Muridke Municipal Committee

Energy Audit Report

June 2023

History of the Document

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The Consultant is also grateful to entire Muridke Municipal Committee representatives for their support extended during the field study.

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ABBREVIATIONS

AC	Air Conditioner
ASD	Adjustable speed drive
BHP	Brake Horsepower
BOQ	Bill of Quantities
CEN	Committee for European Standardization
CFL	Compact Fluorescent Lamp
CO	Chief Officer
CTS	Complaint Tracking System
DCS	Distributed control system
DISCO	Distribution Company
EE	Energy Efficiency
ESMAP	Energy Sector Management Assistance Program
GHG	Green House Gases
GIS	Geographical Information System
GOPb	Government of Punjab
GST	General Sales Tax
HP	Horsepower
ICB	International competitive bidding
ID	Internal Diameter
IES	Illuminating Engineering Society
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicator
LED	Light Emitting Diode
LESCO	Lahore Electric Supply Company
MC	Municipal Committee
N/A	Not available
NG	Natural Gas
NRV	No Return Valve
O&M	Operation and Maintenance
OD	Outer Diameter
PCP	Punjab Cities Program
PF	Power Factor
PHED	Public Health Engineering Department
PKR	Pakistani Rupee
PMDFC	Punjab Municipal Development Fund Company
PMS	Performance Management System
Pumpset	Pump + Motor
QA	Quality Assurance
RPM	Revolutions per minute
SOP	Standard Operating Procedure
TMA	Tehsil Municipal Authority
TWEIP	Tubewell Efficiency Improvement Project
USAID	United States Agency for International Development
USD	US Dollar $
WBG	World Bank Group
WD	Wheel Drive

UNITS OF MEASUREMENTS

Description	UOM
Ampere	A
Calorific value	CV
Days	d
GCV	Gross Calorific Value
NCV	Net Calorific Value
Hours	h
Horsepower	HP
Hertz	Hz
Kilogram	Kg
Kilo Volt Amperes	kVA
Kilo Watt-hour	kWh
Liters	L
Cubic Meter	m^3
Meter	m
Pressure	Bar, PSI
Power Factor	PF
Parts per million	ppm
Revolutions Per Minute	rpm
Voltage	V
Year(s)	y
Pakistani Rupee	PKR
millimeter	mm

CONVERSION FACTORS

Parameters	Unit	Value	Source
Emission factor Petrol	tonne CO_2/GJ	0.0561	IPCC Default Value
Emission factor Diesel	tonne CO_2/GJ	0.0741	IPCC Default Value
Emission factor Natural Gas	tonne CO_2/GJ	0.0631	IPCC Default Value
Emission factor Grid	tonne CO_2/GJ	0.5823	Determined based on the power generation and fuel consumption data provided in Pakistan Energy Yearbook-2017-18

BASELINE PARAMETERS

Parameters	Unit	Value	Source
Costs			
• Petrol	PKR/liter	272.00	Shell Pakistan
• Diesel	PKR/liter	293.00	Shell Pakistan
Exchange Rate	PKR/US$	280.20	State Bank of Pakistan, Average rate for March 2023

1 Summary

1.1 Background

The Punjab Cities Program (PCP) is a World Bank-funded hybrid of Program for Results (PforR) and Investment Project Financing (IPF) operation. It is a USD 200 million 5 years (2018 -2023) program supporting 16 cities in Punjab. The main objective of the program is to strengthen the performance of participating Municipal Committees/Corporations (MCs), focusing on urban management and improvement of municipal infrastructure for satisfactory service delivery.

Under the PforR (Window-1) the Performance Based Grants (PBGs) are being provided to the MCs of the 16 selected cities for investments in municipal infrastructure and services.

The IPF (Window-2) is supporting provincial government agencies i.e. Local Government & Community Development Department (LG&CDD), Punjab Local Government Board (PLGB), Punjab Municipal Development Fund Company (PMDFC), and PFC Unit of Finance Department (FD).

1.2 Scope of work

As per the scope of work specified in the Terms of Reference of the project, the Consultant is required to:

a) develop a detailed work program for carrying out the works immediately after mobilizing
b) prepare an inventory of relevant assets owned/operated by the MC, including municipal buildings, vehicles, streetlights, and water-supply/wastewater disposal pumps
c) collect additional information on location (where applicable), performance and energy consumption analysis, estimation of expenditure incurred
d) provide detailed information for each asset, and an overall inventory and analytical report discussing key performance indicators
e) identify energy saving opportunities, and provide saving potential (in energy and monetary terms) for each opportunity, estimated investment costs and return on investments, engineering plans, and Bill of Quantities, as needed.

1.3 Process of the Energy Efficiency Assessment and Structure of the Report

During the information and data gathered during the on-site assessment, detailed analysis was carried out to determine the baseline energy consumption, energy efficiency of pumpsets, fuel consumption by vehicles and developed KPI's for pumpsets, streetlights, vehicles and buildings. Based on this analysis several energy efficiency measures have been identified and summary of potential savings for each measure (in energy and monetary terms) along with estimated investment costs and payback period is given in Section 6.

1.4 Muridke MC Background

The city of Muridke is located at 31°45'35'' N 73°50'16'' E and has an elevation of 205 m (675 ft). It is situated on the famous Grand Trunk road at the crossroads to Sheikhupura, Gujranwala and Narang Mandi/Narowal. The Administration consists of Administrator, Chief Officer and 4 Municipal Officers to provide basic services to its customers i.e. town planning, water supply, sewerage, streetlights, roads, regulate markets, issue permits and licenses etc. The Muridke MC has the following management.

Sr. No.	Name of Officer	Designation
1	Dr. Zainab Tahir	Administrator
2	Mr. Sheharyar	Chief Officer
3	Mr. Hasneen Hafeez*	Municipal Officer (Infrastructure)

Sr. No.	Name of Officer	Designation
4	Mr. Tariq Mehmood	Municipal Officer (Regulation)
5	Mr. Muhammad Iqbal	Municipal Officer (Finance)
6	Ms. Momina Akram	Municipal Officer (Planning)

*Main Focal Person in the MC for the energy audit exercise

1.4.1 Baseline Energy Consumption of Muridke

The table given below provides a synopsis of electricity consumed by tubewells, wastewater disposals, MC buildings, streetlights, and fuel consumption of MC Vehicles in Muridke, Punjab.

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	1,030,395
Electrical energy used by Wastewater Disposal[2]	kWh/year	2,560
Electrical energy used in Buildings[3]	kWh/year	103,381
Electrical energy used by Streetlights[4]	kWh/year	56,197
Fuel used by Vehicles	liter/year	173,472

1.5 Key Performance Indicators

Key Performance Indicators (KPIs) are measurable values that demonstrate how effectively a system is achieving its key intended objectives. Key performance indicators of potable water, wastewater, streetlights, vehicles and buildings are tabulated in the following sections.

1.5.1 Potable Water & Wastewater Pumps

Table 2: KPIs for Potable Water & Wastewater pumps

Sr. No.	Description	Unit	KPI
1	Energy Density of Potable Water Production	(kWh/m^3)	0.17
2	Energy Density of Wastewater Disposal	(kWh/m^3)	Wastewater is disposed by gravity in Daig Nallah in dry weather and hence no energy is used. Pumping is done when the water level in Daig Nallah rises during floods.
3	Energy Density of Wastewater Treatment	(kWh/m^3) – if applicable	No wastewater treatment is carried out.
4	Energy Cost on Potable Water Production	(PKR/m^3)	7.69
5	Energy Cost on Wastewater Disposal	(PKR/m^3)	Wastewater is disposed by gravity in Daig Nallah in dry weather and hence no energy is used. Pumping is done when the water level in Daig Nallah rises during floods.
6	Energy Cost on Wastewater Treatment	(PKR/m^3) – if applicable	No wastewater treatment is carried out.

[1] Based on 12-month historical billing data
[2] Based on 12-month historical billing data
[3] Based on 12-month historical billing data
[4] Based on 12-month historical billing data

1.5.2 Streetlights

Table 3: KPIs for Streetlights

Sr. No.	Description	Unit	KPI
1	Average electricity consumed per kilometer	(kWh/km)	6,545
2	Annual average electricity consumed per light pole/fixture	(kWh/year/fixture)	282
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	45,599
		PKR/Lighting Equipment	41,940
4	Average cost of installation of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	1,254
		PKR/Lighting Equipment	370
5	Average annual maintenance costs	(PKR)	39,547
6	Average daily duration of operation	(Hours/day)	13.3
7	Average energy costs per kilometer of lit roads	(PKR/km)	294,541
8	Average energy costs per light pole/fixture	(PKR/fixture)	12,708
9	Number and percentage of failed public lights (Total)	%	46%
10	Number and percentage of failed public lights (MC Operated)	%	52%
11	Number and percentage of failed public lights (Privately Operated)	%	8%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	35.39
2	Municipal Buildings Heat Consumption	(kWh/m^2)	8.99
3	Average Energy Cost of Heating	(PKR/m^2)	74
4	Average Energy Cost of Cooling	(PKR/m^2)	660
5	Average Energy Cost of Lighting	(PKR/m^2)	424

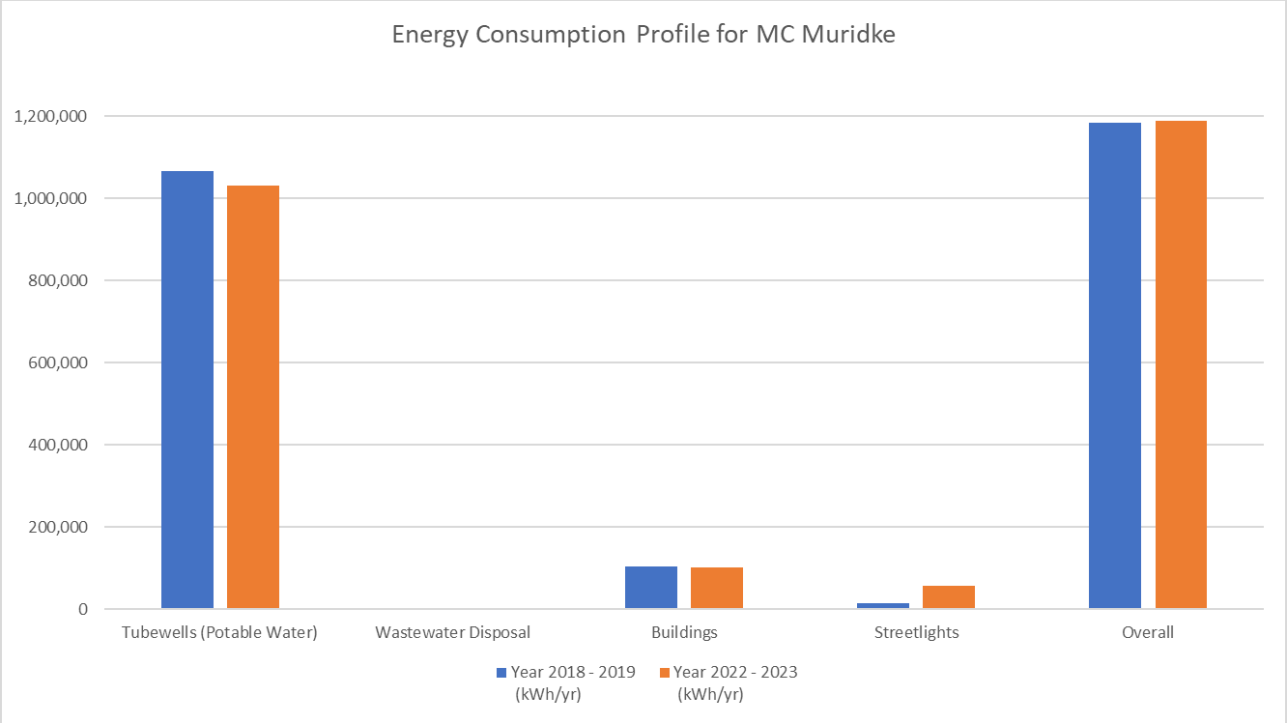
1.5.4 Vehicles

Table 5: KPIs for Vehicles

Sr. No	Description	Unit	KPI
1	Fuel consumption for staff transport vehicles	km/Liter	Cannot be Determined
2	Fuel consumption for solid/liquid waste transport	km/Liter	4.90
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	60

1.6 Impact of Energy Efficiency Investment

The following section provides an overview of the performance of various asset groups, compared to their performance assessed during the baseline audit in 2019, to gauge the impact of various energy efficiency investments carried out by the MC.


Energy Consumption Profile for MC Muridke
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Tubewells (Potable Water)
Wastewater Disposal
Buildings
Streetlights
Overall
Year 2018 - 2019 (kWh/yr)
Year 2022 - 2023 (kWh/yr)

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	16	17	1,066,606	1,030,395	36,211	0.19 kWh/m3	0.17 kWh/m3	Replacement of 12 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 9 pumps which has resulted in significant reduction in the KPI for water supply. The effect of this reduction is reflected in the energy bills for the MC as well.
2	Wastewater Disposal								No performance could be carried out on disposal stations because as per the MC focal person, these pumps are operated by the PHED and that only during the rainy season.
3	Buildings	2	3	102,656	100,564	2,092	53.93 kWh/m2	52.66 kWh/m2	MC's slaughterhouse in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of the salughterhouse has not been considered in the overall energy consumption and KPI calculations.

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	**Parameter**	**Year 2018 - 2019**	**Year 2022 - 2023**	**Year 2018 - 2019 (kWh/yr)**	**Year 2022 - 2023 (kWh/yr)**	**kWh/yr**	**Year 2018 - 2019**	**Year 2022 - 2023**	**Comments**
4	Streetlights	12	107	13,928	56,197	-42,269	1,288 kWh/km	6,545 kWh/km	Based on the previous assessment, there were only 12 operational lights with an average consumption of 1,160kWh/light/annum, whereas, currently there are 107 operational lights with average energy consumption of 525kWh/light/annum. Therefore, even though the overall energy consumption and the KPI/km for streetlights have increased, the MC has significantly improved the energy consumption per light fixture. Since the overall area covered by lighting equipment does not change significantly, the improvement in energy consumption is not reflected in the KPI.
	Overall	30	127	1,183,190	1,187,156	-3,966			

1.7 Energy Efficiency Recommendations Matrix

For all municipalities, the recommended EE measures are categorized into high, medium and low priority measures. High priority EE measures are those which shall be implemented immediately (within 1 year) to meet the baseline demand, medium term measures may be implemented in the near future (within 2-3 years' time) and low priority measures may be implemented in the remote future (within 3-5 years' time).

1.7.1 Energy Efficiency Recommendations Matrix

Table 6: High Priority Measures

High Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Development of New Bore & Replacement of Pumpset at (Pera Mandi - Unique ID: 5264015)	13,204	6,949	1,947,002	2,121	594,187	39	7
Replacement of Pumpset at (Supply Scheme #16 - Itahad Colony - Unique ID: 5260419)	24,941	4,026	1,128,002	4,005	1,122,336	12	13
Replacement of Pumpset at (Supply Scheme #2 - Nizam Park - Unique ID: 5274021)	8,281	3,608	1,011,002	1,330	372,643	33	4
Replacement of Pumpset at (Supply Scheme #4 - Mohallah Shaikhan - Unique ID: 5274023)	7,577	3,608	1,011,002	1,217	340,949	36	4
Replacement/Installation of Capacitors	Not Quantifiable	1,350	378,270	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	9,293	2,603,794	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	3,428	715	200,370	551	154,272	16	2
Total:	**57,431**	**29,548**	**8,279,442**	**9,223**	**2,584,386**		**29**

Table 7: Low Priority Measures

Low Priority Energy Efficiency Measure	Water Savings m^3/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Installation of Flow meters integrated with a centralized DCS system	66,332	13,500	3,782,700	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Total:	66,332	13,500	3,782,700	0	0	0	0

2 Water Pumps and Disposals

Muridke MC has seventeen (17) tubewells for groundwater, all of which are manually operated. All of the pumpsets were found to be in operating condition.

The MC has one (1) disposal station having 5 pumps. However, the pumps are only operated during monsoon season. The pumps are used to dispose the wastewater to the nearby drain. There are five (05) dewatering sets in the MC out of which four (4) are functional. No record of their fuel consumption and operational hours is being maintained by the MC.

During the onsite audits, inventories of all water supply and disposal pumps installed/operated by the MCs were developed, which carried details of GPS Location/geo-tag, primary function (classification between water and wastewater pumps) and name plate data of each pump-motor set, where available (see Section 2.1 for details). The audit team recorded details of design parameters for each pumpset, such as pump efficiency at design flow and head, pump performance curve, motor rated power, motor efficiency at design load, motor power factor at full load from the plates if attached or legible; it performed field performance tests for each pumpset starting with measurement of flow, static water level & pumping water level; furthermore, the draw down, system head and frictional losses were also computed; the team also measured motor power factor, power inputs (Volts, Power Factor, Amperes and Kilowatts), motor & bearing vibrations, motor winding and bearing temperature.

The team was unable to

(i) Determine site load (water demand) and its comparison with pump capacities due to unavailability of relevant data

(ii) Determine system resistance and duty point on six sites since the Sluice valves were either jammed or broken.

(iii) Determine pump performance at Pera Mandi (Unique ID: 5264015) as no flow could be detected due to extremely low flow rate of water in the pipe.

(iv) Undertake audit of 5 disposal pumpsets as the Ravi Ryan Dake Disposal station is only operated during monsoon season

1. Ravi Ryan Dake Disposal (Unique ID: 520535-A)
2. Ravi Ryan Dake Disposal (Unique ID: 520535-B)
3. Ravi Ryan Dake Disposal (Unique ID: 520535-C)
4. Ravi Ryan Dake Disposal (Unique ID: 520535-D)
5. Ravi Ryan Dake Disposal (Unique ID: 520535-E)

Based on the analysis of collected and measured data, pumpset efficiencies were calculated at the current operating conditions; detail is given in Section 2.4. In light of the field audit and energy efficiency analysis, energy saving opportunities have been identified which are discussed in Section 2.5. However, it should be noted that while the efficiencies of the pumpsets are based on field operating conditions, recommendations concerning their replacement (where applicable) are open to discussion with PMDFC, as other factors may also impact their operational efficiency.

2.1 Inventory for water and wastewater pumping equipment

The detailed inventory for tubewells, wastewater disposals and dewatering sets is tabulated below.

2.1.1 Tubewells

Table 8: Inventory of Tubewells/Water Pumps (Potable Water)

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	Year of Motor Manufacturing	Latitude	Longitude
1	5250003	Lari Adha	45-11641-0331400	Turbine	KSB	2020	Siemens	2020	31.808611	74.248333
2	5250410	Qazzafi Park	45-11641-0331300	Turbine	KSB	2020	Siemens	2020	31.808172	74.2512
3	5240411	Old Dawke Muridkay	44-11641-0157601	Turbine	KSB	2020	Siemens	2020	31.815833	74.248056
4	5264014	Hadokay Mohallah	44-11641-0157702	Turbine	KSB	2020	Siemens	2020	31.806667	74.246667
5	5264015	Pera Mandi	45-11641-0331100	Turbine	KSB	1979	Siemens	1979	31.801944	74.251389
6	5264016	Canal Park	45-11641-0331000	Turbine	KSB	2021	Siemens	2021	31.798056	74.253333
7	5264017	Mohallah Rehmania Colony	44-11641-0146902	Turbine	KSB	1998	Siemens	1998	31.786111	74.254444
8	5264018	Mohallah Basra Colony	45-11641-0340100	Turbine	KSB	2020	Siemens	2020	31.784444	74.251667
9	5260419	Itahad Colony	44-11641-0000403	Turbine	Flow Pak	2015	Siemens	2015	31.779444	74.253333
10	5274025	Water Supply Faisal Colony-Bilal Park	24-11641-0001115	Turbine	KSB	2021	Siemens	2021	31.79000	74.253889
11	5250414	Rehman Pura	45-11642-0354600	Turbine	KSB	2021	Siemens	2021	31.810833	74.256667
12	5274021	Nizam Park	44-11642-0169601	Turbine	KSB	2006	Siemens	2006	31.791389	74.259722
13	5274023	Mohallah Shaikhan	45-11642-0354500	Turbine	KSB	2017	Siemens	2017	31.8025	74.257222
14	5250412	Muridkay Town	45-11642-0356500	Turbine	KSB	2020	Siemens	2020	31.801389	74.264444
15	5250413	Hassan Park	45-11642-0356600	Turbine	KSB	2017	Siemens	2017	31.809722	74.266667
16	5274020	Old Committee Office	45-11642-0354800	Turbine	KSB	2020	Siemens	2020	31.80000	74.260000
17	5274022	Ahmad Pura	45-11642-0354700	Turbine	Flow Pak	2017	Siemens	2017	31.796667	74.260278

2.1.2 Dewatering Sets

Table 9: Inventory of Dewatering Set

Sr. No.	Unique Id	Location	Quantity	Latitude	Longitude
1	5274020 A	MC Building	2	31.80868	74.25280
2	5274020 B	Mohalla Qaddafi park near underpass	1	31.80284	74.25449
3	5274020 C	Canal Park Muridke	2	31.79202	74.25544

2.1.3 Disposal Works

Table 10: Inventory of Disposal Works

Sr. No.	Unique ID	Location	Meter Reference No	Pump Type	Pump Capacity Cusec	Pump Manufacturer	Motor Manufacturer	Motor Capacity (hp)	Latitude	Longitude
1	520535-A	Ravi Ryan Dake Disposal	24-11643-0009307R	Centrifugal	10	KSB	Siemens	100	31.07305	74.26000

Sr. No.	Unique ID	Location	Meter Reference No	Pump Type	Pump Capacity Cusec	Pump Manufacturer	Motor Manufacturer	Motor Capacity (hp)	Latitude	Longitude
2	520535-B	Ravi Ryan Dake Disposal	24-11643-0009307R	Centrifugal	10	KSB	Siemens	100	31.07305	74.26000
3	520535-C	Ravi Ryan Dake Disposal	24-11643-0009307R	Centrifugal	10	KSB	Siemens	100	31.07305	74.26000
4	520535-D	Ravi Ryan Dake Disposal	24-11643-0009307R	Centrifugal	5	KSB	Siemens	75	31.07305	74.26000
5	520535-E	Ravi Ryan Dake Disposal	24-11643-0009307R	Centrifugal	5	KSB	Siemens	75	31.07305	74.26000

2.2 GIS Map of water pumps/Tubewells & wastewater disposals in Muridke, Punjab

GIS Map indicating location of tubewells, wastewater disposals and dewatering sets is shown in figure below. The red points show the tubewells spread across the MC and the black color is assigned to disposal works.

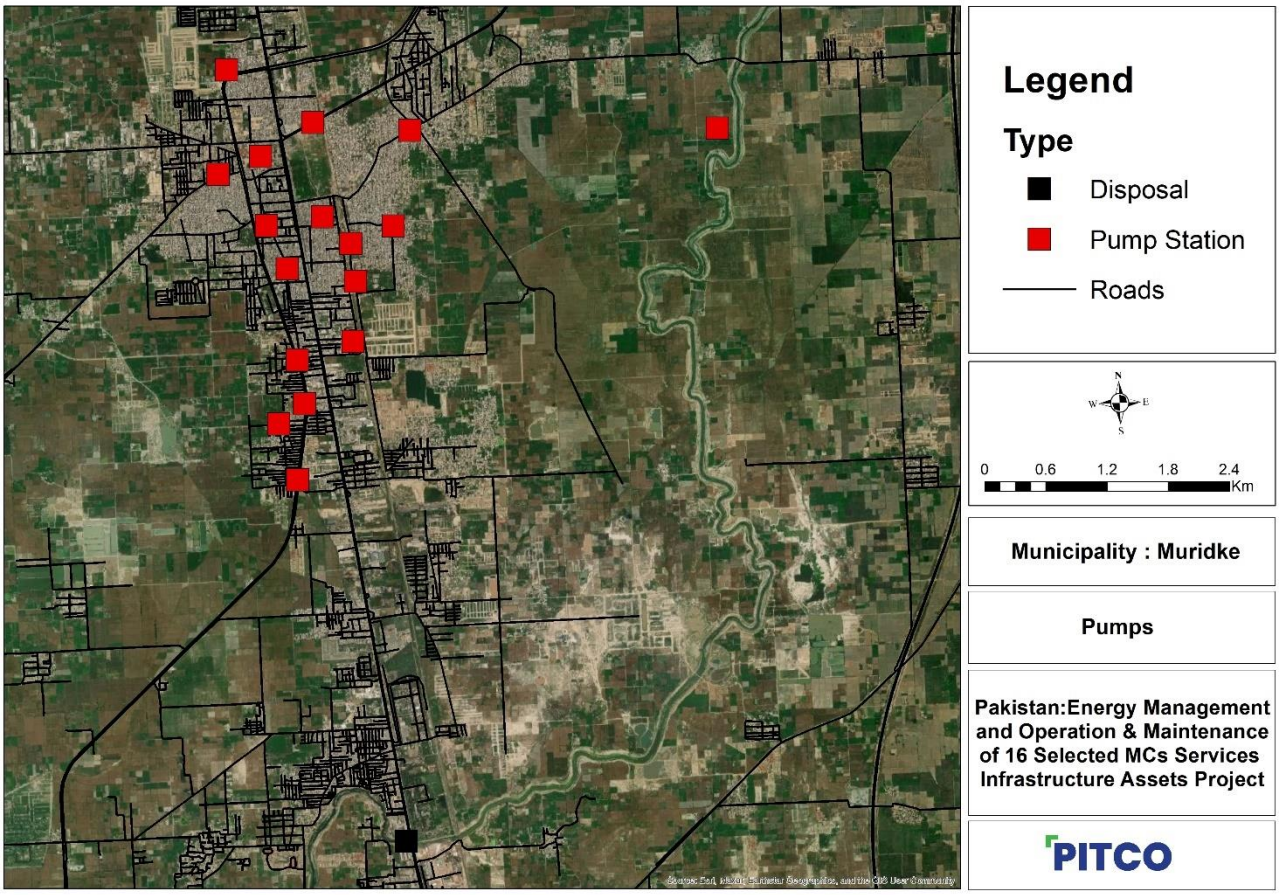


Figure 1: Map for Pumps and Disposal at MC Muridke

2.3 Baseline Energy Consumption Trend

The electricity consumed by tubewells & wastewater disposals is as follows.

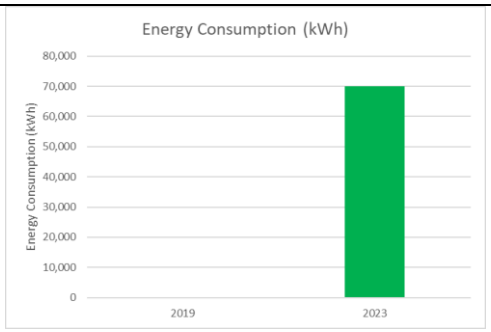
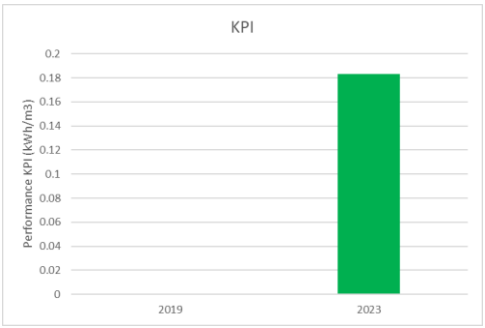
Table 11: Baseline Energy Consumption Trend

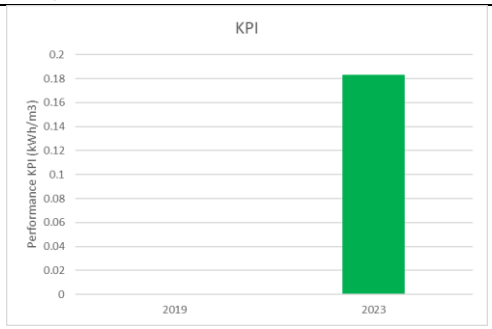
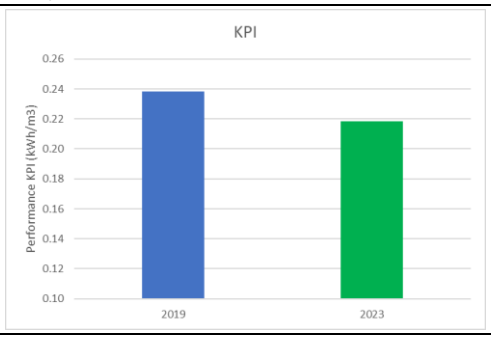
Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	1,030,395
Electrical energy used by Wastewater Disposal	kWh/y	2,560
Electrical energy used (Total)	kWh/y	1,032,955

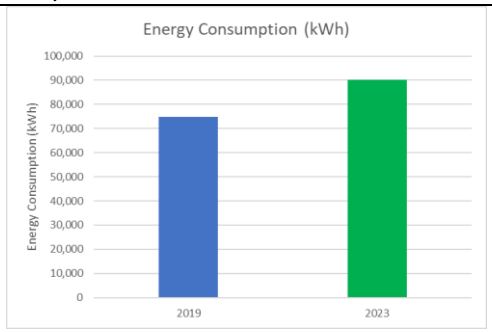
A comparison of current electricity consumption by the MC's water supply and disposal assets compared to results of the energy audit activity carried out in 2019, is presented in the following table:

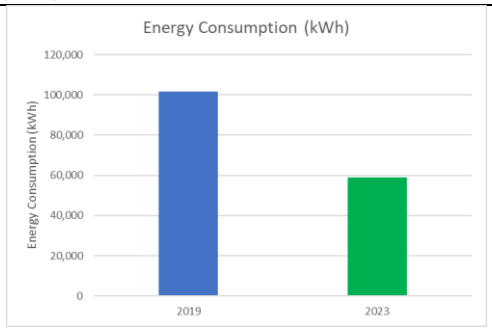
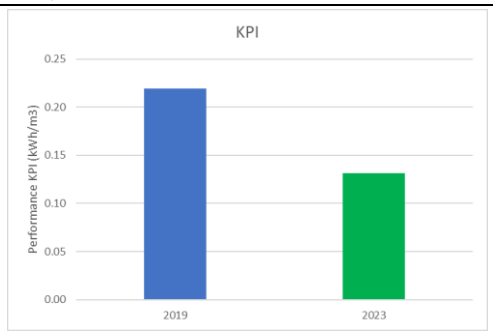
		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	16	17	1,066,606	1,030,395	36,211	0.19 kWh/m3	0.17 kWh/m3	Replacement of 12 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 9 pumps which has resulted in significant reduction in the KPI for water supply. The effect of this reduction is reflected in the energy bills for the MC as well.
2	Wastewater Disposal								No performance could be carried out on disposal stations because as per the MC focal person, these pumps are operated by the PHED and that only during the rainy season.

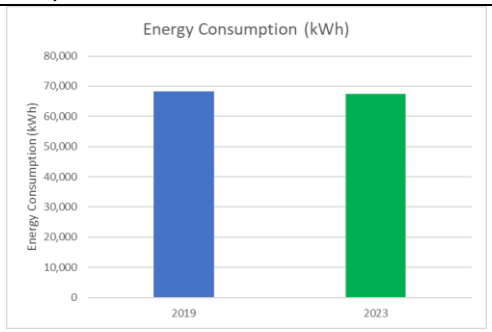
Replacement of 12 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken installation of 9 new pumpsets. A discussion on each newly installed asset is presented below:

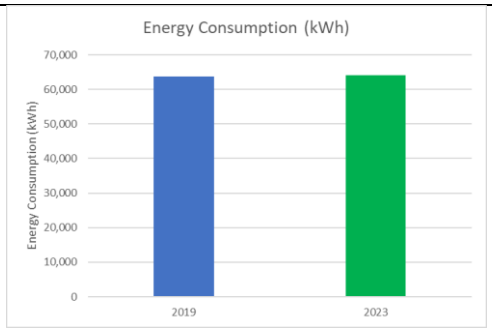
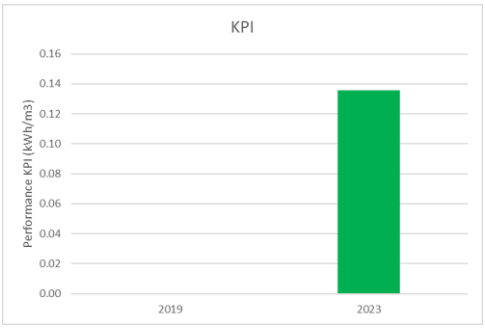
Bus Adda Muridke - Unique ID (5250003)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	70,100 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
#N/A	0.18 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, this site was abandoned by the MC and there were no billing details available. No KPI has been calculated for the 2019 audit as pump performance could not be carried out in the previous audit.	

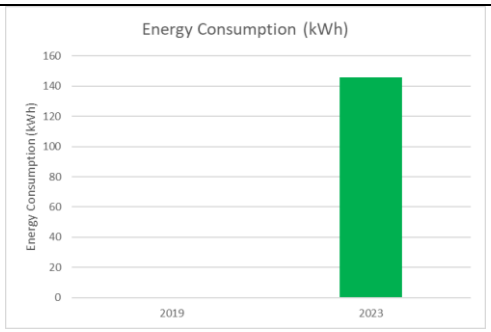
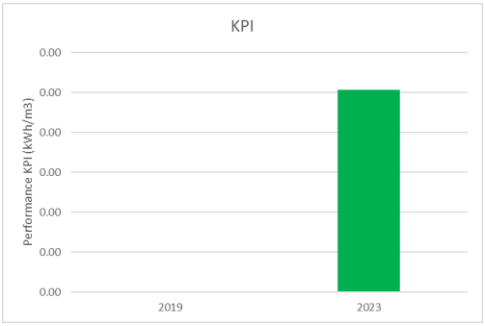
Supply Scheme #10 - Mohala Qadafi park - Unique ID (5250410)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
80,876 kWh	72,616 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.24 kWh/m3	0.22 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of new pumpset and bore was recommended due to low efficiency and detection of sand traces in the water. Annual energy consumption of this pumpset in 2019 was 80,876 kWh whereas, annual energy consumption of this pumpset of current year is 76,616 kWh with an annual energy savings of 8,260 kWh.	

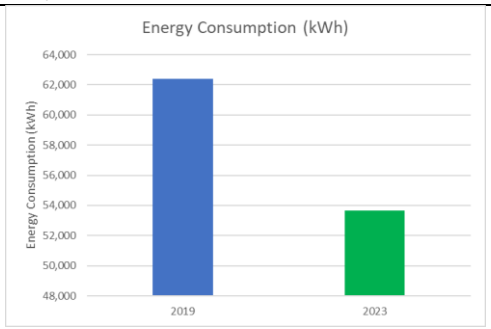
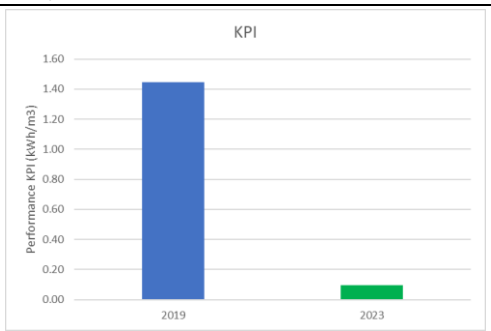
Supply Scheme #8 - Old Dawke Muridke - Unique ID (5240411)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
74,793 kWh	90,075 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.19 kWh/m3	0.18 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of new pumpset was recommended due to low efficiency. Although the energy consumption of this site has increased, the corresponding water supply to the MC from this pumpset has increased as well. As seen from the KPI, the new pumpset is performing more efficiently.	

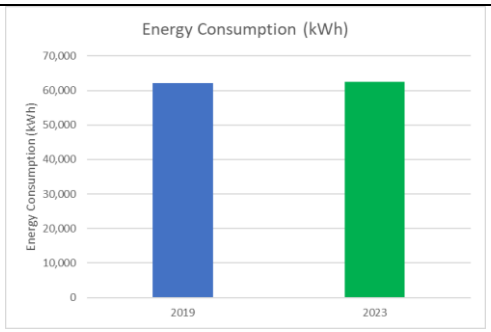
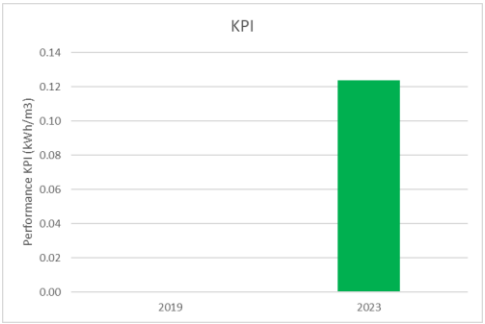
Hadokay Mohallah - Unique ID (5264014)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
101,498 kWh	58,810 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.22 kWh/m3	0.13 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of new pumpset was recommended due to low efficiency. Annual energy consumption of this pumpset in 2019 was 101,498 kWh whereas, annual energy consumption of this pumpset of current year is 58,810 kWh with an annual energy savings of 42,688 kWh.	

Mohallah Canal Park - Unique ID (5264016)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
68,317 kWh	67,395 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.22 kWh/m3	0.14 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of new pumpset and bore was recommended due to low efficiency and choked bore. Annual energy consumption of this pumpset in 2019 was 68.317 kWh whereas, annual energy consumption of this pumpset of current year is 67,395 kWh with an annual energy savings of 922 kWh. There is a significant improvement in the efficiency of the pumpset which is clearly indicated from the KPI.	

Mohallah Bassra Colony - Unique ID (5264018)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
63,648 kWh	64,158 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
#N/A	0.14 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, complete assessment of the pumpset could not be completed due to choked bore. As seen from the KPI, the new pumpset is performing efficiently.	

Water Supply Faisal Colony- Bilal Park - Unique ID (5274025)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
#N/A	146 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
#N/A	#N/A
	
Comments:	
New pumpset and bore has been installed on the new location however, the recorded flow is too low for a new pump with full open gate valve. The Consultant has recommended to get this pumpset rechecked by the pump manufacturer/supplier. There are no accurate billing details available for this pumpset.	

Mohallah Rehman Purah - Unique ID (5250414)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
62,375 kWh	53,678 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
1.45 kWh/m3	0.09 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of new pumpset and bore was recommended due to low efficiency and choked bore. Annual energy consumption of this pumpset in 2019 was 62,375 kWh whereas, annual energy consumption of this pumpset of current year is 53,678 kWh with an annual energy savings of 8,260 kWh.	

Muridke Town - Unique ID (5250412)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
62,119 kWh	62,457 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
#N/A	0.12 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, complete assessment of the pumpset could not be completed due to choked bore. As seen from the KPI, the new pumpset is performing efficiently.	

2.4 Observations and Recommendations

The share of each pumpset in the total water generation and total electricity consumption is illustrated in the figure below.

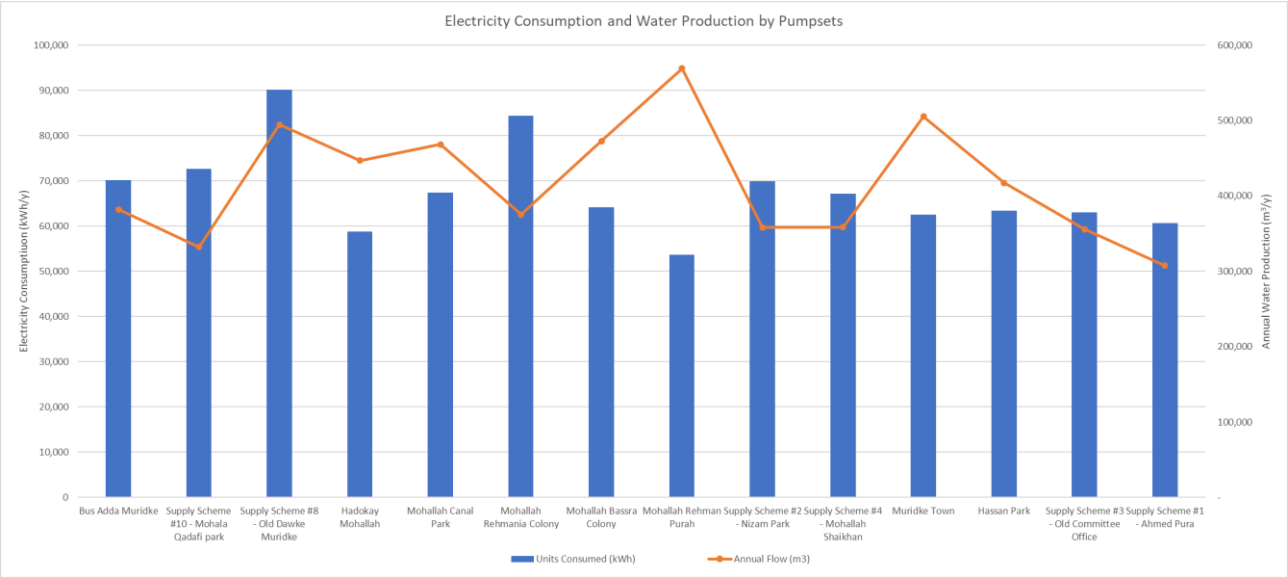
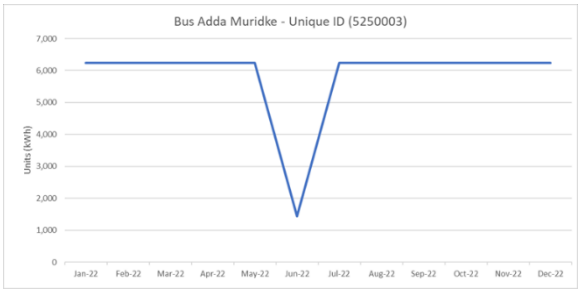


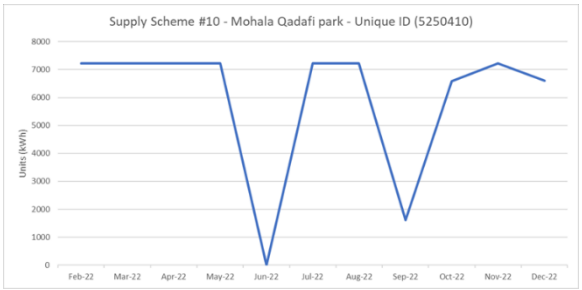
Figure 2: Electricity Consumption and Water Production by Pumpsets

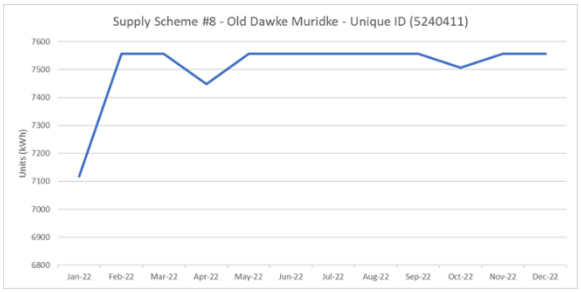
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance could be carried out and complete billing details were available.

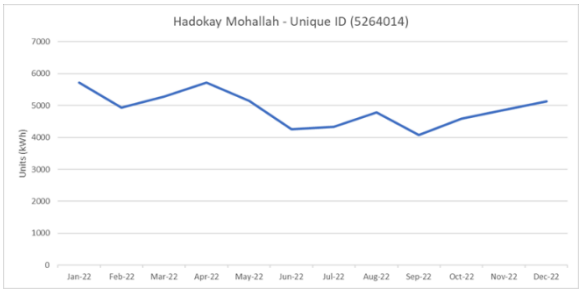
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

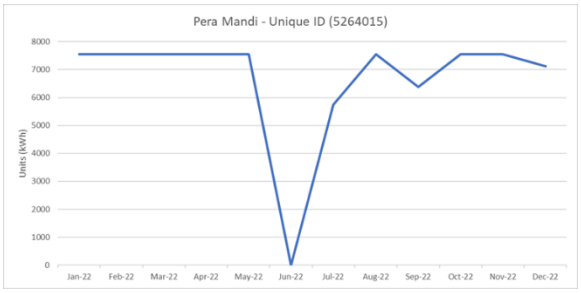
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all 13 operational sites.

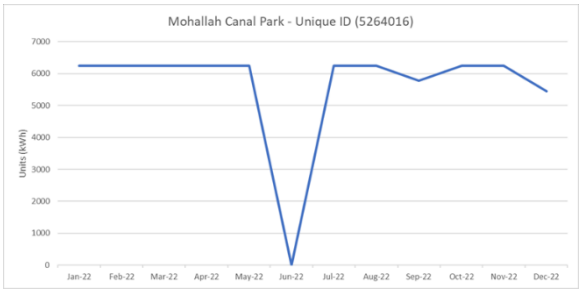


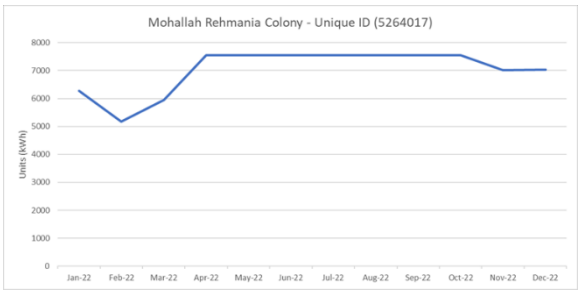


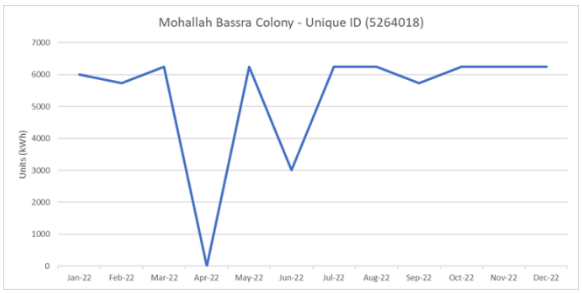


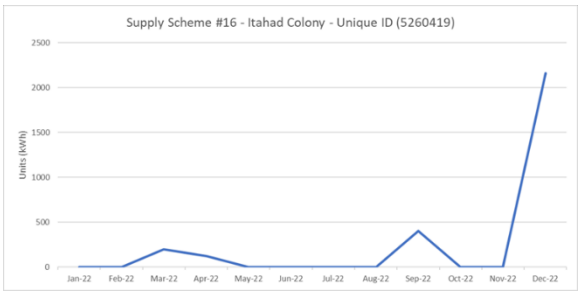


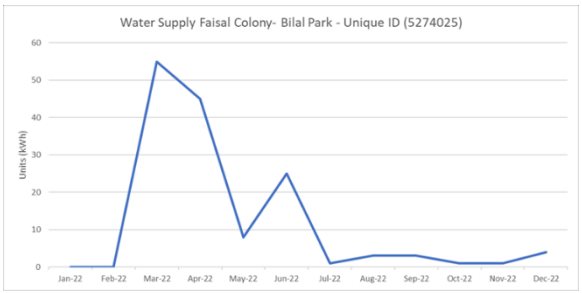

Pera Mandi - Unique ID (5264015)
Units (kWh)
0
1000
2000
3000
4000
5000
6000
7000
8000
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22

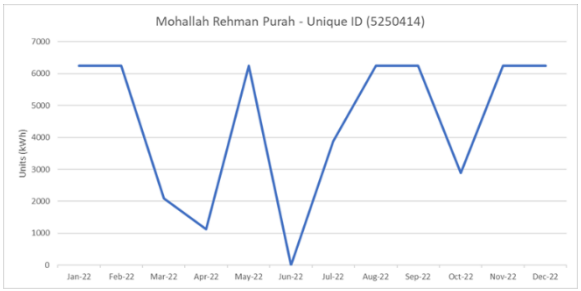

Mohallah Canal Park - Unique ID (5264016)
Units (kWh)
0
1000
2000
3000
4000
5000
6000
7000
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22

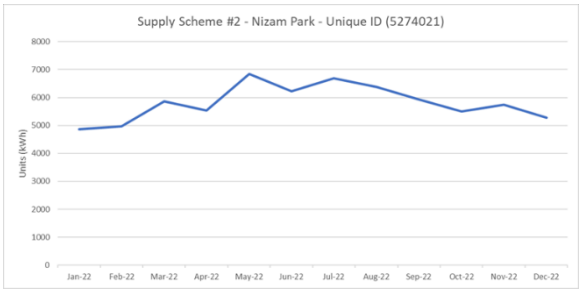

Mohallah Rehmania Colony - Unique ID (5264017)
Units (kWh)
0
1000
2000
3000
4000
5000
6000
7000
8000
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22


Mohallah Bassra Colony - Unique ID (5264018)
Units (kWh)
0
1000
2000
3000
4000
5000
6000
7000
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22


Supply Scheme #16 - Itahad Colony - Unique ID (5260419)
Units (kWh)
0
500
1000
1500
2000
2500
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22


Water Supply Faisal Colony- Bilal Park - Unique ID (5274025)
Units (kWh)
0
10
20
30
40
50
60
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22


Mohallah Rehman Purah - Unique ID (5250414)
Units (kWh)
0
1000
2000
3000
4000
5000
6000
7000
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22


Supply Scheme #2 - Nizam Park - Unique ID (5274021)
Units (kWh)
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1000
2000
3000
4000
5000
6000
7000
8000
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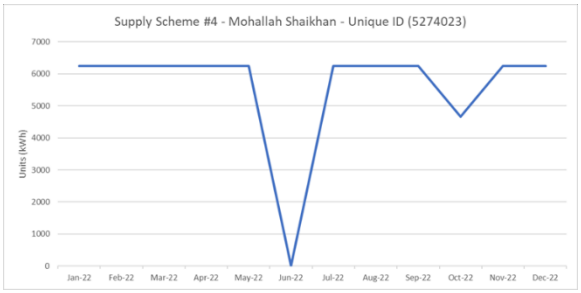
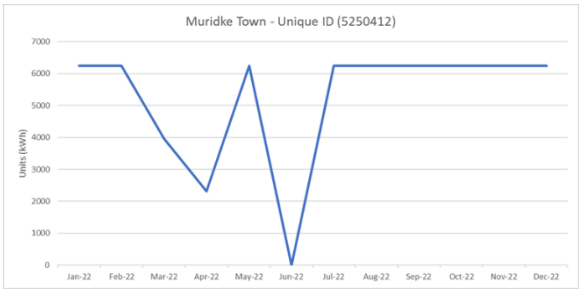
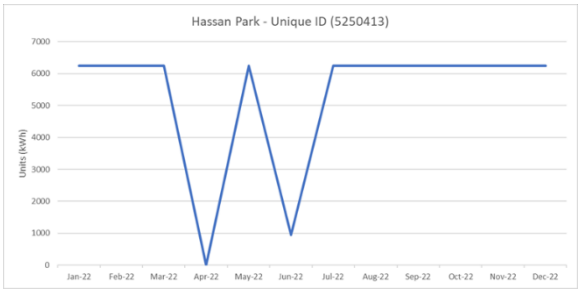
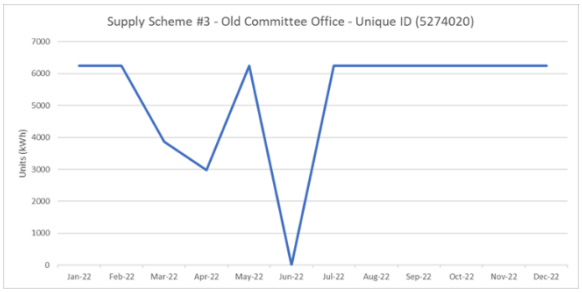
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22


Supply Scheme #4 - Mohallah Shaikhan - Unique ID (5274023)
Units (kWh)
0
1000
2000
3000
4000
5000
6000
7000
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22


Muridke Town - Unique ID (5250412)
Units (kWh)
0
1000
2000
3000
4000
5000
6000
7000
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22





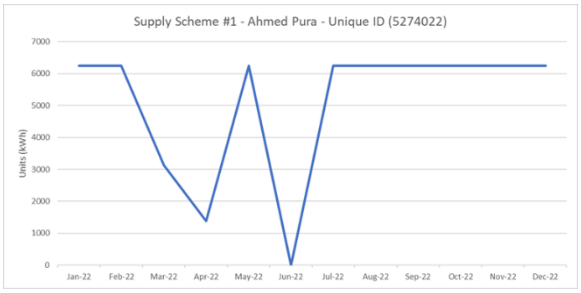


Figure 3: Energy Consumption Trend for Water Pumps

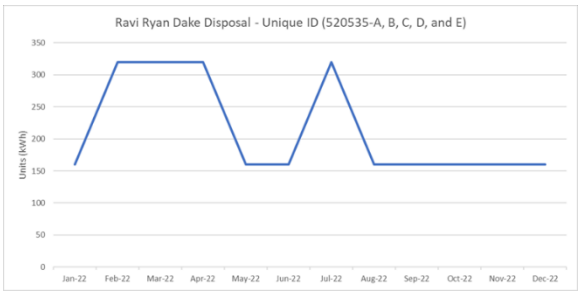


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Muridke MC has seventeen (17) tubewells for groundwater, all of which are manually operated. All pumps were found to be operational. Performance evaluation of pumpsets could be carried out at only 16 locations due to the reasons specified under section 2. Performance analysis was carried out for the operational tubewells, by simultaneous measurement of flow and electrical consumption. The list of audit equipment used by the Consultant is attached as Annexure 2. Since the Sluice valves at several pumping stations were either jammed or broken, it was not possible to determine system resistance and/or assess the pumpset performance at its duty point. Nevertheless, the purpose of the energy audit is to evaluate the energy consumption of MC's water supply network based on their actual/existing working condition. Therefore, any measurements made by altering the actual field operating mode/conditions will not be a true representation of the energy consumption of assets.

Pumps with efficiencies of 55% or higher are deemed satisfactory in terms of performance while those below 55% are recommended for replacement. This approach is based on the methodology adopted by the Consultant for the audits conducted under USAID funded TWEIP project wherein detailed discussions were held with the leading pump manufacturers of Pakistan (KSB, HMA, PECO, Flowpak, etc.) to determine a cut-off efficiency values for replacement; as new pumpsets have an average in-field efficiency value of around 70%, a cut-off value of 55% was agreed upon to ensure at least 25% improvement in energy efficiency for the

end users (Capital Development Authority (CDA), Karachi Water and Sewerage Board (KWSB), and Farmers). This methodology was successfully implemented during the detailed energy audit of 135 pumpsets at CDA and 294 at KWSB.

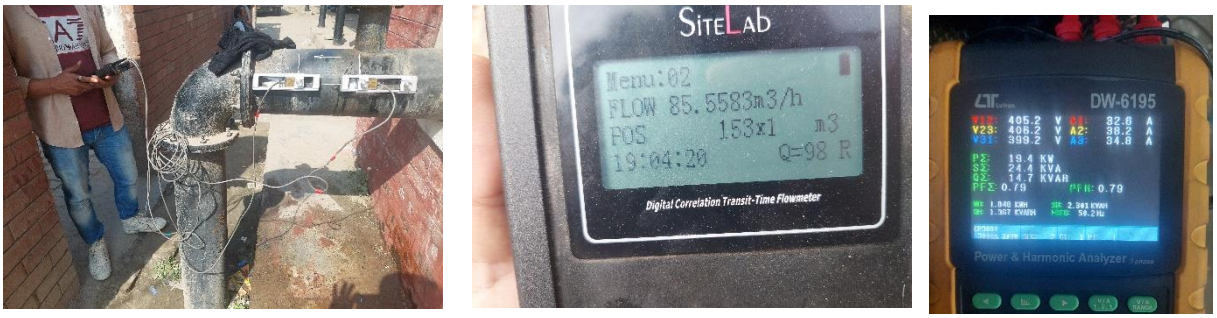


Figure 5: Sample pictures from field audit of pumpsets

Details and location of water supply pumpsets for which pump performance was assessed and sites where complete billing details were available are presented in the following table:

Table 12: Matrix of Pumpset Assessment and Billing Data Availability

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
1	5250003	Bus Adda Muridke	Yes	Yes
2	5250410	Supply Scheme #10 - Mohala Qadafi park	Yes	Yes
3	5240411	Supply Scheme #8 - Old Dawke Muridke	Yes	Yes
4	5264014	Hadokay Mohallah	Yes	Yes
5	5264015	Pera Mandi	Yes	No
6	5264016	Mohallah Canal Park	Yes	Yes
7	5264017	Mohallah Rehmania Colony	Yes	Yes
8	5264018	Mohallah Bassra Colony	Yes	Yes
9	5260419	Supply Scheme #16 - Itahad Colony	Yes	Yes
10	5274025	Water Supply Faisal Colony- Bilal Park	Yes	No
11	5250414	Mohallah Rehman Purah	Yes	Yes
12	5274021	Supply Scheme #2 - Nizam Park	Yes	Yes
13	5274023	Supply Scheme #4 - Mohallah Shaikhan	Yes	Yes
14	5250412	Muridke Town	Yes	Yes
15	5250413	Hassan Park	Yes	Yes
16	5274020	Supply Scheme #3 - Old Committee Office	Yes	Yes
17	5274022	Supply Scheme #1 - Ahmed Pura	Yes	Yes

Table 13: Pumpset Primary Performance Parameters

Sr No.	Unique ID	Location	Rated Pump Flow m^3/hr	Measured Flow m^3/hr	Dynamic Head m	Power Consumption kW	Pump Efficiency %	Measured Power Factor	Comments
1	5250003	Bus Adda Muridke	101.9	115.8	34.90	19.90	65%	0.81	New pumpset has been installed on the site. The efficiency of the pumpset is satisfactory. Previously, this pump station was abandoned by MC.
2	5250410	Supply Scheme #10 - Mohala Qadafi park	101.9	91.6	39.77	17.20	68%	0.76	New pumpset and bore has been installed on the site. The efficiency of the pumpset is satisfactory. A capacitor bank of 2.5 kVAr capacity in each phase is recommended to be installed to avoid low power factor penalty. Previously, replacement of new pumpset and bore was recommended due to the detection of sand traces in the water.
3	5240411	Supply Scheme #8 - Old Dawke Muridke	101.9	149.8	25.63	19.50	63%	0.96	New pumpset has been installed on the site. The efficiency of the pumpset is satisfactory. Previously, replacement of new pumpset was recommended due to the low efficiency i.e., below 55%.
4	5264014	Hadokay Mohallah	101.9	135.5	24.59	18.10	59%	0.80	New pumpset has been installed on the site. The efficiency of the pumpset is satisfactory. Previously, replacement of new pumpset was recommended due to the low efficiency i.e., below 55%.
5	5264016	Mohallah Canal Park	101.9	141.9	26.38	19.70	61%	0.79	New pumpset and bore has been installed on the site. The efficiency of the pumpset is satisfactory. A capacitor bank of 2.5 kVAr capacity in each phase is recommended to be installed to avoid low power factor penalty Previously, replacement of new pumpset and bore was recommended dure damaged/chocked bore.
6	5264017	Mohallah Rehmania Colony	101.9	113.7	29.27	18.40	58%	0.70	The efficiency of the pumpset is satisfactory. A capacitor bank of 2.5 kVAr capacity in each phase is recommended to be installed to avoid low power factor penalty.

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
									Previously, the efficiency of pumpset was 76%.
7	5264018	Mohallah Bassra Colony	101.9	143.2	26.77	18.00	68%	0.77	New pumpset and bore has been installed on the site. The efficiency of the pumpset is satisfactory. A capacitor bank of 2.5 kVAr capacity in each phase is recommended to be installed to avoid low power factor penalty. Previously, replacement of new pumpset and bore was recommended due to damaged/chocked bore.
8	5260419	Supply Scheme #16 - Itahad Colony	101.9	151.9	26.07	32.00	40%	0.83	Replacement of this pump is recommended as the efficiency is below 55%. Previously, replacement of new pumpset was recommended due to the low efficiency i.e., 45%.
9	5274025	Water Supply Faisal Colony-Bilal Park	101.9	87.4	27.05	19.50	39%	0.79	New pumpset and bore has been installed on the new location however, the recorded flow is too low for a new pump with full open gate valve. This should be rechecked by the pump manufacturer/supplier. A capacitor bank of 2.5 kVAr capacity in each phase is recommended to be installed to avoid low power factor penalty.
10	5250414	Mohallah Rehman Purah	101.9	172.4	28.05	20.10	77%	0.82	New pumpset and bore has been installed on the site. The efficiency of the pumpset is satisfactory. Previously, replacement of new pumpset and bore was recommended due to damaged/chocked bore.
11	5274021	Supply Scheme #2 - Nizam Park	101.9	108.5	24.49	16.80	51%	0.75	Replacement of this pump is recommended as the efficiency is below 55%. A capacitor bank of 2.5 kVAr capacity in each phase is recommended to be installed to avoid low power factor penalty. Previously, replacement of new pumpset was recommended due to the low efficiency i.e., 43.5%.
12	5274023	Supply Scheme #4 - Mohallah Shaikhan	101.9	108.6	16.78	16.60	35%	0.89	Replacement of this pump is recommended as the efficiency is below 55%.

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
									Previously, it was recommended to replace the bore & pumpset due to damaged bore.
13	5250412	Muridke Town	101.9	145.9	24.24	17.10	66%	0.76	New pumpset and bore has been installed on the site. The efficiency of the pumpset is satisfactory. A capacitor bank of 2.5 kVAr capacity in each phase is recommended to be installed to avoid low power factor penalty. Previously, replacement of new pumpset and bore was recommended due to damaged/chocked bore.
14	5250413	Hassan Park	101.9	126.5	24.37	17.30	57%	0.76	The efficiency of the pumpset is satisfactory. A capacitor bank of 2.5 kVAr capacity in each phase is recommended to be installed to avoid low power factor penalty. Previously the efficiency of pumpset was 68.4%.
15	5274020	Supply Scheme #3 - Old Committee Office	101.9	107.9	33.92	16.57	71%	0.63	Replacement of this pump is recommended as the efficiency is below 55%. A capacitor bank of 5 kVAr capacity in each phase is recommended to be installed to avoid low power factor penalty. Previously, replacement of new pumpset was recommended due to the low efficiency i.e., 34.3%.
16	5274022	Supply Scheme #1 - Ahmed Pura	101.9	93.1	31.88	16.50	58%	0.91	The efficiency of the pumpset is satisfactory. Previously the efficiency of pumpset was 69.3%.

In addition to the efficiency calculations for the pumpsets, the audit team also considered other parameters that can directly or indirectly affect the performance of the pumping system, such as a low power factor which negatively impacts the health of motors.

Table 14: Pumpset Secondary Performance Parameters

Unique ID	Motor Vibration Hz	Temperature of Motor	Winter Operational Hours	Summer Operational Hours	Motor Rated kW	Motor Rated Efficiency	Transformer kVA	Elec. Connection	Line Leakage	Rated Head of Pump	Motor Rated Voltage V	Full Load PF	PF (Measured)	Load factor %	Observations
5250003	39.79	-	8	8	22	92	-	Safe	Not Ok	150	400	0.84	0.81	90%	-
5250410	53.05	47	9	9	22	92	50	Safe	Ok	150	400	0.84	0.76	78%	Low Power factor
5240411	35.11	49	9	9	22	92	50	Unsafe	Ok	150	400	0.84	0.96	88%	-
5264014	397.89	49	9	9	22	-	50	Safe	Ok	150	400	0.85	0.80	82%	-
5264016	106.10	39	9	9	22	-	50	Safe	Not Ok	150	400	0.84	0.79	89%	Low Power factor
5264017	53.05	39	9	9	22	-	50	Unsafe	Ok	150	380	0.84	0.70	83%	Low Power factor
5264018	122.43	43	8	8	22	-	25	Safe	Not Ok	150	400	0.84	0.77	82%	Low Power factor
5260419	188.09	67	8	8	29	-	50	Safe	Not Ok	150	380	0.86	0.83	109%	-
5274025	159.15	23	9	9	22	-	50	Safe	Not Ok	150	400	0.85	0.79	88%	Low Power factor
5250414	45.47	37	9	9	22	-	25	Safe	Ok	150	400	0.84	0.82	91%	-
5274021	198.94	47	9	9	22	-	50	Safe	Ok	120	380	0.84	0.75	76%	Low Power factor
5274023	46.81	44	9	9	22	90	25	Unsafe	Not Ok	150	400	0.85	0.89	75%	-
5250412	258.63	38	9	9	22	-	25	Safe	Not Ok	150	400	0.84	0.76	77%	Low Power factor
5250413	636.62	34	9	9	22	-	25	Safe	Ok	150	400	0.85	0.76	78%	Low Power factor
5274020	95.49	42	9	9	22	92	25	Safe	Ok	150	400	0.84	0.63	75%	Low Power factor

For the pumpsets on which the sluice valve was operational, the system resistance was varied by throttling the flows (by closing the sluice valve) up to the duty point of the pump and the corresponding operating parameters were used to determine the pump efficiency at various points. The results are provided in the table below.

Table 15: Comparison of Pumpset Efficiency at Existing Conditions and Duty Point

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
1	5250003	Bus Adda Muridke	102	22.065

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	115.8	34.9	Flow at Existing Operating Conditions	19.9	65%
2	101	38.4	Flow nearest to duty point	18.7	67%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
2	5250410	Supply Scheme #10 - Mohala Qadafi park	102	22.065

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	91.55	39.8	Flow at Existing Operating Conditions is the same as Rated Flow	17.2	68%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
3	5240411	Supply Scheme #8 - Old Dawke Muridke	102	22.065

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	149.8	25.6	Flow at Existing Operating Conditions	19.5	63%
2	104	39.7	Flow nearest to duty point	19.3	69%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
4	5264014	Hadokay Mohallah	102	22.065

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	135.45	24.6	Flow at Existing Operating Conditions	18.1	59%
2	110	30.2	Flow nearest to duty point	17.9	60%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
5	5264016	Mohallah Canal Park	102	22.065

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	141.92	26.4	Flow at Existing Operating Conditions	19.7	61%
2	108.95	36.9	Flow nearest to duty point	19.5	66%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
6	5264018	Mohallah Bassra Colony	102	22.065

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	143.2	26.8	Flow at Existing Operating Conditions	18	68%
2	108.46	33.5	Flow nearest to duty point	16.7	70%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
7	5274025	Water Supply Faisal Colony- Bilal Park	102	22.065

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	87.4	27.0	Flow at Existing Operating Conditions is the same as Rated Flow	19.5	39%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
8	5250414	Mohallah Rehman Purah	102	22.065

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	172.43	28.1	Flow at Existing Operating Conditions	20.1	77%
2	135.07	35.1	Flow nearest to duty point	19.4	78%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
9	5250412	Muridke Town	102	22.065

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	145.869	24.2	Flow at Existing Operating Conditions	17.1	66%
2	103.668	39.7	Flow nearest to duty point	18.1	73%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
10	5274020	Supply Scheme #3 - Old Committee Office	102	22.065	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	107.87	33.9	Flow at Existing Operating Conditions is the same as Rated Flow	16.57	71%

2.4.3 Wastewater Disposal System

Muridke MC has one disposal system which has a total of five (05) centrifugal pumps for suction of wastewater from collecting tanks to main sewage drain. All these pumps are manual and run as per requirement. Performance analysis could not be carried out as it operates only when required.

Figure 6: Wastewater Disposal Muridke

2.4.4 Dewatering Sets

There are five (5) dewatering sets in the MC out of which four (4) are functional. It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.

Figure 7: Dewatering sets

Dewatering sets in the MC are primarily being employed to address chocked manholes and other issues relates to sewerage. It is envisaged that once all the improved proposed under the PCP sewerage component are implemented, the need for use of dewatering sets will be minimized, thereby greatly reducing the fuel consumption by these assets.

2.5 Proposed Resource Efficiency Measures- Water Pumps and Disposals

Based on the analysis, energy efficiency measures have been identified, including operational improvement and investment-oriented measures, and are discussed in detail in the table below.

Table 16: Water Pumps and Wastewater Disposal System: Recommendations for improvement

Sr No.	Unique ID	Location	Comments	Recommendation
Pumps				
1	5250410	Supply Scheme #10 - Mohala Qadafi park	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.

Sr No.	Unique ID	Location	Comments	Recommendation
2	5264015	Pera Mandi	No flow could be detected due to the due to extremely low flow rate of water in the pipe.	It is recommended to replace the pumpset and the bore.
3	5264016	Mohallah Canal Park	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
4	5264017	Mohallah Rehmania Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
5	5264018	Mohallah Bassra Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
6	5260419	Supply Scheme #16 - Itahad Colony	Efficiency of the pumpset is below 55%.	It is recommended to replace the pumpset
7	5274025	Water Supply Faisal Colony- Bilal Park	Efficiency of the pumpset is below 55%.	It is recommended to replace the pumpset
8	5274021	Supply Scheme #2 - Nizam Park	Efficiency of the pumpset is below 55%.	It is recommended to replace the pumpset
9	5274023	Supply Scheme #4 - Mohallah Shaikhan	Efficiency of the pumpset is below 55%.	It is recommended to replace the pumpset
10	5250412	Muridke Town	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
11	5250413	Hassan Park	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
12	5274020	Supply Scheme #3 - Old Committee Office	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
General Observations				
13	General	Smart Metering	No flow meters were installed at any of the tubewells.	Smart flow meters connected to a centralized DCS system needs to be installed to calculate the total water drawn by each pump and to monitor flow and water loss due to leakages. This can also help with water billing if the Government of Punjab intends to do so in future
14	General	Operating Time	Pumps should not be run during Peak electricity consumption hours.	Operational hours of pump should be scheduled keeping in mind the varying peak hours across the year to avoid peak charges. Peak hours for LESCO during the entire year are given in Annexure 1.
15	General	Dewatering Sets	Dewatering sets were in satisfactory condition, but no O&M logs were available with the MC	It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.
16	General	Water Supply Network	Proper O&M of Air Release Valves	Air release valves installed on the network should be properly maintained.

3 Streetlights

Street lighting is a significant expense for municipalities due to high electricity and maintenance expenditures. An inventory of streetlights has been developed as well as GIS maps & energy consumption data to assess the KPIs.

3.1 Inventory

Surveyors conducted onsite surveys at Muridke MC and gathered detailed information about streetlights including their numbers, pole/fixture types and operation details. Details of the surveyed lights are provided in the following tables.

Table 17: Inventory Detail of Streetlights

	Streetlights	MC Operated	Privately Operated
Operational Street Lights	141	107	34
Non-Operational Street Lights	53	50	3
Meter Disconnected	68	68	0
Total	**262**	**225**	**37**

The MC has no record or database for streetlights that includes dates of installation for pole/fixture and lighting equipment, capital expenditure and O&M costs.

The 262 streetlights in the MC are installed on a total of 225 poles. The streetlights' structural classification is tabulated below.

Table 18: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Wall Mounted	Grand Total
MC	46	113	38	2	199
Private		2	24		26

Streetlights of Muridke MC are installed in main areas of the city and are not metered. Approximately 14% of the total streetlights are privately operated and maintained while remaining 86% are operated and maintained by the MC. Further details of streetlights in different areas of Muridke are shown in table below.

Table 19: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (meters)
1	Police Station Bazar Muridkey	15	44116410459102U	695
2	Service Bazar	11	44116410305906U	394
3	Bangla Road	11	44116410167902U	372
4	Hassain Town	18	44116431219506U	694
5	Ravi Rayan	14	44116431292101U	1,146
6	Akhtar Mills Road	10	44116420010404U	430
7	Ladies and Children Park	32	44116420504302U	679
8	Green Park Muridkey Town	9	44116422601118U	164
9	Muridkey Town purana narang road.	41	11116420616401U	1,683
10	Lari Ada	12	45116410331400U	268
11	Double Road	8	44116410089806U	186
12	34-36 Bazar	17	44116410028902U	890
13	Manu Main Bazar	8	44116410058002U	206
14	Raheem Baksh Colony	10	44116420004609U	417
15	Chahal Road	9	44116420039109U	363
16	Chatha Park	26	N/A (Privately Operated)	761

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (meters)
17	Imam Bargha Park	11	N/A (Privately Operated)	324

Out of the 262 surveyed lights in the MC, only 141 lights were found to be operational. Details are given in the following table:

Table 20: Details of Operational Streetlights

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours[5]	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	27	14		12.0	1,656	0
LED	120	93	34	12.0	48,881	17,870
Total					50,536	17,870

Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS Map of streetlights is shown below. Red points in the map show nonfunctional streetlights and yellow points denote functional streetlights.

[5] Based on Interview with Client.

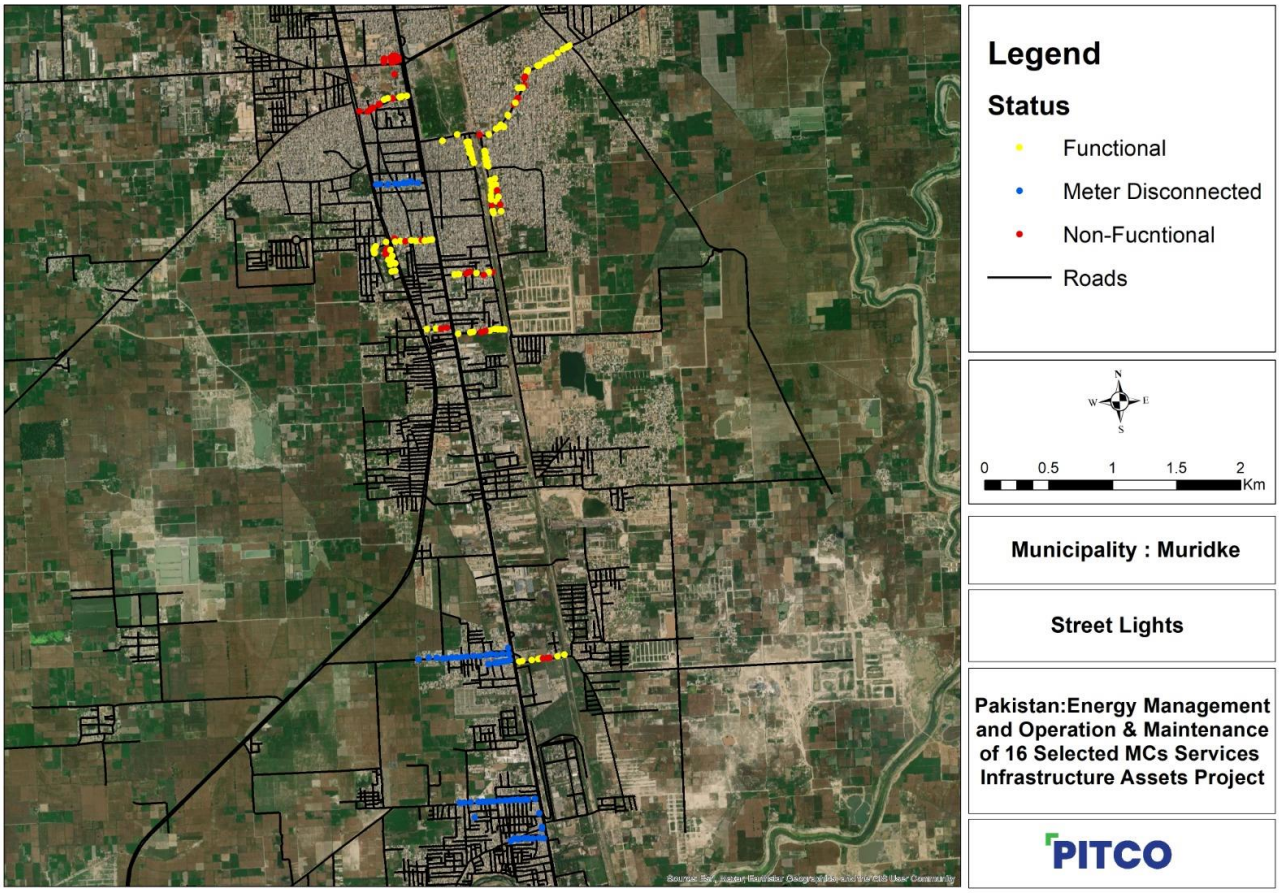


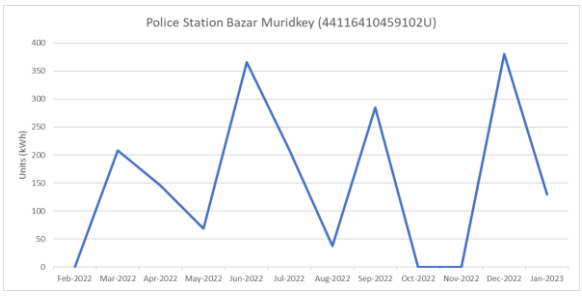
Figure 9: GIS Mapping of street lights in Muridke MC

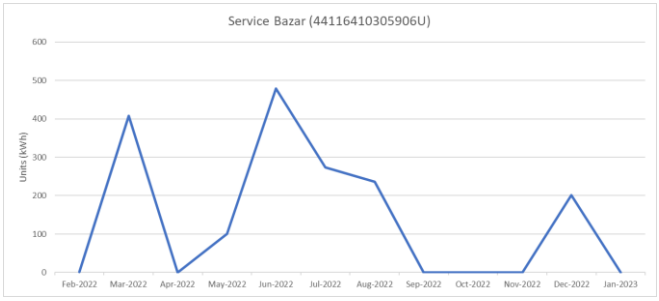
3.3 Baseline Energy Consumption Trend

Details of energy consumption by the streetlights in the MC are given below.

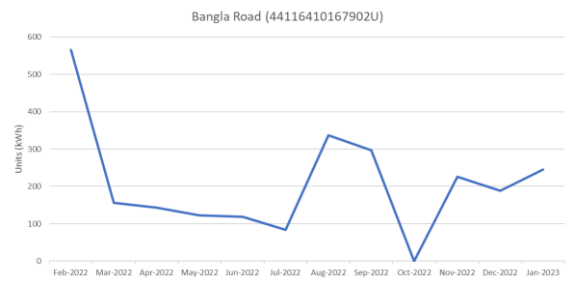
Table 21: Baseline Energy Consumption Trend of MC operated lights

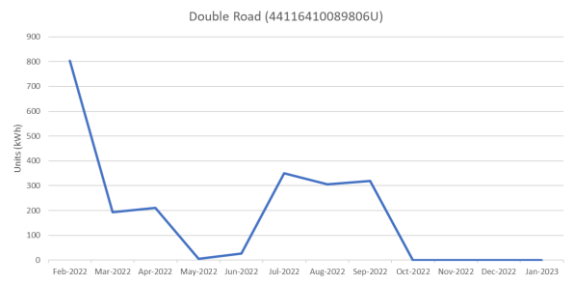
Particulars	Unit	Value
Electrical energy consumed	kWh/y	56,197[6]
Total number of operational lights	No.	107

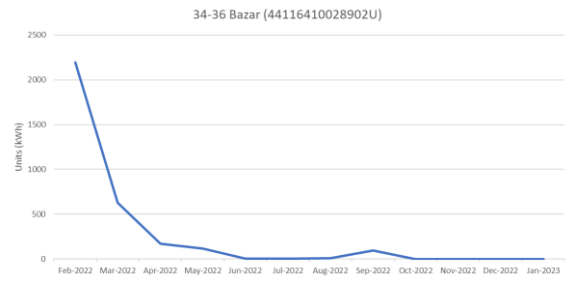


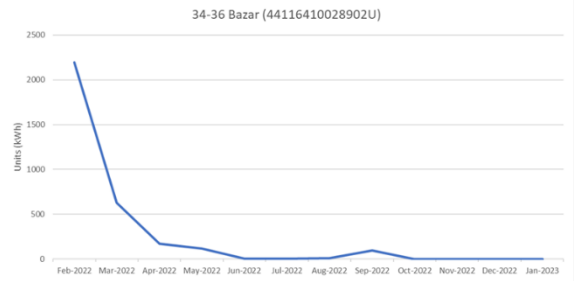


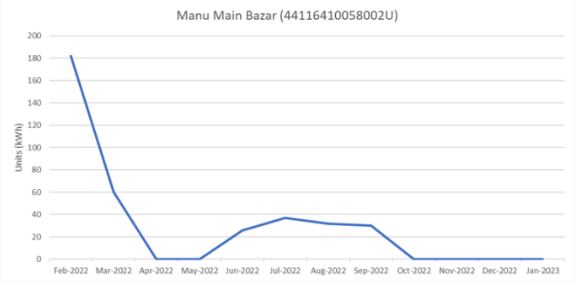
[6] Does not include consumption from 45116410331400U as it is also connected with Pump set.

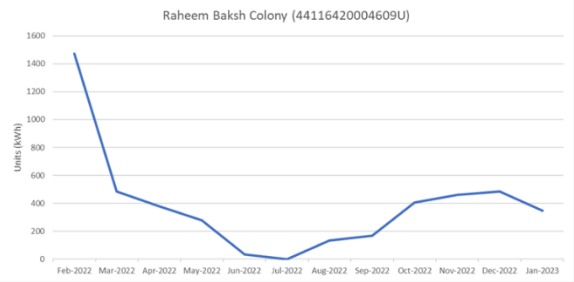

Bangla Road (44116410167902U)
Units (kWh)
600
500
400
300
200
100
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023

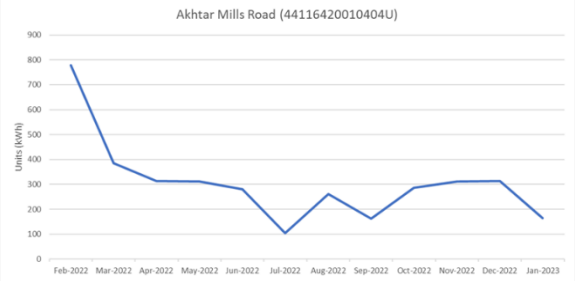

Double Road (44116410089806U)
Units (kWh)
900
800
700
600
500
400
300
200
100
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023

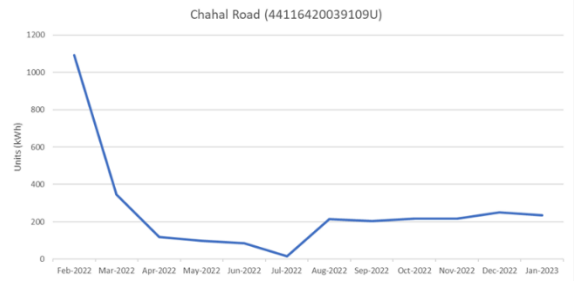

34-36 Bazar (44116410028902U)
Units (kWh)
2500
2000
1500
1000
500
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023

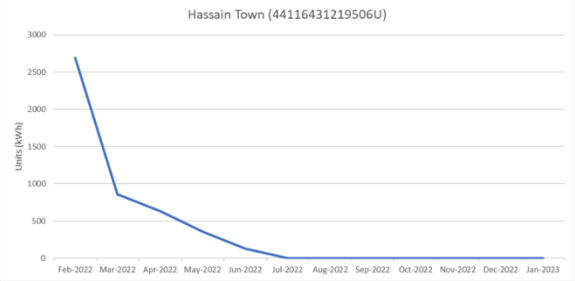

34-36 Bazar (44116410028902U)
Units (kWh)
2500
2000
1500
1000
500
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023


Manu Main Bazar (44116410058002U)
Units (kWh)
200
180
160
140
120
100
80
60
40
20
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023


Raheem Baksh Colony (44116420004609U)
Units (kWh)
1600
1400
1200
1000
800
600
400
200
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023


Akhtar Mills Road (44116420010404U)
Units (kWh)
900
800
700
600
500
400
300
200
100
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023


Chahal Road (44116420039109U)
Units (kWh)
1200
1000
800
600
400
200
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023


Hassain Town (44116431219506U)
Units (kWh)
3000
2500
2000
1500
1000
500
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023

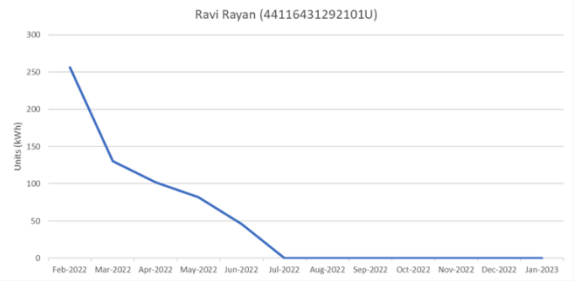

Ravi Rayan (44116431292101U)
Units (kWh)
300
250
200
150
100
50
0
Feb-2022 Mar-2022 Apr-2022 May-2022 Jun-2022 Jul-2022 Aug-2022 Sep-2022 Oct-2022 Nov-2022 Dec-2022 Jan-2023

Figure 10: Energy Consumption trend of Streetlights

A comparison of current electricity consumption by the MC's streetlights compared to results of the survey activity carried out in 2019, is presented in the following table:

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Streetlights	12	107	13,928	56,197	-42,269	1,288 kWh/km	6,545 kWh/km	Based on the previous assessment, there were only 12 operational lights with an average consumption of 1,160kWh/light/annum, whereas, currently there are 107 operational lights with average energy consumption of 525kWh/light/annum. Therefore, even though the overall energy consumption and the KPI/km for streetlights have increased, the MC has siginifcantly improved the energy consumption per light fixture. Since the overall area covered by lighting equipment does not change significantly, the improvement in energy consumption is not reflected in the KPI.

3.4 Maintenance & Replacement of Streetlights

No record was available with the MC for the purchase, maintenance, and repairing (if any) of streetlight(s) that are installed in Muridke.

3.5 Observations

- Streetlights in Muridke MC are mostly operated by MC.
- All of the operational streetlights are LEDs.
- Most of the LED streetlights have a rating of 120 Watts and are operated by MC.
- Muridke MC is not maintaining any record or database of streetlights.

3.6 Action plan for Energy Efficiency Measures – Streetlights

Based on the field observations and data analysis, the following energy efficiency measures have been identified:

Table 22: Streetlights - recommendations for improvement

Sr. No.	Area	Observations	Recommendations/ Remarks
1	Inventory	• Most of the streetlights in Muridke are MC operated • All of the operational streetlights are LEDs • Most of the streetlights are of High wattage	All streetlights shall be operated by designated person of MC rather than being privately operated. All MC owned non-operational streetlights should be repaired to make them functional. As per illuminating engineering society (IES) and Committee for European Standardization (CEN) public areas with dark surroundings should have illumination (lux or lumen/m^2) between 20-50 lux. It is recommended to have lumen method or Zonal cavity method for design of streetlights which means an equal illumination at all areas. This is simple and frequently used method to design street lighting. It is recommended to install LED lights which have effective lux of 20-50 at ground level. With lighting control system for maximum utilization and low energy costs. Reason to recommend LED lights is they have better average rated life & better lamp lumen depreciation.
2	Maintenance & Replacement Log	Muridke MC has no records and database of streetlights despite the fact they are operated and managed by them.	A database shall be developed to record all operation and

Sr. No.	Area	Observations	Recommendations/ Remarks
			maintenance related activities of the streetlights. Every streetlight pole should have a unique identification number. This number should be printed/painted on the streetlight pole. Photo-electric switches are recommended to be installed at each streetlight pole. It is recommended to conduct group maintenance practice to save money.

4 Vehicles

4.1 Inventory

The detailed inventory for vehicles in Muridke MC is tabulated below.

Table 23: Vehicle Inventory Detail

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
1	SAJ-13-14	Tractor Front Loader	Millat	MF 385	2013	4WD	Loading	502358X	84374113	85
2	Applied for 480	Tractor Grass Cutter	Fiat	Fiat 480	2014	2WD	Solid Waste	803506	3276	55
3	SAC - 8365	Tractor Trolley	Millat	MS 240	1990	2WD	Solid Waste	6336S	A155-62	46
4	SAJ-14	Tractor Trolley	Millat	MF 260	2018	2WD	Solid Waste	CN99002V547589D	62342-2018	60
5	SAH-402	Tractor Trolley	Millat	MF 375	2006	2WD	Solid Waste	502L32M	0026-03	75
6	SAG-8115	Jeep	Suzuki	Potohar	2006	2WD	Municipal Officer (Regulation)	5705120	334711	1000 CC
7	SAG-29	Hino Water Tanker	Isuzu	NPR	2019	4WD	Suction	06096P	JAANPR66PH-7568	130
8	SAG-30	Hino Water Tanker	Isuzu	NPR	2018	4WD	Jetting Machine	06097P	JAANPR66PH-7101569	130
9	SAE-4208	Tractor Trolley	Millat	MF 240	1999	2WD	Solid Waste	548300E	0808-93	46
10	SAC-9381	Tractor Trolley	Millat	MF 240	1991	2WD	Solid Waste	3311T	0222-17	46
11	SAJ-14-21	Tractor Trolley	Fiat/ AGTL	New Holland 480	2013	2WD	Solid Waste	13080147	2508761484	55
12	SAJ-13-18	Tractor Trolley	Millat	MF 375	2018	2WD	Solid Waste	LM9B602V519732D	K72911-11-18	75
13	SAJ-13-13	Tractor Front Loader	Millat	MF 385	2013	4WD	Loading	502440X	84389313	85
14	Applied for 385	Tractor Front Loader	Millat	MF 385	2018	4WD	Loading	LM9B572V503761E	84715-01-19	85
15	SAG 8393	Car	Suzuki	Cultus	2006	2WD	Chief Officer	817223	SF310PK354963	1000 CC
16	SAD-1425	Car	Nissan	Sunny	1992	2WD	Municipal Officer (Infrastructure)	168601	510127	1500 CC
17	Unregistered Vehicle 1	Mini Tipper	Pak Suzuki	Ravi	2022	2WD	Solid Waste	PKT384955	SR308PK489603	796
18	Unregistered Vehicle 2	Mini Tipper	Pak Suzuki	Ravi	2022	2WD	Solid Waste	PKT384960	SR308PK489637	796
19	Unregistered Vehicle 3	Mini Tipper	Pak Suzuki	Ravi	2022	2WD	Solid Waste	PKT384958	SR308PK489634	796
20	Unregistered Vehicle 4	Mini Tipper	Pak Suzuki	Ravi	2022	2WD	Solid Waste	PKT384936	SR308PK48598	796
21	Unregistered Vehicle 5	Mini Tipper	Pak Suzuki	Ravi	2022	2WD	Solid Waste	PKT384950	SR308PK489600	796
22	Unregistered Vehicle 6	Mini Tipper	Pak Suzuki	Ravi	2022	2WD	Solid Waste	PKT384951	SR308PK489625	796
23	Unregistered Vehicle 7	Mini Tipper	Pak Suzuki	Ravi	2022	2WD	Solid Waste	PKT384957	SR308PK489630	796
24	Unregistered Vehicle 8	Mini Tipper	Pak Suzuki	Ravi	2022	2WD	Solid Waste	PKT384956	SR308PK489629	796
25	Unregistered Vehicle 9	Truck With Garbage Compactor	Hino Pak	Truck	2022	4WD	Solid Waste	N104CWGM50191	JHHYCK0FX04600170	4009
26	Unregistered Vehicle 10	Dump Truck	Hino Pak	Truck	2022	4WD	Solid Waste	J08EVUM10519	FG8JKLB10297	7684
27	Unregistered Vehicle 11	Truck With Garbage Compactor	Hino Pak	Truck	2022	4WD	Solid Waste	N04CWGM50187	JHHYC0F804600166	4009
28	Unregistered Vehicle 12	Truck With Garbage Compactor	Hino Pak	Truck	2022	4WD	Solid Waste	N04CWGM50177	JHHYC0F504600156	4009
29	Unregistered Vehicle 13	Truck With Garbage Compactor	Hino Pak	Truck	2022	4WD	Solid Waste	N04CWGM50178	JHHYC0F704600157	4009
30	Unregistered Vehicle 14	Truck With Garbage Compactor	Hino Pak	Truck	2022	4WD	Solid Waste	N04CWGM50189	JHHYC0F104600168	4009
31	Unregistered Vehicle 15	Truck With Garbage Compactor	Hino Pak	Truck	2022	4WD	Solid Waste	N04CWGM50185	JHHYC0F404600164	4009
32	Unregistered Vehicle 16	Truck With Garbage Compactor	Hino Pak	Truck	2022	4WD	Solid Waste	N04CWGM50183	JHHYC0F004600162	4009

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
33	Unregistered Vehicle 17	Truck With Garbage Compactor	Hino Pak	Truck	2022	4WD	Solid Waste	N04CWGM50176	JHHYC0F304600155	4009[7]

4.2 Baseline Fuel Consumption Trend

The fuel consumed by vehicles, based on actual field measurements, is as follows:

Table 24: On-field fuel consumption analysis of MC vehicles

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)				
		Testing Start Time	Testing End Time	Fuel Usage (Liters)	Consumption	Testing Start Time	Testing End Time	Distance (km)	Fuel Usage	Consumption
1	SAJ-13-14	10:27 AM	11:27 AM	2.89	2.89 Liters/hr	9:12 AM	10:22 AM		5.51	4.72 Liters/hr
2	Applied for 480	10:35 AM	11:35 AM	4	4 Liters/hr	9:12 AM	10:22 AM		5	4.29 Liters/hr
3	SAC - 8365	10:32 AM	11:32 AM	2.56	2.56 Liters/hr	9:12 AM	10:22 AM		6.1	5.23 Liters/hr
4	SAJ-14	10:40 AM	11:40 AM	3.58	3.58 Liters/hr	9:12 AM	10:12 AM		5.6	5.6 Liters/hr
5	SAH-402	10:30 AM	11:30 AM	5	5 Liters/hr	9:12 AM	10:22 AM		8	6.86 Liters/hr
6	SAG-8115					11:57 AM	12:18 PM	17.5	2	0.11 Liters/km
7	SAG-29					11:10 AM	12:10 PM		9.86	9.86 Liters/hr
8	SAG-30					10:50 AM	11:50 AM		9	9 Liters/hr

Table 25: Vehicle Fuel Consumption-logbook data

Sr. No.	Unique Registration Number	Fuel Consumption as per Logbook Data
1	SAJ-13-14	5.5 Km/Liter
2	Applied for 480	3 Km/Liter
3	SAC - 8365	5 Km/Liter
4	SAJ-14	3 Km/Liter
5	SAH-402	5 Km/Liter
6	SAG-8115	No Logbook Provided
7	SAG-29	5.3 Km/Liter
8	SAG-30	5.5 Km/Liter
9	SAE-4208	5 Km/Liter
10	SAC-9381	3.5 Km/Liter
11	SAJ-14-21	4 Km/Liter
12	SAJ-13-18	No Logbook Provided
13	SAJ-13-13	5.5 Km/Liter
14	Applied for 385	5.5 Km/Liter
15	SAG 8393	No Logbook Provided
16	SAD-1425	No Logbook Provided

[7] Colored data in the table was shared by the MC Muridke in the same format.

The MC made 8 of its vehicles available to the Consultant for carrying out on-field testing. The average fuel consumption of the vehicles in idle condition was found to be 3.61 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 6.51 liters/hour. None of the vehicles except one, were found to have operational odometer.

Furthermore, the Consultant has reservations regarding the logbooks for MC Vehicles; prima facie it appears that the fuel consumption for each vehicle is recorded against a fixed value as reported on the vehicle inspection certificate rather than the actual values. The data collection formats provided to PMDFC after the first phase of assessment/audit project in 2019 are not being used by the MCs for recording fuel consumption.

Table 26: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	173,472
Annual Cost of Fuel (Diesel)	PKR/y	50,827,296

4.3 Maintenance Log of Vehicles

No record was available for the purchase, maintenance, and repairing (if any) of the vehicles that are in use of the MC. Pictures of some of the vehicles owned by Muridke MC are given below.

Figure 10: Muridke MC Vehicles

4.4 Observations and Recommendations

All non-registered vehicles must be registered immediately to avoid any misuse.

Based on the logbook data, the Consultant cannot make any recommendation for replacement of vehicles. The performance of all vehicles needs to be evaluated in detail. A 6-month exercise should be undertaken in which the distance travelled by each vehicle, its fuel consumption, weight of waste carried (in case of waste carrying vehicles), and O&M cost should be properly logged to calculate the efficiency of the vehicles. Once this activity is completed, the inefficient vehicles should be sold in the open market through a transparent auction and more efficient vehicles should be bought in their stead.

As per information available with the Consultant, PMDFC is in the process of installing tracking devices on all new devices procured under PCP. It is recommended that similar devices are installed on the MC's existing fleet as well.

5 Municipal Buildings

There are two MC owned office buildings in Muridke. Detailed assessment of these is given in the following section

5.1 GIS Map

GIS Map indicating location of buildings is shown in the figure below.

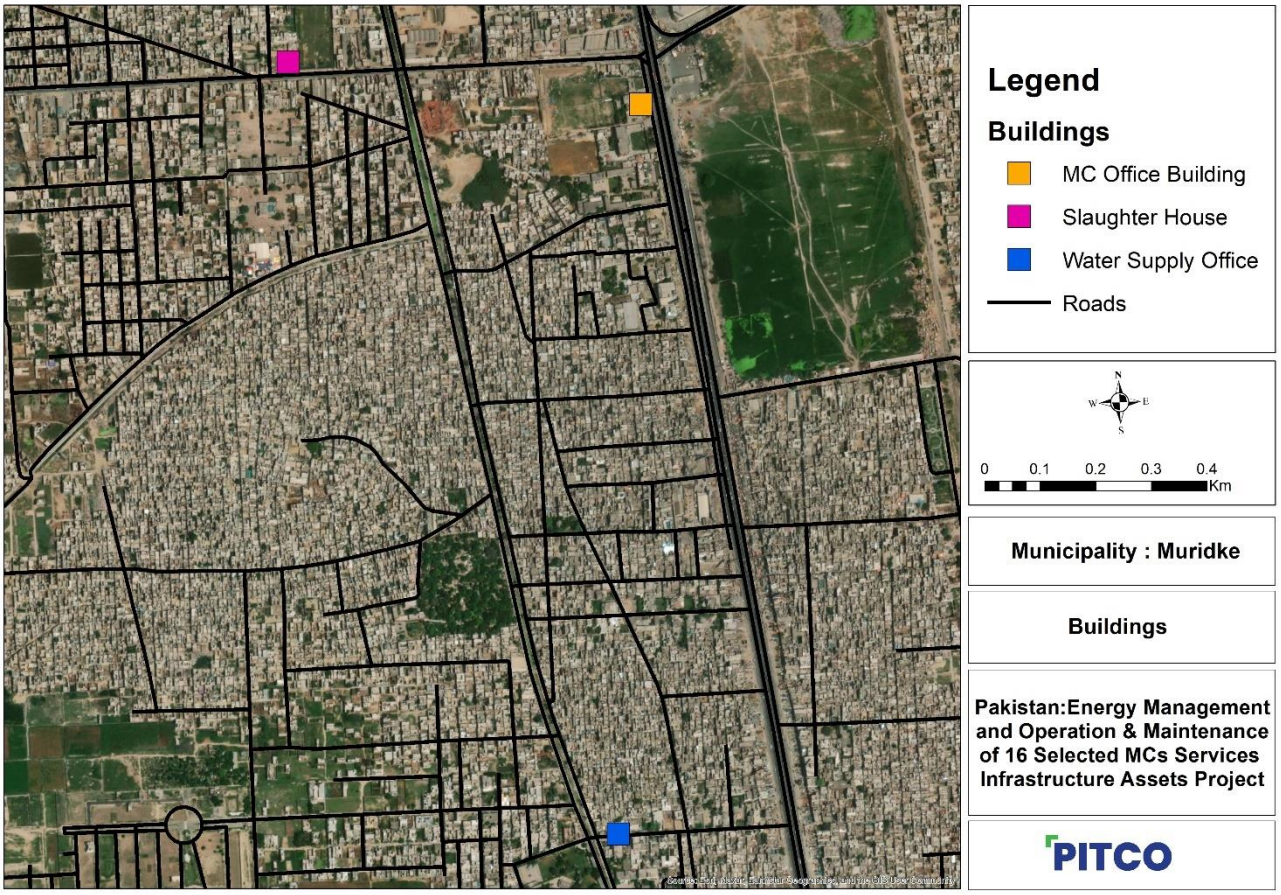


Figure 11: Map for Buildings

5.2 Building Details

Details of the MC office buildings are given below.

Table 27: Buildings' Details

Sr. No.	Address	GPS	Unique ID	Ownership	Age of Building	Condition of Building	Total Area	Insulation of Building	Number of Floors
1	MC Office Building	N:31.80862 E:74.25309	20405222	MC	10	Satisfactory	1,581	No Proper Insulation	2
2	Slaughterhouse	N:31.809576 E:74.246459	20405224	MC	N/A	Satisfactory	1,012	No Proper Insulation	1
3	Water Supply Office	N:31.79687 E:74.25200	20405223	MC	32	Un-Satisfactory	329	No Proper Insulation	1

Details of the various heating, cooling, and lighting equipment used in the MC building is given in the following tables.

Table 28: Number of Heating Units in MC Buildings

Sr. No.	Name of Room	Type of Heating Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	No. of months used per year	Operating days per year	Annual Energy consumption (kWh/year)
MC Main Office								
1	Chief office	Heater Fan	1	960	4	4	104	399
2	Administrative office	Oil Heater	1	2300	2	3	78	359
3	Audit office	Electric Heater	1	900	4	2	52	187
4	MOF branch office	Electric Heater	1	1000	3	3	78	234
5	MOF branch office	Oil Heater	1	2300	2	3	78	359
6	Account Branch	Electric Heater	1	1200	3	2	52	187
Water Supply Office								
	Clerk Room (2)	Electric Rod	1	500	-	-	-	0
	Total							**1,725**

[8] The "daily operating hours" and "no. of months used per year" are based on interview with the MC staff (IWC)

Table 29: Number of Cooling Units in Office Buildings of Muridke MC

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[9]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
MC Office Building								
1	Main Lobby Entrance	Ceiling Fan	1	80	8	7	182	116
2	Left Gallery	Ceiling Fan	1	80	8	7	182	116
3	Clerk room (1)	Ceiling Fan	2	80	8	7	182	233
4	Clerk room (2)	Ceiling Fan	2	80	8	7	182	233
5	Kitchen	Ceiling Fan	1	80	8	7	182	116
6	Administrative Office	Split AC	1	2200	2	5	130	572
7	Administrative Office	Ceiling Fan	7	80	4	7	182	408
8	Administrative Office	Split AC	1	1660	2	5	130	432
9	Administrative Office	Split AC	1	1100	2	5	130	286
10	Chief Office	Ceiling Fan	4	80	5	7	182	291
11	Chief Office	Bracket Fan	1	50	1	7	182	9
12	Chief Office	Split AC	1	1950	2	5	130	507
13	Chief Office	Split AC	1	1920	2	5	130	499
14	Head Office Clerk	Ceiling Fan	1	80	8	6	156	100
15	Superintendent Office Room	Ceiling Fan	2	80	1	6	156	25
16	MOR brnach Clerk Room	Ceiling Fan	2	80	5	6	156	125
17	Store	Ceiling Fan	1	80	1	6	156	12
18	Sub-Engineer Office	Ceiling Fan	2	80	5	6	156	125
19	Sub-Engineer Office	Split AC	1	2100	2	6	156	655
20	MOI Branch	Ceiling Fan	1	80	6	6	156	75
21	MOI Branch	Split AC	1	1700	3	6	156	796
22	Superintendent Office Room	Ceiling Fan	1	80	6	6	156	75
23	Superintendent Office Room	Split AC	1	1800	2	6	156	562
24	Audit officer	Ceiling Fan	1	80	6	6	156	75
25	Audit officer	Bracket Fan	1	50	4	6	156	31
26	Audit officer	Split AC	1	1950	4	6	156	1,217
27	Audit room	Ceiling Fan	1	80	6	6	156	75
28	Tax Clerk Room	Ceiling Fan	1	80	4	6	156	50
29	Tax Clerk Room	Split AC	1	1650	5	4	104	858
30	MOP Room	Ceiling Fan	2	80	8	6	156	200
31	Account Branch	Ceiling Fan	1	80	8	7	182	116
32	Account Branch	Exhaust Fan	1	30	8	12	312	75
33	Account Branch	Split AC	1	1100	4	6	156	686
34	MOF branch	Ceiling Fan	2	80	6	6	156	150

[9] The "daily operating hours" and "no. of months used per year" are based on interview with the MC staff (IWC)

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[9]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
35	MOF branch	Split AC	1	1820	4	6	156	1,136
36	MOP office	Ceiling Fan	1	80	6	6	156	75
37	MOP office	Split AC	1	1100	4	6	156	686
38	Meeting Room	Ceiling Fan	12	80	2	6	156	300
39	Marriage Divorce Room (1)	Ceiling Fan	1	80	8	6	156	100
40	Marriage Divorce Room (2)	Ceiling Fan	1	80	8	6	156	100
41	Mosque	Ceiling Fan	4	80	8	6	156	399
42	Mosque	Exhaust Fan	2	30	8	6	156	75
43	Mosque	Window AC	1	2400	3	6	156	1,123
44	Back Building Room	Pedestal Fan	1	125	6	6	156	117
45	MOR Office	Ceiling Fan	1	80	8	6	156	100
46	MOR Office	Split AC	1	1920	3	6	156	899
Water Supply Office								
1	Clerk room (1)	Ceiling Fan	1	80	8	6	156	100
2	Clerk room (2)	Ceiling Fan	1	80	8	6	156	100
3	Clerk room (2)	Bracket Fan	1	50	8	6	156	62
4	Store	Ceiling Fan	1	80	1	6	156	12
	Total							**15,285**

Table 30: Number of Lighting Unit in Office Buildings of Muridke MC

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[10]	Operating days per year	Annual Electricity consumption (kWh/year)
MC Main Office							
1	Front Side of main Lobby	Tube Light	4	40	12	312	599
2	Front Side of main Lobby	LED	5	20	12	312	374
4	Front Side of main Lobby	LED	2	12	12	312	90
5	Main Building Outside Gallery	Tube Light	4	40	12	312	599
6	Main Building Outside Gallery	LED	2	12	12	312	90
7	Main Gate	CFL	3	24	12	312	270
8	Back Side of Main Building	LED	1	50	12	312	187

[10] "Daily operating hours" is based on interview with the MC staff (IWC)

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[10]	Operating days per year	Annual Electricity consumption (kWh/year)
9	Main Building Entrance	LED	5	12	12	312	225
10	Main Building Entrance	LED	1	18	12	312	67
11	Left Gallery Main Building	LED	4	12	12	312	180
12	Right Gallery Main Building	CFL	1	12	12	312	45
13	Right Gallery Main Building	LED	6	12	12	312	270
14	Clerk Room (1)	Tube Light	2	40	8	312	200
15	Clerk Room (1)	LED	1	30	8	312	75
16	Kitchen	Tube Light	2	40	8	312	200
17	Kitchen	LED	1	12	8	312	30
18	Clerk Room (2)	Tube Light	1	40	8	312	100
19	Clerk Room (2)	LED	2	12	8	312	60
20	MOR Office	LED	10	4	8	312	100
21	MOR Office	LED	4	12	6	312	90
22	Back Building Room No.2	LED	1	12	4	312	15
23	Back building left Wall	LED	1	50	12	312	187
24	Audit Officer	CFL	1	24	4	312	30
25	Audit Officer	LED	13	6	4	312	97
26	Audit Officer	LED	1	12	4	312	15
28	Audit room	CFL	1	24	4	312	30
29	Audit room	LED	1	12	8	312	30
31	Tax Clerk Room	LED	1	18	8	312	45
33	MOP Room	LED	1	12	8	312	30
34	Account Branch	Incandescent light Bulb	1	100	14	312	437
35	MOF Branch	CFL	1	40	6	312	75
36	MOF Branch	LED	8	4	6	312	60
37	MOF Branch	LED	2	6	4	312	15
38	MOF Branch	LED	3	12	6	312	67
39	MOF Branch	LED	1	40	4	312	50
40	MOP Office	LED	10	4	2	312	25
41	MOP Office	LED	3	12	2	312	22
42	Meeting Room	LED	18	12	2	312	135
43	Meeting Room	LED	24	6	2	312	90
45	Marriage & Divorce Room (1)	LED	1	18	8	312	45
47	Marriage & Divorce Room (2)	LED	1	18	8	312	45
48	Mosque	CFL	1	40	10	312	125
49	Mosque	LED	13	4	8	312	130
50	Mosque	LED	2	12	8	312	60
51	Right Side Gallery	LED	4	12	6	312	90
53	Stairs Front	LED	4	6	6	312	45
54	Stairs Front	LED	4	12	6	312	90
55	Washroom	LED	1	12	6	312	22
56	Administrative office	LED	12	4	6	312	90

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[10]	Operating days per year	Annual Electricity consumption (kWh/year)
57	Administrative office	LED	11	12	6	312	247
58	Administrative office	LED	12	7	6	312	157
59	Chief Office	LED	14	12	6	312	314
60	Chief Office	LED	12	6	6	312	135
62	Head Clerk Office	LED	1	12	8	312	30
63	Head Clerk Office	LED	1	18	8	312	45
65	Superintendent Office Room	CFL	1	24	1	312	7
67	MOR Branch Clerk office	LED	1	12	8	312	30
68	MOR Branch Clerk office	Tube Light	1	40	8	312	100
69	Store	Incandescent light Bulb	1	100	1	312	31
71	Sub-Engineer Office	LED	13	6	8	312	195
72	MOI Branch	LED	10	7	8	312	175
73	MOI Branch	LED	5	12	8	312	150
74	Superintendent Office	LED	8	7	8	312	140
75	Superintendent Office	LED	2	10	8	312	50
76	Superintendent Office	LED	1	12	8	312	30
77	Superintendent Office	LED	2	18	8	312	90
78	Washroom	Incandescent light Bulb	1	100	4	312	125
79	Tube Well	Incandescent light Bulb	1	100	1	312	31
80	Back Building Gallery	Tube Light	1	40	12	312	150
81	Back Building Gallery	LED	1	12	12	312	45
82	Room No.1 Back Building	Tube Light	1	40	4	312	50
Water Supply Office							
1	Outside of Building	Incandescent light Bulb	1	100	12	312	374
2	Outside of Building	CFL	1	24	12	312	90
3	Clerk Room (1)	Incandescent light Bulb	1	100	8	312	250
5	Clerk Room (1)	CFL	1	40	8	312	100
6	Clerk Room (1)	LED	1	12	8	312	30
8	Clerk Room (2)	Tube Light	1	40	8	312	100
9	Clerk Room (2)	LED	1	12	8	312	30
10	Clerk Room (2)	Incandescent light Bulb	1	100	8	312	250
11	Small Hall	LED	1	12	8	312	30
12	Kitchen	LED	1	12	8	312	30
14	Store	LED	1	12	8	312	30
15	Store	LED	1	18	8	312	45
Slaughter House							
1	Front Side of Building	Incandescent light Bulb	1	100	4	312	125
	Total						**9,854**

5.3 Baseline Energy Consumption Trend

Energy source used in buildings of at Muridke Municipality for electricity are summarized hereunder.

Table 31: Energy consumption in Office Buildings of Muridke MC

SI No.	Description	Unit	Value[11]
1	Annual Electricity Consumption	kWh	103,381
2	Annual NG Consumption	MMBTU	73.13
3	Annual Water Consumption	m^3	Not metered

[11] Based on 12-month historical billing data March 2022 to February 2023.

A comparison of current electricity consumption by the MC's streetlights compared to results of the survey activity carried out in 2019, is presented in the following table:

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Buildings	2	3	102,656	100,564	2,092	53.93 kWh/m2	52.66 kWh/m2	MC's slaughterhouse in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of the salughterhouse has not been considered in the overall energy consumption and KPI calculations.

Analysis of the replacement proposed to the MC and the current on-ground situation is the presented in the following tables.

Table 32: Cooling Equipment Comparison

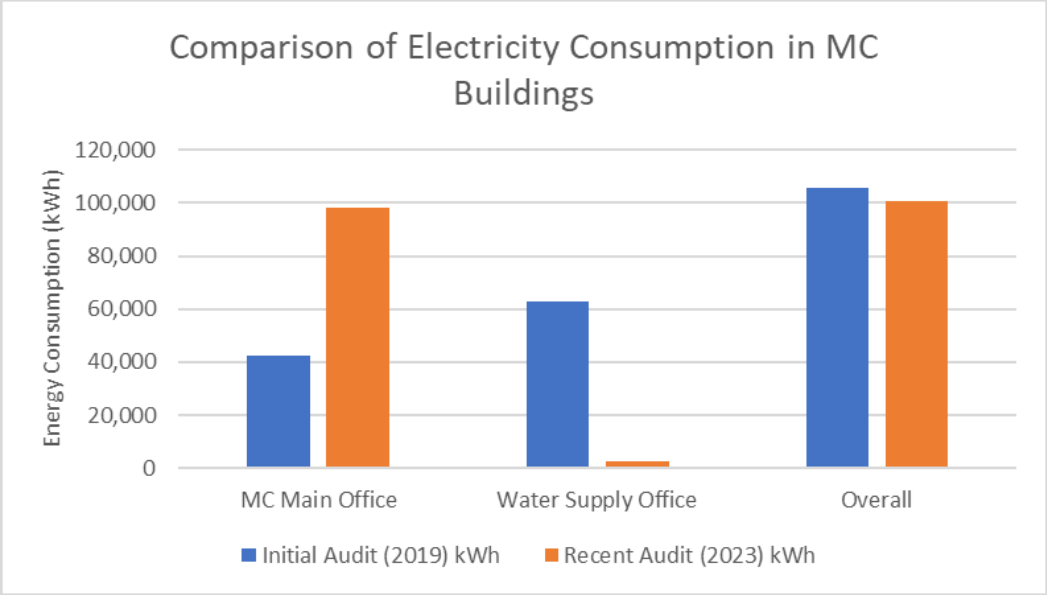
Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Main Office	Ceiling Fan	61	0	56
MC Main Office	Exhaust Fan	5	0	3
MC Main Office	Bracket Fan	-	-	2
MC Main Office	Pedestal Fan	1	0	0
MC Main Office	Split AC	9	0	14
MC Main Office	Window AC	1	1	1
Water Supply Office	Ceiling Fan	3	0	3
Water Supply Office	Pedestal Fan	1	0	1
Water Supply Office	Window AC	1	0	0
Water Supply Office	Bracket Fan	-	-	1

Table 33: Lighting Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Main Office	CFL	46	46	12
MC Main Office	Incandescent light bulb	4	4	4
MC Main Office	LED	200	0	271
MC Main Office	Tube Light	60	60	40
Water Supply Office	CFL	1	1	2
Water Supply Office	Incandescent light bulb	11	11	4
Water Supply Office	Tube Light	6	6	4
Water Supply Office	LED	-	-	6

Table 34: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh
MC Main Office	42,591	98,081
Water Supply Office	62,962	2,483
Overall	**105,553**	**100,564**



5.4 Maintenance Logs of Buildings

No record was available with MC Muridke, for the maintenance, replacement and retrofitting (if any) that took place in the office buildings during past few years.

6 Solar Assessment for MC Muridke

Solar site assessment comprises identification of practical potential to install solar PV projects from the theoretical potential. This is done through a detailed site survey which includes site location assessment, photo-montage considerations and grid integration scheme etc. Given below is the Consultant's assessment of the solar potential at each location. The electrical system at MC Muridke is 100% dependent on the Grid. LESCO is the distribution company which is responsible for providing electricity to the site.

As per the inventory, there are three buildings/sites that are owned and operated by MC.

MC Main Office Building has a Three Phase 400V electrical connection whereas, Slaughterhouse and Water Supply Office has single phase 220V electrical connection. As single-phase connections are not eligible for net metering, therefore, the Consultant has only carried out detailed assessment of system size requirement for the three phase connection buildings. Metering details of each building is presented below.

Table 35: Metering details at MC Muridke

Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
MC Office Building	20405222	45116410330900	22.6	A3 (66)
Slaughterhouse	20405224	11116411042012	-	A-2a (04)
Water Supply Office	20405223	44116410167902	2	G-1 (72)

6.1 MC Office Building

The project site i.e. MC Office Building is located near Mohalla Gaddafi Park Muridke, Sheikhupura, Punjab, Pakistan while the geographical co-ordinates of location are 31.80862°N (latitude) and 74.25309°E (longitude).

Figure 12: Front view of MC Office Building

Figure 13: Ariel view of MC Office Buildings

6.1.1 Solar System Requirement

Based on the analysis of energy bills from January 2022 to December 2022, it is identified that the annual energy consumption of MC Office Building is 98,081 kWh with the peak electricity consumption of 13,400 kWh in August 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 36 Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
98,081	8,173	13,400	72

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Building is 16,910 ft^2 whereas, the total area of rooftop available for the solar installation is 5,595 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

Figure 14: Top View of complete building

After the detailed assessment, The Consultant has identified two locations for the installation of rooftop solar systems. Geographical representation of these location is shown in the figures below.

Figure 15: Location for Solar Installation - A

Figure 16: Location for Solar Installation - B

Table 37: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B
Area availability (ft^2)	2,261	2,347
Solar system capacity (kW)	22	23

6.2 Slaughter House

The project site i.e. Slaughter House is located near Daoke Muridke, Sheikhupura, Punjab, Pakistan while the geographical co-ordinates of location are 31.809576°N (latitude) and 74.246459°E (longitude).

Figure 17: Front view of Slaughter House

Figure 18: Ariel view of Slaughter House

6.2.1 Solar System Requirement

Based on the analysis of energy bills from January 2022 to December 2022, it is identified that the annual energy consumption of Slaughter house 2,817 kWh with the peak electricity consumption of 518 kWh in November 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 38 Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
2,817	235	518	2

***Note:** Based on the analysis of the historical electricity billing data, it is identified that the solar system requirement for this site is only **2 kW,** furthermore as building is connected to the national grid through a single-phase electricity connection, it is not recommended to install the solar system at this site.

6.3 Water Supply Office

The project site i.e. Slaughter House is located near Bangla Pulli Road, Muridke, Sheikhupura, Punjab, Pakistan while the geographical co-ordinates of location are 31.79687°N (latitude) and 74.25200°E (longitude).

Figure 19: Front view of Water Office

Figure 20: Ariel view of Water Supply Office

6.3.1 Solar System Requirement

Based on the analysis of energy bills from January 2022 to December 2022, it is identified that the annual energy consumption of Water Supply Office 2,483 kWh with the peak electricity consumption of 565 kWh in February 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 39 Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
2,483	207	565	2

Note: Based on the assessment of the historical buildings it is identified that the system requirement for this site is 2kW and it is a single-phase connection therefore it is not recommended to install the solar system at this site.

6.4 Net Metering Consideration

With the rising costs of electricity in Pakistan and owning to unreliable grid supply, an ever increasing number of industries and commercial organizations are turning to captive solar solutions. There has been a strong surge in domestic installation of rooftop photovoltaic panels in larger cities. For projects under 1 MW, net metering regulations came into effect in September 2015.

The key highlights of net-metering regulation are as follows:

- Any three phase consumers (residential, commercial and industrial) will be considered eligible for the net metering system.
- Only plants installed and commissioned by AEDB registered vendors/consultants shall be eligible for net metering.
- Any empty space on the roof or facades of buildings, car parking, garages, factory or industrial buildings or sheds or similar buildings or at land within own premise of the consumer or any other suitable area where utility meter exists, is acceptable by the utility.
- Interconnection standards shall comply with the interconnection rules and standards set by the Utility or other relevant governing authority.

- 150% on the customer's sanctioned load is specified as the maximum permissible generator size (installed output DC capacity).
- The maximum output DC capacity of the installed RE system for Net Metering cannot be more than 1 MW.
- Load flow study for the facility having capacity up to 250kW is not required.
- The NOC by Electrical Inspector is not required for Net Metering of a system below 250 kW capacity.
    - In case the kWh supplied by Distribution Company exceed the kWh supplied by Distributed Generator, the Distributed Generator shall be billed for the net kWh in accordance with the Applicable Tariff.
    - The tariff payable by the Distribution Company shall only be the off-peak rate of the respective consumer category of the respective month.
- The equipment installed for net metering shall be capable of accurately measuring the flow of electricity in two directions.
- The net meter shall conform to the specifications mentioned in Net metering regulation or approved by relevant authority (Utility or NEPRA).
- A Distributed Generator shall be responsible for all costs associated with Interconnection Facilities up to the Interconnection Point including metering installation
- A variation of ±5%in Voltage and ±1% in frequency is permissible to the nominal voltage and frequency respectively
- The Distributed Generator will furnish and install a manual disconnect device that has a visual break to isolate the Distributed Generation Facility from the Distribution facilities
- The grid connected inverters and generators shall comply with Underwriter Laboratories UL 1741 standard (Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources) which addresses the electrical interconnection design of various forms of generating equipment, IEEE 1547 2003, IEC 61215, EN
- The Distributed Generator shall not have any right to utilize Distribution Company's Interconnection Facilities for the sale of electricity to any other person.

6.4.1 Net-metering application procedure

The net-metering application procedure applicable for all types of eligible consumers as per Net-metering regulation is explained **below.**

- Any person who meets the requirements of a Distributed Generator as defined under the regulations 2(k) is eligible for submitting application. Regulation 2(k) states the definition of a Distributed Generator as "a Distribution Company's 3 Phase 400V or 11 kV consumer i.e: domestic, commercial or industrial and who owns and/or operates the Distributed Generation **Facility and** is responsible for the rights and regulations related to the agreement and licensed by the Authority under these regulations".
- Application to Distribution Company along with necessary documents shall be submitted by intending Distributed Generator.
- Within five working days of receiving an Application, the Distribution Company shall acknowledge its receipt and inform the Applicant whether the Application is completed in all respect. Provided that in case of any missing information or documents the Applicant shall provide the same to Distribution Company within seven working days of being informed by Distribution Company.

- Upon being satisfied that the Application is complete in all respect, the Distribution Company shall perform an initial review (20 days) to determine whether the Applicant qualifies for Interconnection Facility or may qualify subject to additional requirements.
- In case the initial review reveals that the proposed facility is not technically feasible, the Distribution Company shall return the Application and communicate the reasons to the Applicant within three working days after the completion of initial review.
- For connections up to 250 kW, no technical feasibility study is needed. Power Ministry, GOP has directed DISCOs to carry out relevant technical studies and approve the connections at sub-division level. If the DISCO is satisfied that the Applicant qualifies as a DG, then the DISCO and DG will enter into an agreement.
- The DISCO office will send the copy of the Agreement between DISCO and DG to NEPRA along with application for issuance of Generation License (GL). NEPRA will issue GL within forty (40) hours of submission of application by DISCOs.
- After the Agreement. DISCO will issue the Connection Charge Estimate, if any, to the Applicant for the proposed interconnection facility up to the interconnection point including net metering installation (it is the Applicant's choice to purchase Net Meter from DISCO or open market)
- The Applicant shall make the payment of Connection Charge Estimate within twenty days of its issuance.
- Within Thirty (30) days of payment by Applicant, the DISCO office will install and commission the proposed interconnection facility after the confirmation of GL license to the DG by NEPRA.

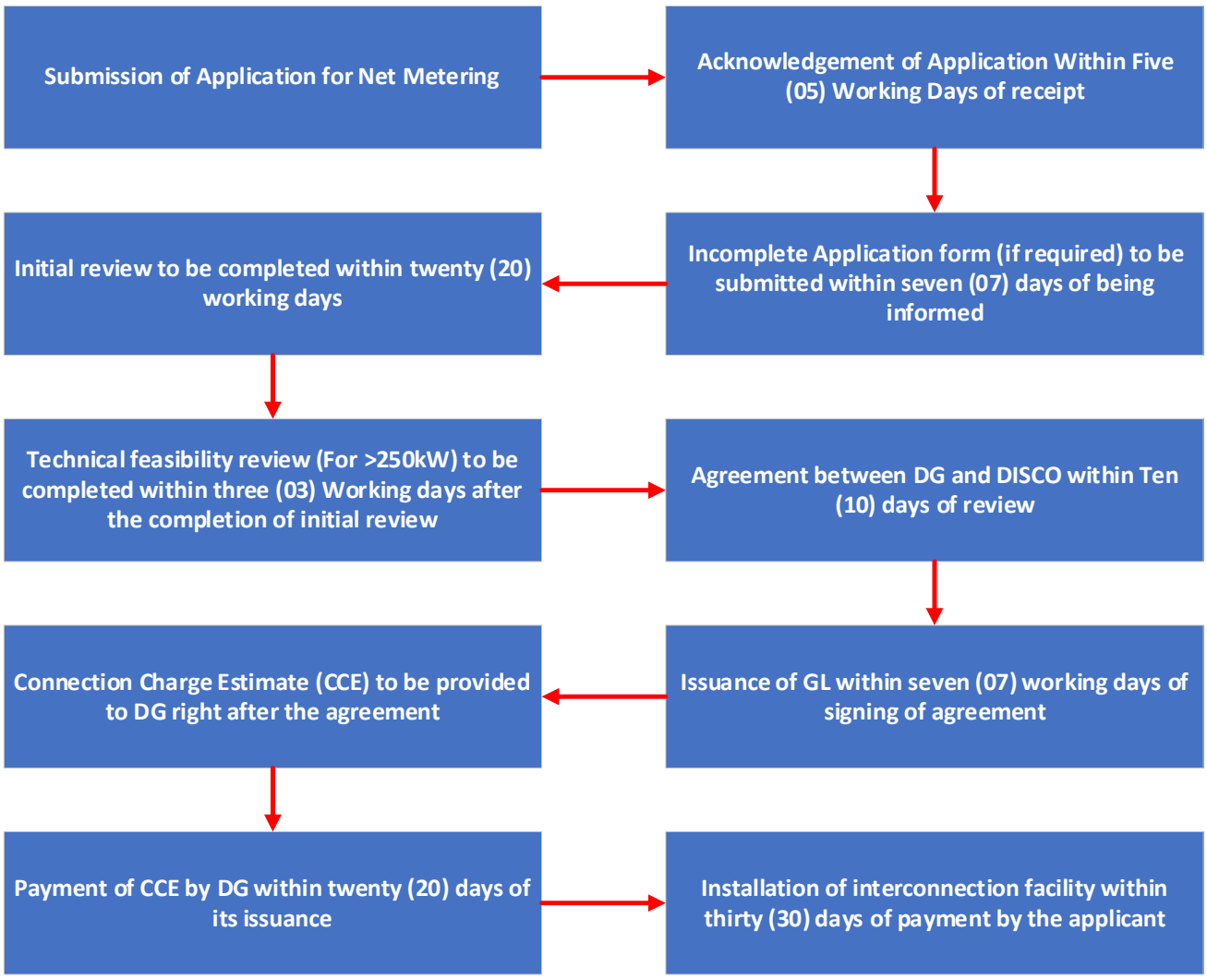


Figure 21: Pakistan Net Metering Application Process

The Consultant strongly recommends that net metering facility be utilized in the PV system design for municipal buildings. The basis of this recommendation is based on the nature of the loads. During the day, solar can supplement the electronic, lighting, and cooling loads while exporting the excess energy to the Grid.

7 Recommended Energy Efficiency Measures

For all municipalities, the recommended EE measures are categorized into high, medium and low priority measures. High priority EE measures are those which shall be implemented immediately (within 1 year) to meet the baseline demand, medium term measures may be implemented in the near future (within 2-3 years' time) and low priority measures may be implemented in the remote future (within 3-5 years' time).

7.1 Energy Efficiency Measures for Water Pumps & Wastewater Disposal System

7.1.1 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Development of New Bore & Replacement of Pumpset at (Pera Mandi - Unique ID: 5264015)

Study & Investigation

No flow could be detected due to the due to extremely low flow rate of water in the pipe.

Recommended Action

Development of a new bore and replacement of Pump with new PECO 10MC 4-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

- Negligible maintenance (during the first 3 years of its operation)
- Reduced electricity consumption and less operational hours.

Saving Assessment

Table 40: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	150
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	
Measured Head	m	3.7
Measured Motor Power	kW	
Pump Efficiency	%	
Existing Operational Hours	h	10.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	10.0
Pump Operational Days	days	330
Efficiency	%	85%
Annual Water Generation from proposed pump	m^3	336,404
Energy Required per m^3 by Existing Pump Network to Supply abovementioned quantity of water	(kWh/m^3)	0.17
Energy Required by Existing Pump Network to Supply abovementioned quantity of water	kWh	57,499
Energy Required by Proposed Pump to Supply abovementioned quantity of water	kWh	44,295
Saving Potential	kWh/y	13,204
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,121
Investment	US $	6,949
Simple Payback Period	months	39

7.1.2 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Supply Scheme #16 - Itahad Colony - Unique ID: 5260419)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 40%.

Recommended Action

Replacement of Pump with new PECO 10MC 4-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

- Negligible maintenance (during the first 3 years of its operation)
- Reduced electricity consumption and less operational hours.

Saving Assessment

Table 41: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	150
Design Motor Power of Existing Pump	kW	29
Measured Flow	m^3/h	152
Measured Head	m	26.1
Measured Motor Power	kW	32.00
Pump Efficiency	%	40%
Existing Operational Hours	h	10.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	14.9
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	105,600
Energy Required by Proposed Pump	kWh/y	80,659
Saving Potential	kWh/y	24,941
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	4,005
Investment	US $	4,026
Simple Payback Period	months	12

7.1.3 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Supply Scheme #2 - Nizam Park - Unique ID: 5274021)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 51%.

Recommended Action

Replacement of Pump with new PECO 10MC 4-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

- Negligible maintenance (during the first 3 years of its operation)
- Reduced electricity consumption and less operational hours.

Saving Assessment

Table 42: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	120
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	109
Measured Head	m	24.5
Measured Motor Power	kW	16.80
Pump Efficiency	%	51%
Existing Operational Hours	h	10.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	10.6
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	55,440
Energy Required by Proposed Pump	kWh/y	47,159
Saving Potential	kWh/y	8,281
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,330
Investment	US $	3,608
Simple Payback Period	months	33

7.1.4 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Supply Scheme #4 - Mohallah Shaikhan - Unique ID: 5274023)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 35%.

Recommended Action

Replacement of Pump with new PECO 12MC 2-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

- Negligible maintenance (during the first 3 years of its operation)
- Reduced electricity consumption and less operational hours.

Saving Assessment

Table 43: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	150
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	109
Measured Head	m	16.8
Measured Motor Power	kW	16.60
Pump Efficiency	%	35%
Existing Operational Hours	h	10.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	10.7
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	54,780
Energy Required by Proposed Pump	kWh/y	47,203
Saving Potential	kWh/y	7,577
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,217
Investment	US $	3,608
Simple Payback Period	months	36

7.1.5 High Priority Energy Efficiency Measure: Replacement/installation of Capacitors for Power Factor improvement.

Description

Replacement/installation of capacitors for power Factor (PF) improvement.

Study & Investigation

The power factor (PF) was measured using an energy analyzer during normal pump operation.

Recommended Action

Replacement/Installation of capacitors to improve Power Factor. The recommended capacitor size has been calculated for achieving a PF value of 0.9

Saving Assessment

Table 44: Financial Analysis of installation of capacitors for improvement of Power Factor

Sr. No.	Location	Unique ID	Capacitor kVAr	Quantity	Unit Cost (USD)	Total (USD)
1	Supply Scheme #10 - Mohala Qadafi park	5250410	2.5	3.0	50	150
2	Mohallah Canal Park	5264016	2.5	3.0	50	150
3	Mohallah Rehmania Colony	5264017	2.5	3.0	50	150
4	Mohallah Bassra Colony	5264018	2.5	3.0	50	150
5	Water Supply Faisal Colony- Bilal Park	5274025	2.5	3.0	50	150
6	Supply Scheme #2 - Nizam Park	5274021	2.5	3.0	50	150
7	Muridke Town	5250412	2.5	3.0	50	150
8	Hassan Park	5250413	2.5	3.0	50	150
9	Supply Scheme #3 - Old Committee Office	5274020	5.0	3.0	50	150
	Total					**1350**

7.1.6 Low Priority Energy Efficiency Measure: Installation of Smart Flow Meters

Description

Installation of Smart flow meters at all pumps and disposals integrated with a smart DCS system

Study & Investigation

Currently there is no metering system at water supply sites. The consumption of water is distributed over the entire city based on demand. The absence of information at the input level is a constraint to make water management and water efficiency an ongoing activity in the city.

Recommended Action & Benefits

- It is recommended to install twenty-two (22) smart water meters on all operational potable water and disposal pumps.
- DCS system will help in water data review, development of KPI, analysis of generation and consumption trends during different seasons and times of year.
- In the long term, the measure will help the GoPb tremendously if it intends to meter the water usage of its commercial and domestic consumers, and determine a water tariff (based on actual consumption).
- Overall reduction in water & corresponding energy consumption

Saving Assessment

It has been estimated that a minimum of 1 % savings in water production can be achieved by putting in place a water management system (actual savings achievable are 3-5%). In the long term, the measure may help the GoPb tremendously if it intends to meter the water usage of its commercial and domestic consumers and determine a water tariff (based on actual consumption). Other ancillary benefits of installing online monitoring system are timely detection of line leakages, sudden drop in pump discharge or pumpset efficiency, etc.

Table 45: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	5,723,250
Annual Water consumption (post-implementation)	m^3/y	5,666,018
Annual Water saving per year	m^3/y	57,233
Estimate of Investment (including the cost of the server)	US$	13,500

7.2 Energy Efficiency Measures for Streetlights

7.2.1 High Priority Energy Efficiency Measure: Installation of LEDs at all non-functional MC streetlights

Project

Installation of non-functional streetlights operated by municipality with LEDs along with photocell switches.

Study & Investigation

During the assessment it was observed that there are 225 streetlights which are being operated by the municipality. Out of these, 50 were found to be non-operational and 68 were found to be disconnected from electricity meters. It was also observed that all of streetlights are manually operated.

12 of these streetlights are installed at a height of more than 20 feet.

Recommended Action

It is recommended to install LEDs at all non-functional MC operated streetlights along with photocell switches and energy meters for measurement of energy consumption. It is recommended to install 50-watt LED for streetlights installed at a height of 20 feet of more & 30-watt LED for the streetlight installed at a height of less than 20 feet. LED lamps always have less maintenance issues as compared to conventional ballast; also, the life of the lamp will be increased because of electronic ballast. It will improve visibility during night and foggy season and reduce electricity consumption.

Figure 22: Picture of proposed LED, Photocell switch and energy meter for streetlights

Saving Assessment

LED lamps will have less maintenance issues as compared to conventional tube lights and energy savers (CFLs), because they have longer operational life.

Automatic photocell switches will optimize the daily operational hours of streetlights resulting in electricity savings and cost of operation (no more dedicated person will be required for operation of streetlights).

Since this measure is for all non-functional lights hence no direct electricity savings could be quantified.

Table 46: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	50
Number of non-functional streetlights (>20 feet)	#	12
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	38
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	2,586,794
Proposed number of photocell switches	#	17
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	17,000
Upfront investment cost	PKR	2,603,794
Upfront investment cost	US$	9,293
Annual Operating Electricity unit	kWh/yr	7,621
Annual Operating Cost	PKR/yr	342,954
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	148,580
Monthly diesel cost for operating fork lifter for two days	PKR/month	20,000
Monthly cost of renting Fork Lifter for two days	PKR/month	80,000
Miscellaneous Cost	PKR/month	20,000
Monthly maintenance cost	PKR/month	120,000

7.3 Energy Efficiency Measures for Buildings

7.3.1 High Priority Energy Efficiency Measure No. 18: Replacement of inefficient equipment in the buildings

Project

Replacement of inefficient equipment with new efficient equipment.

Study & Investigation

Following equipment are found to be inefficient and should be replaced with their more efficient counterparts.

Table 47: Replacement of inefficient equipment at office buildings

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment (Watt)	Overall Wattage of Proposed Equipment (Watt)	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters (PKR)
MC Main Office											
1	Window AC	1	2400	2400	1,123	Inverter 1.5 Tons	1,452	1,452	680	143,000	143,000

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment (Watt)	Overall Wattage of Proposed Equipment (Watt)	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters (PKR)
2	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
3	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
4	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
5	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
6	CFL	3	24	72	180	LED Bulb 13 Watts	13	39	97	350	1,050
7	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
8	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
9	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
10	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
11	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
12	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
13	Tube Light	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
14	Tube Light	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
15	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
16	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
17	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
18	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
19	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
20	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
Water Supply Office											
1	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
2	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
3	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
4	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
5	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
6	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
Slaughter House											
1	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 48: Saving & cost benefit analysis

Parameters	Unit	Value
Average Operational Days for Building lighting Equipment	days/year	312
Average Operational Hours for Building lighting Equipment	Hours/day	8
Average Operational Days for Building Cooling Equipment (Window AC)	days/year	156
Average Operational Hours for Building Cooling Equipment (Window AC)	Hours/day	3
Energy consumption of inefficient Equipment	kWh/yr	5,613
Energy consumption of Proposed Equipment	kWh/yr	2,185
Energy Savings	kWh/yr	3,428
Unit cost of electricity	PKR/kWh	24
Annual cost savings	USD	293
Upfront Investment (including change in fixtures)	USD	715
Payback Period	Months	29

8 Investment Estimate (including Material Specification/Quantities)

8.1 Potable Water Pump

The total investment estimate (including Material Specification/Quantities) of all the energy efficiency measures proposed for pumpsets to improve their efficiency and facilitate the public with uninterrupted supply of potable water throughout the year, are discussed in detail below.

8.1.1 Investment Estimate (including Material Specification/Quantities) for PECO 10 MC /4 Stages, 25hp Motor

Pump Size		10 MC /4 Stages			
Capacity		101.94 m3/hr	Max. O.D bowl		9.5 Inches
Speed		1450 rpm	I.D tubewell	-	
Pump Input		25 HP	Length of suction pipe		
Prime Mover (SEM/DE)		25 HP			
			Length of bowl assembly		
			Length of column pipe		
			Length of top pipe		1 Ft
			Total length of column		1 Ft

Material Specifications

Pump Assembly

Bowls	Cast Iron
Impellers	Bronze
Wearing Ring	Cast Iron
Shaft	Stainless Steel
Shaft Sleeves	Bronze
Bearing	Bronze

Column Pipe assembly

Column Pipe	Steel
Shaft	Carbon Steel
Shaft Sleeves	S.S
Shaft Couplings	Steel
Bearings	Rubber Lined
Bearings retainer	Cast Iron
Column Pipe Coupling	Flanged
Top Shaft	Stainless Steel

Component parts of each pumping unit

Pump assembly of	5	stages with flow type impellers				
Column assembly of	6	inches I.D with flanged joins		each 10 ft length	0	Sets
				and one top set	1	feet length
Discharge head Inch	6			column shaft dia	0	mm
Electric Motor vertical hollow shaft 30 HP/4 Pole						included
DWT with Discharge Head						included
Mechanical installation within Pump House Only						included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	864,104
Sales Tax @ 17%	Rs:	146,898
Total Cost of Pumpset	Rs:	1,011,002

8.1.2 Investment Estimate (including Material Specification/Quantities) for PECO 10 MC /4 Stages, 30hp Motor

Pump Size		10 MC /4 Stages			
Capacity		101.94 m3/hr	Max. O.D bowl		9.5 Inches
Speed		1450 rpm	I.D tubewell	-	
Pump Input		30 HP	Length of suction pipe		
Prime Mover (SEM/DE)		30 HP			
			Length of bowl assembly		
			Length of column pipe		
			Length of top pipe		1 Ft
			Total length of column		1 Ft

Material Specifications

Pump Assembly

Bowls	Cast Iron
Impellers	Bronze
Wearing Ring	Cast Iron
Shaft	Stainless Steel
Shaft Sleeves	Bronze
Bearing	Bronze

Column Pipe assembly

Column Pipe	Steel
Shaft	Carbon Steel
Shaft Sleeves	S.S
Shaft Couplings	Steel
Bearings	Rubber Lined
Bearings retainer	Cast Iron
Column Pipe Coupling	Flanged
Top Shaft	Stainless Steel

Component parts of each pumping unit

Pump assembly of	5	stages with flow type impellers			
Column assembly of	6	inches I.D with flanged joins	each 10 ft length	0	Sets
			and one top set	1	feet length
Discharge head Inch	6		column shaft dia	0	mm
Electric Motor vertical hollow shaft 30 HP/4 Pole					included
DWT with Discharge Head					included
Mechanical installation within Pump House Only					included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	964,104
Sales Tax @ 17%	Rs:	163,898
Total Cost of Pumpset	Rs:	1,128,002

8.2 Investment Estimate (including Material Specification/Quantities) Streetlights

The total investment estimate (including Material Specification/Quantities) of all the energy efficiency measures proposed for streetlights to improve their efficiency and facilitate the public with uninterrupted lighting at night throughout the year, are discussed in detail in this section.

8.2.1 Investment Estimate (including Material Specification/Quantities) for High Priority EE Measure: Installation of LED at all non-functional MC Operated streetlights

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 50W	50	7000 Lm	140 Lm/Watt	187	53,873	646,476
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	1,534	51,061	1,940,318
3	Accessories	Photocell switch				17	1,000	17,000
Lumpsum Price (PKR)								**2,603,794**
Lumpsum Price (USD)								**9,293**

8.3 Investment Estimate (including Material Specification/Quantities) Buildings

The total investment estimate (including Material Specification/Quantities) of all the energy efficiency measures proposed for buildings to improve their efficiency and facilitate the public throughout the year, are discussed in detail in this section.

8.3.1 Investment Estimate (including Material Specification/Quantities) for High Priority EE Measure: Replacement of inefficient equipment in the buildings

Sr. No	Proposed Equipment	Wattage of Proposed Equipment	Equipment Count	Overall Wattage of Proposed Equipment	Individual Cost of Proposed Equipment (PKR)	Cost of Proposed Equipment
1	Inverter 1.5 Tons	1452	1	1452	143,000	143,000
2	LED Bulb 13 Watts	13	15	195	350	5,250
3	LED Bulb 8 Watts	8	1	8	330	330
4	LED Bulb 20 Watts	20	3	60	830	2,490
5	LED Rod 20 Watts	20	17	340	2,900	49,300
Lumpsum Price (PKR)						**200,370**
Lumpsum Price (USD)						**715**

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9 Summary of Energy Efficiency Measures

MC Muridke's annual energy consumption is 2,942,698 kWh which is mainly in the form of electricity (water supply, buildings & streetlights) and fuel for vehicles. The study has helped in successfully identifying resource and energy efficiency improvement measures which will help:

- Yield annual savings of **US$ 9,223** with an estimated investment of **US$ 43,048.**
- Reduce electricity consumption by approx. **57,431 kWh.**
- Reduce GHG Emissions by **29 tCO_2/y**.

10 Annexures

Annexure 01: PEAK / OFF PEAK TIMINGS of LESCO

Season	Peak Timing	Off-Peak Timing
Dec to Feb	5 PM to 9 PM	Remaining 20 hours
Mar to May	6 PM to 10 PM	-do-
Jun to Aug	7 PM to 11 PM	-do-
Sep to Nov	6 PM to 10 PM	-do-

Annexure 2: List of Energy Audit Equipment

Sr. No.	Name	Picture	Function	Type	Model	Manufacturer
1	**Ultrasonic Flow Mater – Tubewell**		Measurement of Flow Rate (m3/sec)	Contact Type	SL 1168P	Sitelab
2	**Ultrasonic Flow Mater – Disposal Station**		Measurement of Flow Rate (m3/sec)	Contact Type	PF-D550	Micronics
3	**Energy Analyzer**		Measurement of Electrical Parameters (V,A,Hz,kW,kVA,kvar,PF)	Non-Contact Type	DW-6195	Lutron
4	**Digital Tachometer**		Measurement of Shaft Rotation (RPM)	Non-Contact Type	MS6208B	Mastech
5	**Infrared Thermometer**		Measurement of Temperature (°C)	Non-Contact Type	62 mini	Fluke
6	**Vibrometer**		Measurement of Acceleration, Velocity & Displacement (Hz)	Contact Type	GM63B	Benetech
7	**Pressure Gauge**		Measurement of Fluid Hygienic Pressure (bar g)	Contact Type	EN 877-1	Wika

Sr. No.	Name	Picture	Function	Type	Model	Manufacturer
8	**Sonic Water level meter**		Measurement of water level depth	Non-Contact Type	200 U	Ravensgate
9	**Ultrasonic Thickness Gauge**		Measurement of thickness of delivery pipe	Contact Type	TM-8812	Landtek
10	**Water level Probe**		Measurement of water level depth	Contact Type	N/A	Local