

# ENERGY AUDIT OF NAGPUR BOOSTER PUMPING STATIONS AND ITS ENERGY CONSERVATION MEASURES

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## ABSTRACT

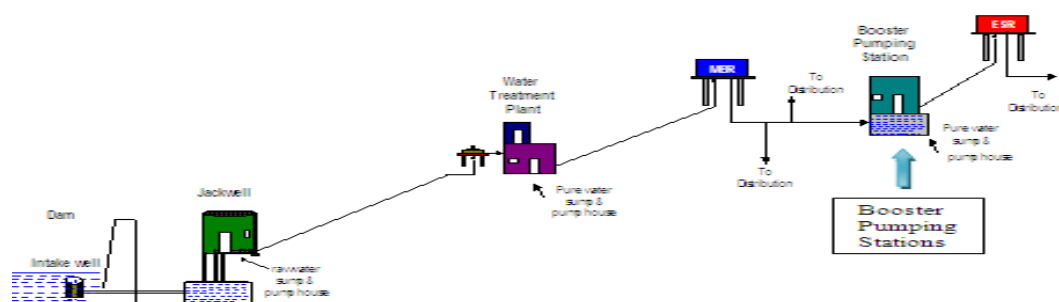
The water Supply system is one of the major functions of urban local bodies in terms of providing safe water to its residents. The energy charges on water supply pumping system also occupy a major portion of the electricity bill. Hence special attention shall be paid for energy conservation in the water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

## I. INTRODUCTION

The Water Supply system is one of the major needs of urban & rural bodies in terms of facilitating 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 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:

**Table No.1: Nagpur BPS Pump Details**

Sr. no.	Location of pump House	No. of pumps	Capacity (HP)	Flow (m <sup>3</sup> /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

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 possibility 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.

## II. 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. Estimate the scope for saving energy. Identified easiest areas for attention.

Necessary technical information collected it includes following:-

1. Details of pump , motor & starter.
2. Pump suppliers and its make, pump efficiency curves,
3. Last 1 year MSEDCL. Electricity bills
4. Pump House Log book record for daily operation
5. Electrical Single Line Diagram
6. Water Flow Diagram
7. Details of Power supply inputs & electrical data.

In Detailed Energy audit, offers a more accurate estimate of energy saving and cost. It considered the interactive effects of all projects ,accounts for the energy use of all major equipments & includes detailed energy cost saving calculations and project cost.

In Detailed Energy Audit 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.

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.

### III. ELECTRICITY BILLS ANALYSIS

Nagpur Booster Pumping Stations MSEDCL Tariff structure applicable. Analysis of Last 12 months electricity Bills of Nagpur Booster Pumping Stations.

Following table shows electricity bills analysis details of Nagpur Booster Pumping Stations:

**Table No.2: Electricity Bills details of Nagpur BPS**

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
	<b>Total</b>		<b>794868</b>			<b>2824572</b>

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.

### III. 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.

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

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

Sr. No.	Location of Pumping Stations	Pump No.	Motor Input Power (kW)	Motor Loading (%)	Discharge Pressure (Kg/cm <sup>2</sup> )	Pump Flow (m <sup>3</sup> /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

## V. 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.

### 5.1 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.

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

Nagpur BPS TOD Rebates				
Sr. No.	Location of Pumping Stations	Present Annual TOD 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		<b>1059706</b>

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.

### 5.2 Savings by Replacing Existing Lamps with Energy Efficient

At Nagpur Booster pumping station installed T12 Lamp. It is proposed to replace these existing lamps with the new energy efficient lamps. The T12 Lamps should be replaced with the T5 Lamps.

**Table No.5: Saving by Energy Efficient Lamp at Nagpur BPS**

Sr. No.	Locations	Annual Savings (kWh)	Energy Saving in Rs.	Investment Cost in Rs.	Simple Payback Period
1	University Campus	841	4457	5200	14
2	Karve Nagar	1261	6686	7800	14
3	Boriyapura	1051	5571	6500	14
4	Wadi tekadi	841	2943	5200	21
5	Jaitala Pump	420	1472	2600	21
	<b>Total</b>	<b>4414</b>	<b>21129</b>	<b>27300</b>	<b>15</b>

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.

### 5.3 Power Factor Improvement

It is imperative to maintain power factor always above 0.90 to avoid unnecessary and high surcharge. 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 Maximum demand and line losses.

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

Nagpur BPS Power Factor Improvement							
Sr. No.	Location	Pre sent Power Factor	Pro posed 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	<b>Maintained Power Factor Unity.</b>			
4	Wadi tekadi	0.913	1	21151	24	38400	21
5	Jaitala	0.95	1	170750	9	14400	1
	<b>Total</b>			<b>424137</b>		<b>140800</b>	4

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 & Jaitala Booster Pumping Stations Electricity Bills Maximum demand is more than contract demand due to which Excess demand charges paid by NMC.

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

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
	<b>Total</b>				<b>207555</b>	<b>117000</b>	7

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.

### 5.4 Efficiency Improvement of pumps by Applying Corrocoat Coating & replacement of internal parts

The efficiency of energy consumption in Nagpur Booster Pumping Stations is low due to inefficient operation & of poor preventive maintenance, Over sizing of equipments or due to ageing process efficiencies of pumping machinery gets deteriorated. Naturally these deteriorated increases the power input & ultimately result in very heavy energy bills.

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

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

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
	<b>Total</b>		<b>27670</b>	<b>130877</b>

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.

## VI. RESULT

As per conducted study, Energy Audit of Nagpur Booster Pumping station to evaluate energy efficiency based on actual measurement using Energy Audit instruments. 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.

- Operation of Booster Pumping Stations pumps working at non peak period.
- Replacement of inefficient T12 Lamps with energy efficient T5 Lamps.
- Nagpur Booster Pumping Stations power factor can be improved to unity by installing capacitors along with APFC panel. Also reduce Maximum demand and line losses.
- It is also important to enhance contract demand of University Campus, Wadi Tekadi & Jaitala Pumping Stations to avoid excess demand charges penalty.
- Saving in Pump Power Consumption by applying Corrocoat powder Coating & replacement of internal parts.

**Table No.9: Energy Conservation Measures for Nagpur BPS**

<b>Nagpur Booster Pumping Station Energy Conservation Measures</b>					
<b>Sr. No.</b>	<b>ECM Description</b>	<b>Estimate of Energy Saving Potential</b>		<b>Estimate of Costs</b>	<b>Cost Benefit Analysis</b>
		<b>Annual Savings (kWh)</b>	<b>Rs. (in Lacs)</b>	<b>Investment Cost</b>	<b>Simple Payback Period</b>
<b>ECMs without Investment (Phase I)</b>					
1	TOD Rebates		10.597		
<b>ECMs with Minor investment (Phase II)</b>					
2	Replacing existing lamps with energy efficient lamps	4414	0.211	0.273	15
<b>ECMs with Medium investment (Phase III)</b>					
3	Power Factor Improvement		4.241	1.408	4
4	Saving by Increasing Contract Demand		2.076	1.17	7
<b>ECMs with Major Investment (Phase IV)</b>					
5	Efficiency Improvement of Pumps by Corrocoat coating & replacement Internal parts	27670	1.30	1.800	17
	<b>Total</b>	<b>32084</b>	<b>18.425</b>	<b>4.651</b>	<b>3</b>

Nagpur Booster Pumping Stations total % saving in annual Electricity Bill using Energy Conservation Measure is 62%. Also saving in annual kWh Consumption due to reduce specific energy input in water supply i.e. kWh/ML.

For optimum utilization automation placed important role. The SCADA system use in Nagpur Booster Pumping Stations for energy efficiency, automatic control of pump daily operation and maintenance activity, cost effective use of Equipment Monitoring of Electrical & Mechanical parameters at Booster Pumping Stations for evaluation system for energy efficiency.

## VII. CONCLUSIONS

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. Also due to low power factor Maximum demand of Booster Pumping Stations increase.
- Nagpur Booster Pumping low power factor effects on overloading of cables and Transformers, Decreased line voltage at point of application & inefficient operation of plants.
- 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.



- There is high energy wastage during operation so energy usage should be properly organized for optimum utilization.
- There is no flow meter installation at Nagpur Booster Pumping Stations on discharge line for determination of actual flow.

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