.	For Anantpur, By installing APFC and new capacitors, Increase the average power factor to 0.998 from the present average 0.88	-	4.50	3.0	8.0
2.	Improve P.F at identified areas by making capacitors properly functioning hence reducing cable losses and save energy.	173646	11.28	6.48	7.0
3.	It is suggested to undertake immediate maintenance and preventive maintenance for Pump-Motor assembly replace old and inefficient Pump-motors with energy efficient motors and also reduce pipe line losses across the whole network to save energy for identified pumps.	424359	27.57	31.8	14.0
4.	Replace 30 no. conventional Tube lights of 36 W, with energy efficient LED tube lights of (20 Watts) in all pumping stations.	8694	0.69	0.57	10.0
Total		606699	44.04	41.85	11.5

Results

Energy conservation and water conservation measures were taken based on recommendations which helped to improve overall efficiency of water supply system including major pumps.

Following was improvement in pump system efficiency after implementtaions of recommendtaions.

Fig 7: For V.T. Pumps

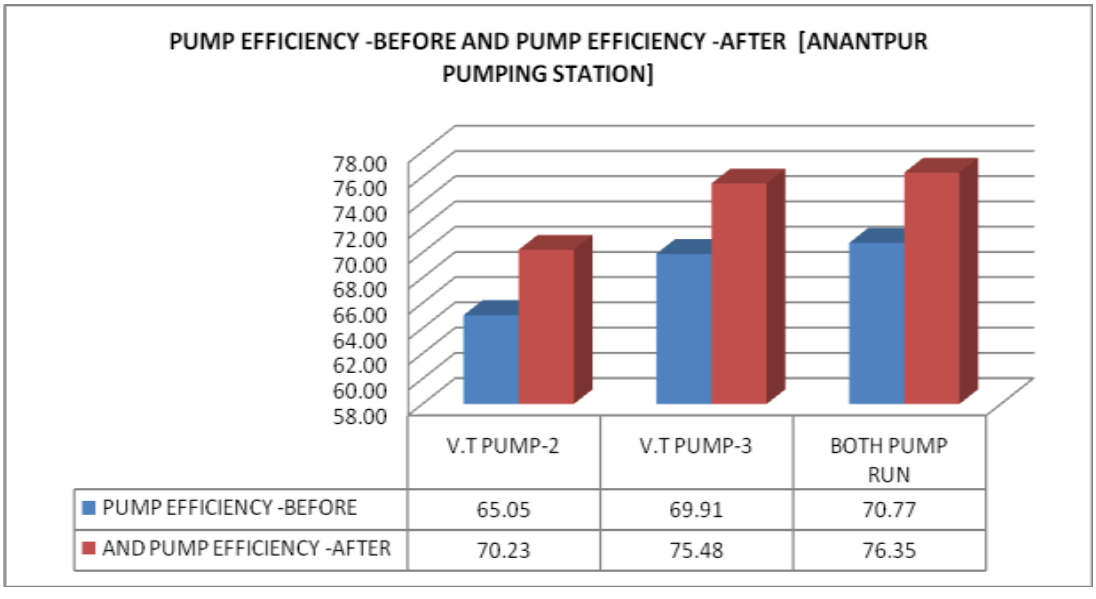
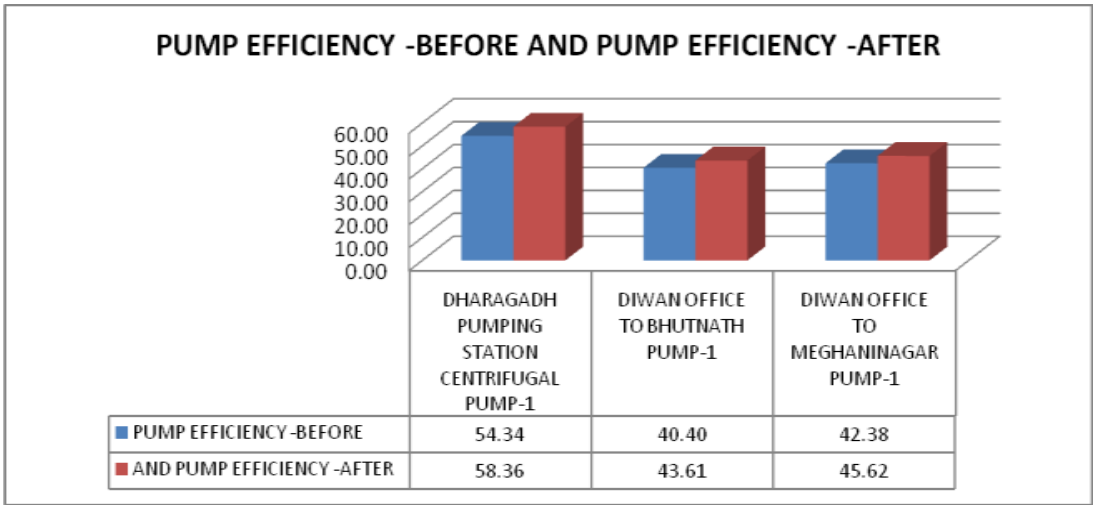


Fig 8: For Centrifugal Pumps



Based on actions taken, following were actual savings achieved, investment and payback period. Table: 2

Table: 2 Details of actual savings, investment and payback period.

Sr. No.	Details of Recommendation	Savings (KWH)	Savings (Rs.)lacs	Investment (Rs.)lacs	Payback period (months)
1.	For Anantpur, By installing APFC and new capacitors, Increase the average power factor to 0.998 from the present average 0.88	-	4.50	3.0	8.0
2.	Improve P.F at identified areas by making capacitors properly functioning hence reducing cable losses and save energy.	164963	10.71	6.15	7.0
3.	It is suggested to undertake immediate maintenance and preventive maintenance for Pump-Motor assembly replace old and inefficient Pump-motors with energy efficient motors and also reduce pipe line losses across the whole network to save energy for identified pumps.	381923	24.81	28.62	14.0
4.	Replace 30 no. conventional Tube lights of 36 W, with energy efficient LED tube lights of (20 Watts) in all pumping stations.	7825	0.62	0.51	10.0
Total		554711	40.64	38.28	11.30

Calculation for CER: 1 unit of Electricity KWH is equal to 0.90 Kgs of CER, total CER anticpated 546029.1 kgs.

Fig:9 For Electrical Energy

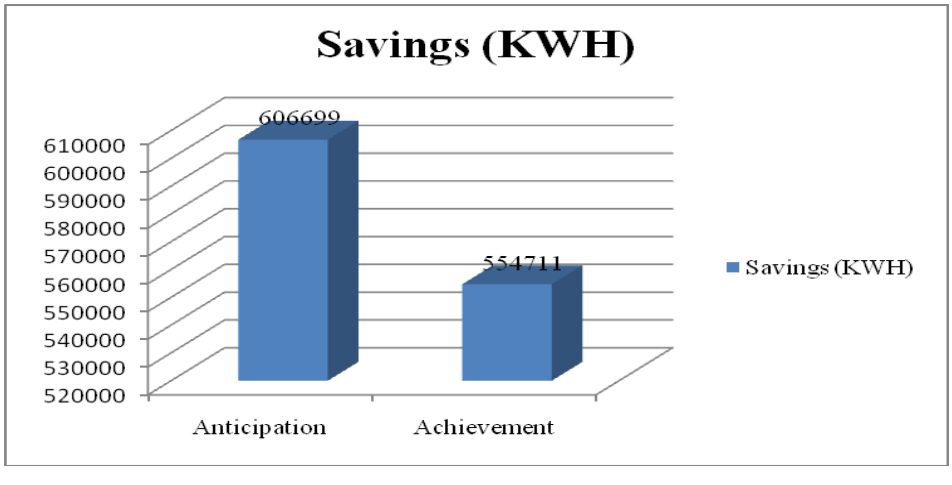


Fig 10: For Fiscal benefits

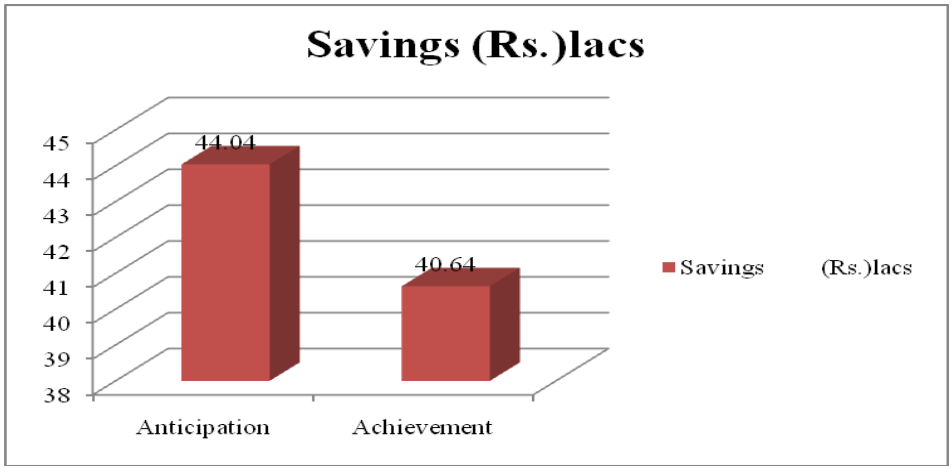
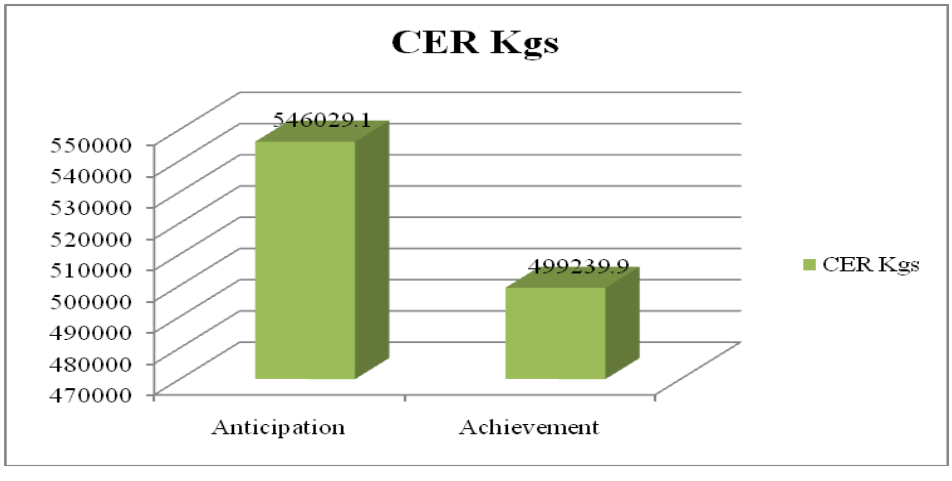


Fig 11: For Carbon Emission Reduction



Total CER achieved is 499239.9 kgs.

As per results achieved as given in Table 2, Fig 9,10 and 11 due to water system audit, energy perofrmance was improved and as energy is associated with environemntal impacts, environmental performance was improved . Thus our hypotheses H1 and H2 are in line with our results.

Discussions

Government commitment toward energy and environment:

Decision of conducting water audit or water system audit very much depends upon the prevailing government in the state of Gujarat. Scholars working in the field of economics analyzed that Structure of political situations and Government actions are co related. (Levy & Spiller 1994). This is very much important in case of Municipal corporations. Due to government and political situations, it has been noted by researchers that uncertainty in policy results for lower level of investment (Henisz 2000).

Effectiveness varies according to government's commitment to a particular policy with its socio-political situations.

The role of community and people:

Apart from governments, Citizens of Gujarat state, Non Governmental Organizations (NGOs), may impact government for decision on energy savings and environmental pratcies in municipal corporations of Gujarat. NGO prefers to implement international standards for reducing environmental impacts.

As supporting initiative for compliance to statements of COP24 (24th Conference of the parties to the UNFCCC):

Senior bureaucrat and India's head of delegation at COP24, Mr. A K Mehta, while de¬livering India's country statement on 12th December 2018, again reminded the gather¬ing that the country's per capita emissions continued to be much less than many countries. He said, "India is guided by its own values and belief in sustainable life¬styles which respects nature, evident from the fact that our share in cumulative histori¬cal global GHG emissions is only about 3% and our per capita emissions are just about one-third of global average. Activities of water system audit play major role as supporting initiative to conserve energy and natural resources hence this statement is supported on implementations of actions as given in this paper.

Also, seeking to end the deadlock on criti¬cal issues, the European Union (EU) and 27 countries have decided to raise emis¬sion reduction targets by 2020. In answer to environ-mentalists who wanted cur¬rent big polluters like China and India to do the same, the two countries have cited their lower per capita emis¬sion and huge developmen¬tal needs.

Limitations:

There are practical limitations during measurement of locations which are inaccessible such as underground pipes, find leakages form in-depth underground pipes, very old and rusted pipes do not give correct measurements by ultrasonic flow meter instruments.

Water system audit practices by itself may not improve total energy and environmental performance because there may be a potential for conflicts between environmental performance objectives and energy management principles. (General Guidelines for Water Audit & Water Conservation, 2005)

Environmental management practices do require additional resources of investments. It is important for municipal corporations to implement both energy management and environmental management practices. Future research may need to develop multi-dimensional energy and environment performance measures which predict the socio economical and political conditions better.

There may be a need to develop grassroots policies associated with grassroots financing for meeting the needs of energy and environment efficiency in water audit or water system audit for many municipal corporations. This paper is on water system audit done for a corporation in a city which has population of around 2.88 Lacs when audit was done two years ago and at present population is 3.19 lacs. In Gujarat, there are 8 municipal corporations hence still lot of efforts are required to be done.

In this paper, methods and details of bulk metering at the source for zones and revenue metering for consumers is not covered which helps in identifying the reaches of undue wastewater generation (Nguyen Cong Thanh ,2006).

Although this was in depth study, water balance as per International Water Association (IWA) / American Water Work Association (AWWA) is not done due to limitations of scope of the work given (Lambert A.O, Brown Timothy G., Takizawa M., Weimer D ,2000).

Conclusions

Based on water system audit as given in this paper, Electrical energy savings, fiscal savings and carbon emission reduction achieved was 93.75% of total anticipation. Water system audit in any water municipal corporation helps to conserve energy, save energy, save natural resources, save foreign exchange by reducing demand of energy, reduce environmental impacts and serve to society. It also helps to prepare sustainable master plan to mitigate future demand of water combating increase in population, modifications and additions in city areas due to development, make government stronger on their achievements which are beneficial to society and also financially.

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