



NEC Consultants (Pvt.) Ltd.

Punjab Cities Governance Improvement Project

Energy Audit & Energy Efficiency Improvement Program for WASAs in Punjab



REPORT
Rakh Branch Faisalabad

March 2016



THE URBAN UNIT
Urban Sector Planning & Management Services Unit (Pvt.) Ltd.
A Public Sector Company.



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Energy Audit & Energy Efficiency Improvement Program for WASAs in Punjab

March 2016

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LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|-------------------------|------------------------------------|
| 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 |
| m³/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 **Rakh Branch 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 14 WASA water supply stations in Rakh Branch Canal 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 Rakh Branch

| # | WASA Station | No. of Water Supply Pumps Installed | Installed Capacity (Cusec) | Actual Discharge (Cusec) |
|--------------|-------------------------------|-------------------------------------|----------------------------|--------------------------|
| 1 | Tube Well No:01, Mana Wala | 01 | 1.0 | 1.03 |
| 2 | Tube Well No:01, Mansoor Abad | 01 | 1.0 | 0.65 |
| 3 | Tube Well No:02, Madina Town | 01 | 1.5 | 1.62 |
| 4 | Tube Well No:02, Mana Wala | 01 | 1.0 | 1.05 |
| 5 | Tube Well No:03, Madina Town | 01 | 1.0 | 1.14 |
| 6 | Tube Well No:03, Mansoor Abad | 01 | 1.0 | 1.24 |
| 7 | Tube Well No:04, Mansoor Abad | 01 | 1.0 | 1.30 |
| 8 | Tube Well No:04, Madina Town | 01 | 1.0 | 0.83 |
| 9 | Tube Well No:05, Mansoor Abad | 01 | 1.0 | 0.57 |
| 10 | Tube Well No:06, Mansoor Abad | 01 | 1.0 | 1.27 |
| 11 | Tube Well No:07, Mansoor Abad | 01 | 1.0 | 1.36 |
| 12 | Tube Well No:08, Mansoor Abad | 01 | 1.0 | 1.55 |
| 13 | Tube Well No:09, Mansoor Abad | 01 | 1.0 | 1.36 |
| 14 | Tube Well No: 17, Malik Pur | 01 | 1.0 | 0.85 |
| Total | | 14 | 14.50 | 15.82 |

The installed capacity of WASA tube wells of Rakh Branch is 3.24 million m³ per annum whereas actual discharge is 3.53 million m³ per annum, for average 6 hours per day operation and 365 days per year. This actual discharge is about 9% greater 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

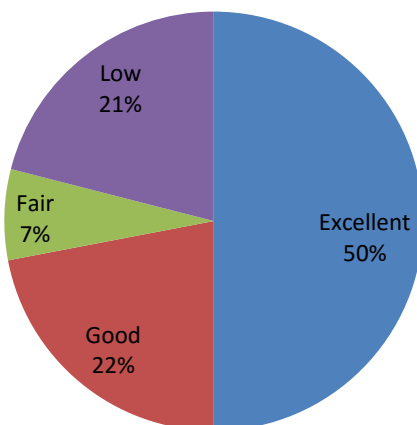
each pump in **Annexure-1**.

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

| WASA Station | Motor Load (%) | Pumping System Efficiency (%) | Pumping System Efficiency Rating |
|-------------------------------|----------------|-------------------------------|----------------------------------|
| Tube Well No:03, Madina Town | 100 | 68 | EXCELLENT |
| Tube Well No:03, Mansoor Abad | 99 | 73 | EXCELLENT |
| Tube Well No:04, Mansoor Abad | 98 | 70 | EXCELLENT |
| Tube Well No:07, Mansoor Abad | 98 | 83 | EXCELLENT |
| Tube Well No:08, Mansoor Abad | 87 | 81 | EXCELLENT |
| Tube Well No:09, Mansoor Abad | 99 | 76 | EXCELLENT |
| Tube Well No:01, Mana Wala | 99 | 62 | EXCELLENT |
| Tube Well No:02, Mana Wala | 84 | 60 | GOOD |
| Tube Well No:06, Mansoor Abad | 92 | 61 | GOOD |
| Tube Well No:02, Madina Town | 100 | 59 | GOOD |
| Tube Well No:01, Mansoor Abad | 58 | 50 | FAIR |
| Tube Well No: 17, Malik Pur | 96 | 41 | LOW |
| Tube Well No:04, Madina Town | 107 | 23 | LOW |
| Tube Well No:05, Mansoor Abad | 63 | 40 | LOW |

About 72% of the tube wells are under excellent and good category of pumping system efficiency whereas 28% are under fair and low category as illustrated in Fig-1.

Figure-1: Pumping System Efficiency Category



2.2 Electricity Consumption Trend

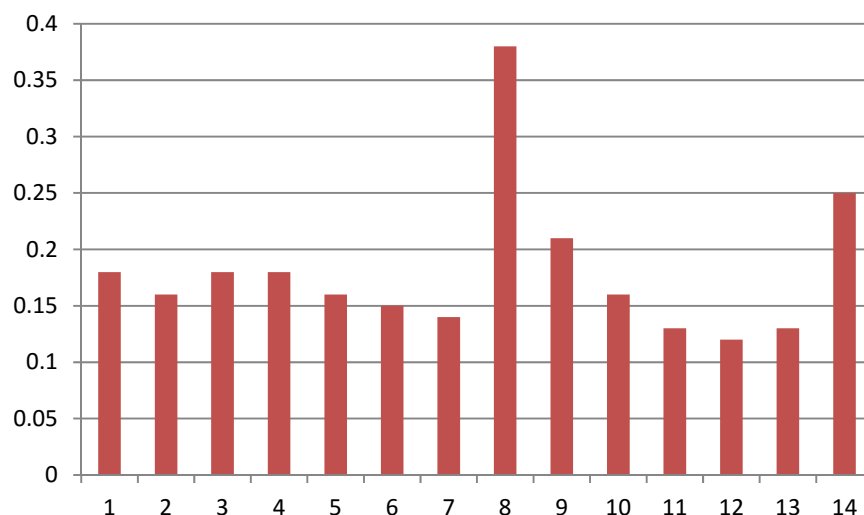
The detail of annual water discharge and correspondingly electricity consumption and unit electricity consumption of each WASA station is given in Table-5.

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 | Tube Well No:01, Mana Wala | 231,352 | 41,026 | 0.18 |
| 2 | Tube Well No:01, Mansoor Abad | 146,730 | 23,933 | 0.16 |
| 3 | Tube Well No:02, Madina Town | 361,350 | 65,722 | 0.18 |
| 4 | Tube Well No:02, Mana Wala | 235,206 | 41,760 | 0.18 |
| 5 | Tube Well No:03, Madina Town | 256,230 | 41,261 | 0.16 |
| 6 | Tube Well No:03, Mansoor Abad | 278,130 | 40,930 | 0.15 |
| 7 | Tube Well No:04, Mansoor Abad | 485,450 | 67,153 | 0.14 |
| 8 | Tube Well No:04, Madina Town | 186,150 | 70,896 | 0.38 |
| 9 | Tube Well No:05, Mansoor Abad | 127,020 | 26,113 | 0.21 |
| 10 | Tube Well No:06, Mansoor Abad | 284,700 | 45,752 | 0.16 |
| 11 | Tube Well No:07, Mansoor Abad | 304,410 | 40,600 | 0.13 |
| 12 | Tube Well No:08, Mansoor Abad | 348,210 | 42,971 | 0.12 |
| 13 | Tube Well No:09, Mansoor Abad | 304,410 | 40,897 | 0.13 |
| 14 | Tube Well No: 17, Malik Pur | 190,180 | 47,631 | 0.25 |
| Total | | 3,739,528 | 636,645 | 0.18 |

Total annual energy cost of Rakh Branch is about Rs. 8 million. The unit electricity consumption trend for each WASA station is illustrated in Fig-2.

Figure-2: Unit Electricity Consumption Trend (Tube Wells)



2.3 Pumping System Efficiency Improvement Potential

The 04 tube wells having system efficiency in the category of FAIR to LOW, as given in Table-4, have 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) | Saving (Rs) | Intervention | | | |
|-------------------------------|---------------------------------|---------------------------------|---------------------|----------------|--------------|------------|-------------|------------|
| | | | | | Imp .Adj | Rep & Main | Motor Repl. | Pump Repl. |
| Tube Well No:01, Mansoor Abad | 50 | 57 | 2,860 | 37,184 | x | | | |
| Tube Well No:04, Madina Town | 23 | 59 | 43,098 | 560,270 | | | x | |
| Tube Well No:05, Mansoor Abad | 40 | 57 | 7,986 | 103,822 | x | X | | |
| Tube Well No: 17, Malik Pur | 41 | 59 | 14,227 | 184,947 | x | X | | |
| Total | | | 68,171 | 886,223 | | | | |

2.4 Interventions for the Improvement of WASA Stations

Energy audit activity of Rakh Branch 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 and safe operation of WASA station.

About Rs. 7.16 million are required to improve WASA stations of Rakh Branch of Faisalabad city.

Table-7: Interventions & Investment Required in WASA Stations- Rakh Branch

| WASA Interventions | | | | | | | | | | | | | | |
|--|-----------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|--------------------------------------|--------------------------------------|-------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|------------------------------------|
| Interventions | Tube Well No:01, Mana Wala | Tube Well No:01, Mansoor Abad | Tube Well No:02, Madina Town | Tube Well No:02, Mana Wala | Tube Well No:03, Madina Town | Tube Well No:03, Mansoor Abad | Tube Well No:04, Mansoor Abad | Tube Well No:04, Madina Town | Tube Well No:05, Mansoor Abad | Tube Well No:06, Mansoor Abad | Tube Well No:07, Mansoor Abad | Tube Well No:08, Mansoor Abad | Tube Well No:09, Mansoor Abad | Tube Well No: 17, Malik Pur |
| Electrical | | | | | | | | | | | | | | |
| Install VFD | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Install hour meter | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Replace ampere meter | | | | | | | | | | x | | | | |
| Replace volt meter | | | | | | | | | | | | | | |
| Replace over current relays | x | x | x | x | x | x | x | x | x | x | x | | x | x |
| Replace over voltage relay | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Install/maintain PFI plant | x | x | x | x | x | x | 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 | | | | | | | | x | | | | | | |
| Install fan in the panel | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Replace PFI HRC fuses | | | | | | | | | | | | | | |
| Replace PFI display meter | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Correct date & time of electrical meter | | | | | | | | | | | | | | |
| Replace/correct electrical meter | | | | | | | | | | | | | | |
| Replace change over | | | | | | | | | | | | | | |
| Replace main circuit breaker | | | | | | | | | | | | | | |

| WASA Interventions | | | | | | | | | | | | | | |
|--|-----------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|--------------------------------------|--------------------------------------|-------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|------------------------------------|
| Interventions | Tube Well No:01, Mana Wala | Tube Well No:01, Mansoor Abad | Tube Well No:02, Madina Town | Tube Well No:02, Mana Wala | Tube Well No:03, Madina Town | Tube Well No:03, Mansoor Abad | Tube Well No:04, Mansoor Abad | Tube Well No:04, Madina Town | Tube Well No:05, Mansoor Abad | Tube Well No:06, Mansoor Abad | Tube Well No:07, Mansoor Abad | Tube Well No:08, Mansoor Abad | Tube Well No:09, Mansoor Abad | Tube Well No: 17, Malik Pur |
| Mechanical | | | | | | | | | | | | | | |
| Replace damaged/install new flow meter | | | | | | | | | x | | | | x | |
| Replace damaged/install new digital pressure gauge | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Control gland leakage | | | | | | | | | | | | | | |
| Make operational/install new chlorinator | | x | | | x | x | x | x | x | x | x | x | x | x |
| Maintain ratchet plate | | | | | | | | | | | | | | |
| Adjust impeller | | x | | | | | | | x | | | | | x |
| Repair & maintenance of pump | | | | | | | | | x | | | | | x |
| Replace existing pumping system | | | | | | | | | | | | | | |
| Maintain/install new non return valve | | | | | | | | | | | | | | |
| Housekeeping | | | | | | | | | | | | | | |
| Improve general housekeeping | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Install shades on motor & pump | | | | | | | | | | | | | | |
| Rain protection of motor & pump | | | | | | | | | | | | | | |
| Fix panel properly | | | | | | | | | | | | | | |
| Proper support of discharge pipeline | | | | | | | | | | | | | | |
| Maintain monthly record of fuel consumption | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Station Wise Investment (M. Rs) | 0.41 | 0.38 | 0.54 | 0.40 | 0.31 | 0.31 | 0.31 | 1.06 | 0.83 | 0.43 | 0.31 | 0.38 | 0.56 | 0.94 |
| Annual Saving (M. Rs) | - | 0.04 | - | - | - | - | - | 0.49 | 0.10 | - | - | - | - | 0.18 |
| Payback (Year) | - | 10.17 | - | - | - | - | - | 2.17 | 7.98 | - | - | - | - | 5.10 |
| Total Investment (M. Rs)=7.16 | | | | | | | | | | | | | | |

ANNEXURE-1

Energy Audit Reports