NEC Consultants (Pvt.) Ltd.

Punjab Cities Governance Improvement Project

Energy Audit & Energy Efficiency Improvement Program for WASAs in Punjab

REPORT
Water Works Faisalabad

March 2016

THE URBAN UNIT
A Public Sector Company.

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Energy Audit & Energy Efficiency Improvement Program for WASAs in Punjab

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Bhp	Brake Horsepower
Cusec	Cubic Feet per Second
Ehp	Electrical Horsepower
Gpm	Gallon Per Minute
Hp	Horsepower
kVA	Kilo Volt Ampere
kW	Kilo Watt
kWh	Kilo Watt Hour
LESCO	Lahore Electric Supply Company
m/s	Meter Per Second
m^3/hr	Cubic Meter Per Hour
MCB	Fuses or Miniature Circuit Breaker
Mm	Millimeter
MS	Mild Steel
Psig	Pound Per Square Inch (Gauge)
RPM	Revolution Per Minute
TDH	Total Dynamic Head
VFD	Variable Frequency Drive
WASA	Water and Sanitation Agency
Whp	Water Horsepower

GLOSSARY

Discharge Pressure	The pressure obtained at center line of pump discharge pipe using a calibrated gauge (psig). Discharge pressure is converted to feet and expressed as “Discharge Head”.
Brake Horsepower	The output horsepower of a motor to a pump; may also be used to refer to the required input horsepower to the pump itself.
Deep Well Turbine Pump	A turbine pump installed inside a well casing below the pumping water level in the well.
Discharge Head	Head measured above center line of pump discharge pipe.
Drawdown	The measured distance that a well’s water level changes from standing/static level to operating pumping level during observed test conditions.
Dynamic Head	The sum of the pressure and the pumping head developed by a pump
Friction Head	The head required to overcome the fluid friction in a pipe or water system
Friction Losses	Energy losses associated with moving water against rough surfaces. In water pumping applications, it is the water pressure lost as a result of contact between moving water and a pipeline or open channel.
GPM per Foot Drawdown	The ratio of capacity (GPM) to drawdown feet is useful in determining the well’s performance.
Head	Alternate term for pressure. One pound per square inch (psi) = 2.31 feet of water head

Overall Plant or Pumping System Efficiency	The ratio of the water horsepower (the overall output of the plant) to input horsepower (the power input). The overall output can also be defined as the amount of horsepower required to deliver the measured capacity (water gallons per minute) and the measured total head.
Pumping Water Level	The well's operating water level below center line of discharge pipe as observed during test condition
Static Water Level	The well's water level obtained when pumping plant is at rest.
Suction Head	Head measured above center line of pump suction intake. Most often obtained with calibrated bourdon tube pressure gauge (suction pressure) and converted to feet by conversion factor 2.31 ft. water/psi
Suction Lift	The distance between pump discharge head and water level.
Total Head	The sum of the water head above and below the center line of the pump discharge pipe. For well applications, the Total Head is the sum of the Discharge Head and the Pumping Water Level. Total head is used in determination of water horsepower and pump performance.
Water Horsepower	The output horsepower of a water pump. It is the combination of flow rate and pressure.

1.0 Introduction

1.1 Background

Government of the Punjab, Pakistan with financial assistance from the World Bank, is implementing "Punjab Cities Governance Improvement Project (PCGIP)" for strengthening systems for improved planning, resource management, and accountability in five large cities of Punjab i.e. Lahore, Faisalabad, Multan, Gujranwala and Rawalpindi.

The project utilizes a result-based approach and, consistent with this focus, the disbursement decisions to the city and its entities are based on achievement of pre-specified results, referred to as Disbursement linked Indicators (DLIs) which reflect priority elements in furthering the Government's urban agenda, critical at the provincial level, within the existing legislative, regulative and policy framework of the Government. DLIs includes intermediate outcomes, incremental steps and results contributing to improved efficiency, effectiveness, accountability and service delivery during and beyond the project life by building capacities , system and processes .

Disbursement Linked Indicator 4 (DLI -4) aims for improvements in own source revenue collection system that encourages the City Local Government (CDGs), Development Authorities (DAs) and Service providers (WASAs) to bring improved systems for revenue enhancement. This DLI is linked with the initiative of WASAs to carry out the Energy Audit for resources conservation and efficiency to improved service delivery, accountability and own source revenue.

One of the proposed actions & initiatives to enhance revenue was to conduct energy audit of WASAs to reduce the power cost by various systematic analysis of the energy use and finding out the energy management opportunities. WASAs each year incur significant cost. It was ***Rs. 4,697 million*** in 2014 year for energy/Electricity bills, with an installed capacity of approximately 131 MW for 5,663 Million Gallons per Day (water management), which can be reduced through detailed energy audit and implementing its findings.

In the context of existing scenario energy audit of WASAs is a technical and efficient way to obtain energy analysis and savings through improvements that optimize pumping systems of tube well stations and disposal stations to operate efficiently with significant cost saving.

The Urban Planning and Management Services Unit, Pvt. Ltd. has assigned NEC Consultants Pvt. Ltd to conduct energy audits of WASAs in Punjab in five major cities of Lahore, Rawalpindi, Faisalabad, Multan and Gujranwala.

This is the energy audit report of **Water Works of Faisalabad city**.

1.2 Methodology

The primary and secondary sources were used to collect data for different WASAs and pumps installed there. The Urban Unit provided information and contact detail of all the WASAs. An energy audit report template was developed to collect field data from each WASA subdivision. Prior to start the on field measurements of each subdivision, meetings were conducted with the respective WASA management and briefed them about the activity. The technical team then collected data by on field measurements of each pump and recorded in their energy audit report template. On the basis of this energy audit report template, The Urban Unit also developed Android based software to record data of each pump online. This data was also recorded on line in this Android based application.
On the basis of field measurements, efficiency of the pumping system was calculated and energy efficiency opportunities were identified.

1.3 Scope

The scope of the this assignment is to conduct energy audits of about 1,600 fresh water supply and wastewater disposal pumps installed at different WASA stations in five major cities of Lahore, Rawalpindi, Multan, Faisalabad and Gujranwala. The detail of these pumps is given in Table-1.

Table-1: Detail of WASAs Pumps

WASA	Population Served (Million)	Total Water Connections	Total Sewerage Connections	Total Supply Stations	Total Disposal Stations	Total No. of Pump Sets
WASA Lahore	5.48	587,595	583,532	491	99	776
WASA Gujranwala	0.54	29,375	97,236	66	23	112
WASA Faisalabad	1.55	110,452	217,002	87	43	222
WASA Multan	1.2	43,996	175,615	102	21	161
WASA Rawalpindi	1.17	92,468	38,437	362	-	362
Total	**9.94**	**863,886**	**1,111,822**	**1,108**	**186**	**1,633**

The efficiency of each pumping system was evaluated and energy efficiency improvement opportunities were identified for those pumping systems whose efficiencies were not at required level. The detail of reports prepared is as under:

- The energy audit report of each pump was prepared.
- On the basis of each pump report, summary report of findings of each WASA subdivision/zone was prepared.
- On the basis of each subdivision/zone summary report, one consolidated report of each city for energy efficiency improvement opportunities of the WASAs was prepared.

2.0 Energy Audit Findings

There are 11 WASA water supply stations in Water Works of Faisalabad city. The detail of these stations along with pumps installed capacity and actual discharge is given in Table-2:

Table-2: Detail of Water Works

#	WASA Station	No. of Water Supply Pumps Installed	Installed Capacity (Cusec)	Actual Discharge (Cusec)
1	Allama Iqbal WATER WORKS P # 100	01	2.00	1.83
2	Allama Iqbal WATER WORKS P # 101	01	2.00	1.21
3	Allama Iqbal WATER WORKS P # 102	01	1.00	1.35
4	Millat Town Water Works High Lift P # 005	01	1.67	1.45
5	Millat Town Water Works High Lift P # 006	01	1.67	1.00
6	Millat Town Water Works High Lift P # 007	01	1.34	1.08
7	Millat Town Water Works High Lift P # 008	01	1.67	1.72
8	Millat Town Water Works P # 001	01	2.00	1.77
9	Millat Town Water Works P # 002	01	1.67	1.86
10	Millat Town Water Works P # 003	01	2.00	1.92
11	Millat Town Water Works P # 004	01	1.67	1.86
	Total	**11**	**18.69**	**17.05**

The installed capacity of WASA pumps of Water Works is 2.78 million m^3 per annum whereas actual discharge is 2.54 million m^3 per annum, for average 4 hours per day operation and 365 days per year. This actual discharge is about 9% lesser than the installed capacity.

2.1 Pumping System Efficiency

Pumping plant performance can be classified as “Low”, “Fair”, “Good”, or “Excellent” by referring to the following table, which is based upon the results of thousands of pump tests conducted by Pacific Gas & Electric Company, USA. This classification is used to categorize WASA pumps.

Table-3: Typical Overall Pumping System Efficiency Classification

Motor HP	Low	Fair	Good	Excellent
3-7.5	<44.0	44-49.9	50-54.9	>54.9
10	<46.0	46-52.9	53-57.9	>57.9
15	<47.1	48-53.9	54-59.9	>59.9
20-25	<48.0	50-56.9	57-60.9	>60.9
30-50	<52.1	52.1-58.9	59-61.9	>61.9
60-75	<56.0	56-60.9	61-65.9	>65.9
100	<57.3	57.3-62.9	63-66.9	>66.9
150	<58.1	58.1-63.4	63.5-68.9	>68.9
200	<59.1	59.1-63.8	63.9-69.4	>69.4
250	<59.1	59.1-63.8	63.9-69.4	>69.4
300	<60	60-64.0	64.1-69.9	>69.9

Source: Pacific Gas & Electric Company, USA

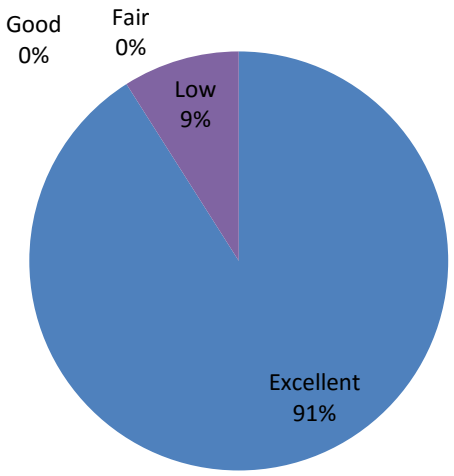
The detail of pumping system efficiency and motor loading of each WASA station is given in Table-4. The calculations for the efficiency determination are given in the energy audit report of each pump in **Annexure-1**.

Table-4: Detail of Motor Loading and Pumping System Efficiency

WASA Station	Motor Load (%)	Pumping System Efficiency (%)	Pumping System Efficiency Rating
Allama Iqbal Water Works P # 100	88	77	EXCELLENT
Allama Iqbal Water Works P# 102	89	66	EXCELLENT
Millat Town Water Works High Lift P# 5	56	67	EXCELLENT
Millat Town Water Works High Lift P # 6	41	61	EXCELLENT
Millat Town Water Works High Lift P # 7	47	66	EXCELLENT
Millat Town Water Works High Lift P # 8	65	69	EXCELLENT
Millat Town Water Works P # 001	86	82	EXCELLENT
Millat Town Water Works P # 2	82	64	EXCELLENT
Millat Town Water Works P # 3	87	78	EXCELLENT
Millat Town Water Works P # 4	82	72	EXCELLENT
Allama Iqbal Water Works P # 101	80	43	LOW

About 91% of the pumps are under excellent category of pumping system efficiency whereas 9% are under low category as illustrated in Fig-1.

Figure-1: Pumping System Efficiency Category



2.2 Electricity Consumption Trend

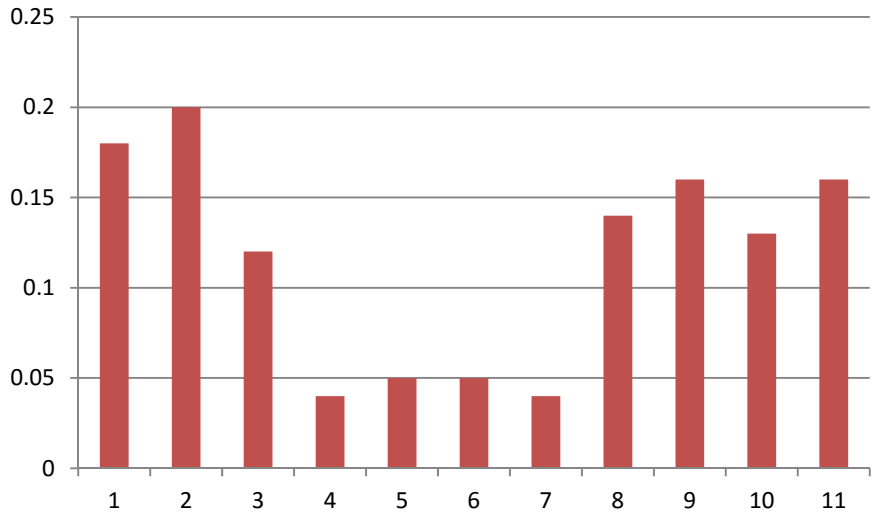
The detail of annual water discharge and correspondingly electricity consumption and unit electricity consumption of each WASA station is given in Table-5.

Table-5: Detail of Water Discharge and Electricity Consumption

#	WASA Station	Annual Water Discharge (m^3)	Annual Electricity Consumption (kWh)	Unit Electricity Consumption (kWh/m^3)
1	Allama Iqbal Water Works P # 100	409,311	72,658	0.18
2	Allama Iqbal Water Works P #101	359,189	70,456	0.20
3	Allama Iqbal Water Works P #102	301,607	36,696	0.12
4	Millat Town Water Works High Lift P # 005	108,223	4,648	0.04
5	Millat Town Water Works High Lift P # 006	148,920	6,850	0.05
6	Millat Town Water Works High Lift P # 007	80,300	3,914	0.05
7	Millat Town Water Works High Lift P # 008	127,750	5,382	0.04
8	Millat Town Water Works P # 001	262,800	37,674	0.14
9	Millat Town Water Works P # 002	277,400	45,013	0.16
10	Millat Town Water Works P # 003	285,430	38,164	0.13
11	Millat Town Water Works P # 004	276,232	45,013	0.16
	Total	**2,637,162**	**366,468**	**0.12**

Total annual energy cost of Water Works is about Rs. 5 million. The unit electricity consumption trend for each WASA station is illustrated in Fig-2.

Figure-2: Unit Electricity Consumption Trend



2.3 Pumping System Efficiency Improvement Potential

The 01 pump having system efficiency in the category of LOW, as given in Table-4, has the potential of efficiency improvement into the GOOD category. Table-6 gives detail of this efficiency improvement potential.

Table-6: System Energy Efficiency Potential of Pumps

WASA Station	Existing Pumping Efficiency **(%)**	Improved Pumping Efficiency **(%)**	Annual Saving (kWh)	(Rs)	Intervention Imp .Adj	Rep & Main	Motor Repl.	Pump Repl.
Allama Iqbal Water Works P # 101	43	59	21,298	276,879	x	x		
Total			**21,298**	**276,879**				

2.4 Interventions for the Improvement of WASA Stations

Energy audit activity of Water Works revealed that there are certain areas of electrical, mechanical and housekeeping which needs improvement. Table-7 presents detail of interventions and investment requirement in each WASA station for better, efficient and safe operation of WASA station.

About Rs. 5.65 million are required to improve WASA stations of Water Works of Faisalabad city.

Table-7: Interventions & Investment Required in WASA Stations- Water Works

Intervention	WASA Stations														
	Allama Iqbal 100	Allama Iqbal 101	Allama Iqbal 102	Millat Town 005	Millat Town 006	Millat Town 007	Millat Town 008	Millat Town 001	Millat Town 002	Millat Town 003	Millat Town 004				
Electrical															
Install VFD	x	x	x	x	x			x	x	x	x				
Install hour meter	x	x	x	x	x	x	x	x	x	x	x				
Replace ampere meter	x														
Replace volt meter															
Replace over current relays															
Replace over voltage relay	x		x	x	x	x	x		x		X				
Install/maintain PFI plant	x	x	x	x	x	x	x				X				
Install/connect capacitors at PFI plant															
Install PFI control/relay															
Install/replace motor terminal box /Improve open and loose motor connection															
Improve panel condition															
Improve wiring condition															
Replace de-rated capacitors															
Relocate panel away from bore hole															
Replace electrical motor															
Install fan in the panel															
Replace PFI HRC fuses															
Replace PFI display meter															
Correct date & time of electrical meter															
Replace/correct electrical meter															
Replace change over															
Replace main circuit breaker															
Mechanical															
Replace damaged/install new flow	x	x		x	x	x	x	x	x	x	X				

Intervention	WASA Stations														
	Allama Iqbal 100	Allama Iqbal 101	Allama Iqbal 102	Millat Town 005	Millat Town 006	Millat Town 007	Millat Town 008	Millat Town 001	Millat Town 002	Millat Town 003	Millat Town 004				
meter															
Replace damaged/install new digital pressure gauge	x	x	x	x	x	x	x	x	x	x	X				
Control gland leakage															
Make operational/install new chlorinator															
Maintain ratchet plate															
Adjust impeller		x													
Repair & maintenance of pump		x													
Replace existing pumping system															
Maintain/install new non return valve	x	x		x											
Housekeeping															
Improve general housekeeping															
Install shades on motor & pump															
Rain protection of motor & pump															
Fix panel properly															
Proper support of discharge pipeline															
Maintain monthly record of fuel consumption															
Station Wise Investment (M. Rs)	0.459	0.825	0.245	0.505	0.485	0.485	0.485	0.525	0.525	0.525	0.585				
Annual Saving (M. Rs)	---	0.277	---	---	---	---	---	---	---	---	---				
Payback (Year)	---	2.98	---	---	---	---	---	---	---	---	---				

ANNEXURE-1

Energy Audit Reports