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Energy Audit of Booster Pumping Stations and its Energy Conservation measures

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Abstract

The water Supply system is one of the major functions of urban local bodies in terms of providing safe water to its residents. The energy charges on water supply pumping system also occupy a major portion of the electricity bill. Hence special attention shall be paid for energy conservation in the water supply system to minimize the expenditure related to energy consumption, based on the associated energy tariffs.

"The main aim of study is to conduct Energy Audit of Booster Pumping station installed in Nagpur Water Supply system & evaluate energy efficiency based on actual measurements. During Energy Audit carried out measurements of various Electrical/Mechanical parameters. Like voltage, Current, KWH, Frequency, Maximum Demand, Power factor, Flow, Pressure using Energy Audit instruments. to calculate the total electrical energy consumption and total actual energy use , maximum (VA) demand, consumption figures of the whole pump in the plant, energy cost figures of the plant in (KWh), where we discovered very high energy wastage during operation .Therefore ways to reduce energy consumption by various energy conservation methods are recommended for optimum utilization. For optimum utilization automation placed important role".

Keywords: - Energy Audit, Energy Conservation Methods, Pumps Operation, Energy Consumption.

1. Introduction

The Water Supply system is one of the major needs of urban & rural bodies in terms of faciliting drinking water to its residential areas. The water supply system mostly includes Raw & Treated water pumping stations. Apart from this, Intermediate Booster pumping stations are also installed to lift the water to ESRs & distribution Network. An energy audit is the study of a plant

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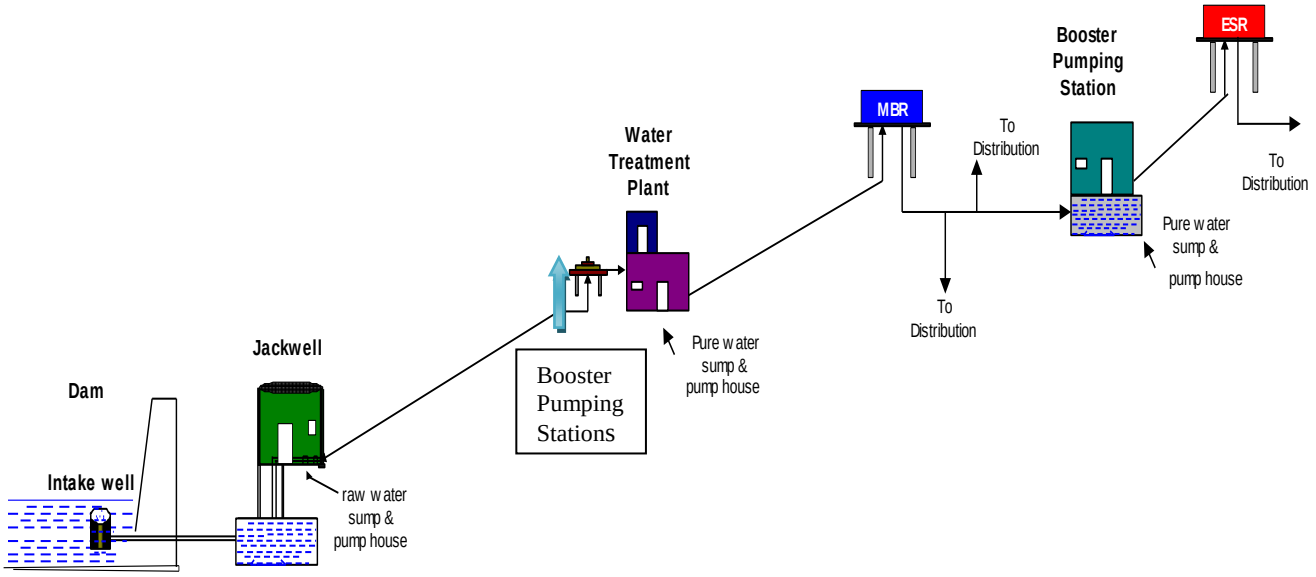
or facility to determine how and where energy is used and identify methods for energy savings.



Nagpur Water Supply system consists of five numbers of Booster Pumping Stations at different locations. Existing Booster Pumping Stations for the Nagpur Water Supply Scheme are

1. University Campus Pump House
2. Boriyapura Pump House
3. Karve Nagar Pump House
4. Wadi Tekadi Pump House
5. Jaitala Pump House

Following table shows the Nagpur Booster pumping stations pump installation details:

Sr. no.	Location of pump House	No. of pumps	Capacity (HP)	Flow (m^3/Hr.)	Head (m)	Pump Type
1	University Campus	2	120	340	64	Centrifugal Pump
2	Boriyapura	2	75	400	33	Centrifugal Pump
3	Karve Nagar	2	75	400	33	Centrifugal Pump
4	Wadi Tekadi	3	30	161	33	Centrifugal Pump
5	Jaitala	4	15	93	31	Monoblock Centrifugal Pump

Table No.1: Nagpur BPS Pump Details

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From this booster pumping stations treated water from sump supplies to ESRs & distribution network.

Energy Audit of Booster Pumping Station in Nagpur Water Supply system for evaluates overall energy efficiency based on actual measurements. Energy conservation methodology may be suggested which could lead to savings in the electricity consumption, thereby resulting in energy cost reduction.

From Energy Conservation Measures of the Nagpur Booster Pumping Stations will result in the dramatic improvement in the plant energy efficiency, the need for such modifications will be used for reduction in electricity bills.

The actual use of electrical energy has been calculated /measured at the output of electrical equipment in the detail audit, improving the efficiency of energy conversion process will result in lower loading levels in the electrical equipment and lower use of electrical energy. In examining the major low efficiency energy conversion processes and arrive at ways to reduce the energy consumption in those process. The possiblity of using automatic controls in order to switch off electrical equipment when the process does not really need energy and to adjust the efficient operation of electrical equipment against varying process load levels should be critically examined. It is often possible to reset the process variables to new levels conducive for lower energy consumption after a critical examination of the process.

2. Methodology

Energy Audit helps in understanding more about the ways energy is used in the pumping station & helps in identifying the areas where energy waste can occur & where scope for improvement. The energy audit will give a positive orientation to the energy cost reduction.

Energy Audit can be classified into the following types:

1. Preliminary Energy Audit
2. Detailed Energy Audit

In Preliminary energy audit, physical site visit of all five Nagpur Booster pumping stations. Discuss with the site's Engineer/Official for the information regarding Pumping station operation & Maintenance. Analysis of the major energy consumption data with the relevant personnel.

Necessary technical information collected it includes following Details:

1. Details of pump & motor machineries.
2. Pump suppliers and its make, pump efficiency curves,
3. Copy of last 1 year MSEB Electricity bills
4. Pump House Log book record for daily operation
5. Electrical Single Line Diagram
6. Water Flow Diagram

In Detailed Energy audit, field study includes measurement of Electrical/Mechanical machinery.

Performance Evaluation in order to find out the operating performance i.e. loading, operating efficiencies of the various installed equipments at pumping stations, measurements were carried out.

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Nagpur Booster Pumping Stations Pump efficiency was evaluated using Energy Audit Instruments are listed below:-

1.Ultrasonic Flow meter for Flow Measurement
2.Power Analyzer for Power Measurement
3. Tachometer for Speed Measurement
4. Pressure Gauge for Pipe line Pressure Measurement

Energy Conservation Measures & cost reduction of pumping Station can be taken to improve energy efficiency.

3. Electricity Bills Analysis

Nagpur Booster Pumping Stations MSEDCL Tariff structure applicable.
Following table shows electricity bills analysis details of Nagpur Booster Pumping Stations:

Nagpur BPS Electricity Bills Analysis from Jun-13 to May-14						
Sr. No.	Locations Pumping Stations	MSEB Tariff	Unit Consumed in kWH	Power Factor	Power Factor Incentive / Penalty	Total Current Bill Rs.
1	University Campus	HT-IV	323403	0.974	-49047	170692
2	Karve Nagar	HT-IV	228207	0.945	-605	1405039
3	Boriyapura	HT-IV	142307	1	-65061	893093
4	Wadi tekadi	LT-III	39727	0.913	-494	24216
5	Jaitala	LT-III	61224	0.245	146583	331532

Table No.2: Electricity Bills details of Nagpur BPS

Based on the details of Nagpur Booster Pumping Stations Last one year Electricity bills available at the time of study, it can be concluded that the power factor is low except Boriyapura Pumping Stations. Due to which NMC not getting 7% incentive from MSEDCL. NMC has paid power factor penalty for Jaitala Pumping Stations. Although with installing additional capacitor bank, power factor can be maintained at unity and NMC will get additional incentive from MSEB on energy bills.
Also for University Campus, Wadi Tekadi & Jaitala Pumping Stations Maximum demand is more than contract demand due to which Excess demand charges paid by NMC.

4. Performance Evaluations

In order to find out the operating performance i.e. loading, operating efficiencies of the various installed equipments at pumping stations, measurements were carried out.

Existing efficiency of the pump is evaluated by measuring of flow head and head losses and power, operating characteristics curves of pumps are known by the measurement of all parameters at various load conditions. Recommendation made to improve the overall efficiency pumping system with the review and understanding the operational conditions and process of operation of pumping system.
Logged details of daily measurements like flow head, power parameters are referred to where available, and used as appropriate, in arriving at conclusion regarding energy measures. Determination of power consumption of pumps while running the pumps in parallel, every minute data logging and power is made for a minimum period of 20minutes.Based on this study suggestions were made.

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Following table shows the performance evaluation of Pumps for operations at Nagpur Booster Pumping Stations:

Sr. No.	Location of Pumping Stations	Pump No.	Motor Input Power (kW)	Motor Loading (%)	Discharge Pressure (Kg/cm²)	Pump Flow (m3/hr)	Efficiency of Pump (%)
1	University Campus	.1	96.2	100.69	5.6	367	65.2
		2	99.55	104.2	5.6	379	64.99
2	Boriyapura	1	50.18	85.3	2.2	428	59.81
		2	49.48	84.11	2.2	415	58.83
3	Karve Nagar	1	51.36	87.31	2.2	435	60.60
		.2	51.51	87.57	2.2	431	59.86
4	Wadi tekadi	1	23.95	100.16	2.2	183	56.58
		2	24.09	100.73	2.2	176	54.10
		.3	25.05	100.75	2.2	179	53.01
5	Jaitala	1	11.29	102.62	1.9	104	51.47
		.2	12.32	111.96	1.9	107	52.73
		3	12.27	111.51	2.1	101	53.15
		4	11.47	104.29	2.1	97	49.71

Table No.3: Performance Evaluation of Pump at Nagpur BPS

5. Energy Conservation Measures with Cost Benefit Analysis

The Energy Conservations Measures (ECMs) identified for Nagpur Booster Pumping Stations are explained one by one as below.

Time of Day (TOD) Rebates:-

Booster pumping Stations peak hours operation pumping shifted to non peak hour which give Time of Day (TOD) saving,

As per MSEDCL tariff, the TOD incentives are applicable for Nagpur Booster Pumping Station is as follows.

Nagpur BPS TOD Rebates				
Sr. No.	Location of Pumping Stations	Present Annual TOD Rebates / Surcharge in Rs.	Proposed Annual TOD Rebates / Surcharge in Rs.	Total Annual TOD Saving in Rs.
1	University Campus	-597297	-808508	211211
2	Karve Nagar	-50759	-360456	309697
3	Boriyapura	17849	-294093	311942
4	Wadi tekadi	6608	-99385	105993
5	Jaitala	15872	104991	120863
		Total		**1059706**

Table No.4: Time of Day Saving at Nagpur BPS

For getting TOD rebates for Nagpur Booster Pumping Station the working hours of pumps should adjusted in such a manner that non peak hour pumping should get used fully and avoid peak hour pumping operations. The savings can be realized with immediate effect after implementation which is Rs. 1059706 per annum.

2. Savings by replacing existing lamps with energy efficient

At Nagpur Booster pumping station installed T12 Lamp. It is proposed to replace these

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existing lamps with the new energy efficient lamps. The T12 Lamps should be replaced with the T5 Lamps.

ECM with minor investment is replacement of existing lamps with energy efficient options. The investment required is Rs.27300. Implementation of these measures will result into saving of 4414 kWh per annum i.e. Rs.21, 129 per annum with a payback period of 15 months.

3. Power Factor Improvement

The average power factor at Nagpur Booster Pumping Stations is low. This power factor can be improved to unity by installing additional power factor correction capacitors. This will help to get more incentives and will reduce down demand and line losses.

Nagpur BPS Power Factor Improvement							
Sr. No.	Location	Present Power Factor	Proposed Power Factor	Total Annual Saving in Rs.	kVAr require	Cost of APFC panel	Simple payback period (Month)
1	University Campus	0.974	1	126684	32	51200	5
2	Karve Nagar	0.945	1	105552	23	36800	4
3	Boriyapura	1	1	Maintained Power Factor Unity.			
4	Wadi tekadi	0.913	1	21151	24	38400	21
5	Jaitala	0.95	1	170750	9	14400	1
	Total			**424137**		140800	4

Table No.6: Power Factor Improvement Saving at Nagpur BPS

The power factor at this Pumping stations is not maintained at unity. The investment required for this is Rs. 1, 40, 800 for installing additional capacitors with a payback period of 4 months. NMC will save Rs. 4.24,137 annually by installing additional power factor correction capacitors.

Also Saving by Increasing Contract Demand at Nagpur Booster Pumping Stations. In University Campus, Wadi Tekadi & Jaiatala Booster Pumping Stations Electricity Bills Maximum demand is more than contract demand due to which Excess demand charges paid by NMC.

Saving by Increasing Contract Demand (KVA)							
Sr. No.	Location of Pumping Stations	Contract Demand in (KVA)	Average Actual MD in (KVA)	Proposed Contract Demand (KVA)	Annual Excess Demand Charges in Rs.	Increase in Contract Demand in Rs.	Pay Back Period in Month
1	University Campus	80	147	160	181830	80000	5
2	Wadi tekadi	48	59	70	15525	22000	17
3	Jaitala	15	26	30	10200	15000	18
	Total				**207555**	**117000**	**7**

Table No.7: Saving by Increasing Contract Demand at Nagpur BPS

The investment required for this is Rs. 1, 17,000 for increasing contract demand with a payback period of 7 months. NMC will save Rs. 207555 annually by increasing contract demand.

4. Efficiency Improvement of pumps by Applying Corrocoat Coating & replacement of internal parts

It is seen that over the years, may be because of poor preventive maintenance or due to ageing process efficiencies of pumping machinery gets detoriated. Naturally these detoriated increases the power input & ultimately result in very heavy energy bills.

At Nagpur Booster Pumping Station Saving in Pump Power Consumption by Applying Corrocoat Coating & replacement internal parts. Nagpur Booster Pumping Station pumps are

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operating at lower efficiency. Corrocoat coating is applied on the pump internals. It reduces corrosion, erosion, wear and tear of the pump internals and thereby reduces the frictional loss. It gives 4% saving in the power consumption.

Saving in Pump Power Consumption by Applying Corrocoat Coating & replacement internal parts				
Sr. No.	**Location of Pumping Stations**	**Pump No.**	**Annual Energy Savings (kWh/annum)**	**Monetary Savings (Rs./annum)**
1	University Campus	Pump No.1	5695	26938
		Pump No.2	5734	27122
2	Karve Nagar	Pump No.1	4456	21077
		Pump No.2	4275	20221
3	Boriyapura	Pump No.1	3801	17977
		Pump No.2	3709	17542
	Total		**27670**	**130877**

Table No.8: Saving in Pump by Corrocoat Coating using at Nagpur BPS

The investment required is Rs.1, 80,000. Implementation of this measure will result into saving of 27670 kWh per annum i.e. Rs.1, 30,877 per annum with a payback period of 17 months.

6. Conclusions and Future work

6.1 Conclusions

The during study it is observed that the basic for making the following conclusions;

- Nagpur Booster Pumping Stations power factor is low due to which NMC has to pay penalty & not getting 7% incentive from MSEDCL.
- University Campus, Wadi Tekadi & Jaitala Pumping Stations Maximum demand is more than contract demand due to which Excess demand charges paid by NMC.
- Operation of Booster Pumping Stations pumps working on peak period zone due to which NMC not giving TOD rebates.
- Due to ageing process & long period of operation usually results into deteriorations of operating efficiencies of Booster pumping stations.

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6.2. Future Work

For optimum utilization automation placed important role. The SCADA system use in Booster Pumping Stations for energy efficiency, automatic control of pump daily operation and maintenance activity, cost effective use of Equipment. Monitoring of Electrical parameters at Booster Pumping Stations such as Current, Voltage, Power Consumption, Frequency,RPM etc,Also monitoring of level, flow, pressure at ESR / GSR Locations and water quality at pumping Stations, Also used for Energy & Water Audit Analysis.

7. Result

As per conducted study, to evaluate Demand, Power factor, Flow, Pressure using Energy Audit instruments & also to Energy Audit of Booster Pumping station in Nagpur Water Supply system & Therefore ways to reduce energy consumption by various energy conservation methods are recommended for optimum utilization & savings in the electricity consumption, thereby resulting in energy cost reduction.

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Nagpur Booster Pumping Stations Energy Conservation Measures					
Sr. No.	ECM Description	Estimate of Energy Saving Potential		Estimate of Costs	Cost Benefit Analysis
		nual Savings (kWh)	Rs. (in Lacs)	Investment Cost	Simple Payback Period
ECMs without Investment (Phase I)					
1	TOD Rebates		10.597		
ECMs with Minor investment (Phase II)					
2	Replacing existing lamps with energy efficient lamps	4414	0.211	0.273	15
ECMs with Medium investment (Phase III)					
3	Power Factor Improvement		4.241	1.408	4
4	Saving by Increasing Contract Demand		2.076	1.17	7
ECMs with Major Investment (Phase IV)					
5	Efficiency Improvement of Pumps by Corrocoat coating & replacement Internal parts	27670	1.480	1.800	17
	Total	32084	18.605	4.651	3

Table No.9: Energy Conservation Measures for Nagpur BPS

REFERENCES

1. Bashir Garba. I.1,*, Yusuf Jibril2, Laminu S. K3,"An Electrical Energy Audit of Water Pumping Machines", International Journal of Energy Engineering 2012, 2(3): 86-90 DOI: 10.5923/j.ijee.20120203.05.
2. Instruction for energy auditor, Vol I & II U.S. Dept of Energy, Sept 1978
3. Energy conversion guide for industry & Commerce, hand book & supplement.
4. G rudra narsimha rao , E Nnd Gopal, K V Sharma " Analysis of Electrical Systems of Water Utilities to Enable Cost Savings"
5. G Rudra Narsimba Rao,"Analysis of Electrical Systems of Water Utilities to Enable Cost Savings" The Energy & Resources Institute (TERI).
6. Shu Shihu, Zhang Dong, Liu Suiqing ,"Power saving in water supply system with pump operation optimization" 978-1-4244-4813-5/10©2010 IEEE
7. Bureau of energy efficiency guidance book.
8. MSEDCL Tariff
9. Gelu GURGUIATU, Ciprian Daniel BALANUTA," Energy savings generated by installing active power filters in water pumping stations" 978-1-4799-2442-4/13/2013 IEEE.
10. G. Yu, R. S. Powell, and M. J. H. Sterling, "Optimized pump scheduling in water distribution systems," Journal of Optimization Theory and Applications, Vol. 83, no. 3, 1994, pp. 463–488
11. M. J. H. Sterling and B. Coulbeck, "A dynamic programming solution to the optimization of pumping costs, in Hybrid genetic algorithm in the optimization of energy costs in water supply networks," ICE Proceedings, Vol. 59, no. 2, 1975, pp. 813–818
12. K. E. Lansey and K. Awumah, "Optimal pump operations considering pump switches," Journal of Water Resources Planning and Management, Vol. 120, no. 1, 1994, pp. 17–35
13. G. McCormick and R. S. Powell, ''Optimal Pump Scheduling in Water Supply Systems with Maximum Demand Charges,'' Journal of Water Resources Planning and

ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM)
Volume 2, Issue 2, May 2015

Management, Vol.129, No. 5, 2003, pp 372–379

14. Rao, G.R.N, Sharma, K.V. Energy conservation opportunities in municipal water supply systems: a case study, Resources, Energy and Development, 9(1), 2012, pp. 35-48
15. E. Stancel, I. Stoian, I. Kovacs, B. Z. Gyurka, Sz. Balogh SC IPA SA Subsidiary Cluj, ‘‘Urban Water Supply Distributed Control System,’’ 1-4244-2577-8/08/$20.00 ©2008 IEEE