Jhelum Municipal Committee

Energy Audit Report

June 2023

History of the Document

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The Consultant is also grateful to entire Jhelum 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
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 Jhelum MC Background

The city of Jhelum is located at 32.9425° N, 73.725556° E. Jhelum District has an approximate population of 1.2 million.

Jhelum city is located at right bank of river Jhelum at N-5 highway previously called G-T road (Rawalpindi – Lahore section). It has got a distance of 165 km from Lahore and 115 km from Rawalpindi. This is an ancient city and is a district head quarter. MC Jhelum comprises of city itself and Dina town (urban locality) along with the rural area of Tehsil Jhelum.

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 Jhelum MC has the following management.

Sr. No.	Name of Officer	Designation
1	Mr. Babar Sahib Din	Administrator
2	Muhammad Usman Gondal	Chief Officer
3	Muhammad Ahmed*	Municipal Officer (Infrastructure)
4	Mr. Tariq Javed	Municipal Officer (Regulation)
5	Mr. Muhammad Abid	Municipal Officer (Finance)
6	Mr. Salam Abbasi	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Jhelum

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	634,697
Electrical energy used by Wastewater Disposal[2]	kWh/year	6,056
Electrical energy used in Buildings[3]	kWh/year	37,865
Electrical energy used by Streetlights[4]	kWh/year	86,588
Diesel used by Vehicles	liter/year	86,328
Petrol used by Vehicles	liter/year	0

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)	0.18
2	Energy Density of Wastewater Disposal	(kWh/m^3)	Disposal Pumpsets are not operational
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)	8.29
5	Energy Cost on Wastewater Disposal	(PKR/m^3)	Disposal Pumpsets are not operational
6	Energy Cost on Wastewater Treatment	(PKR/m^3) – if applicable	No wastewater treatment is carried out

1.5.2 Streetlights

Table 3: KPIs for Streetlights

Sr. No.	Description	Unit	KPI
1	Average electricity consumed per kilometer of lit roads	(kWh/km)	2,635
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	89
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	45,770
		PKR/Lighting Equipment	37,771
4	Average cost of installation of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	1,254
		PKR/Lighting Equipment	370

[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

Sr. No.	Description	Unit	KPI
5	Average annual maintenance costs	(PKR)	182,952
6	Average daily duration of operation	(Hour)	12.0
7	Average energy costs per kilometer of lit roads	(PKR/km)	118,572
8	Average energy costs per light pole/fixture	(PKR/ fixture)	4,403
9	Number and percentage of failed public lights		48%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	6.73
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.08
3	Average Energy Cost of Heating	(PKR/m^2)	4
4	Average Energy Cost of Cooling	(PKR/m^2)	110
5	Average Energy Cost of Lighting	(PKR/m^2)	100

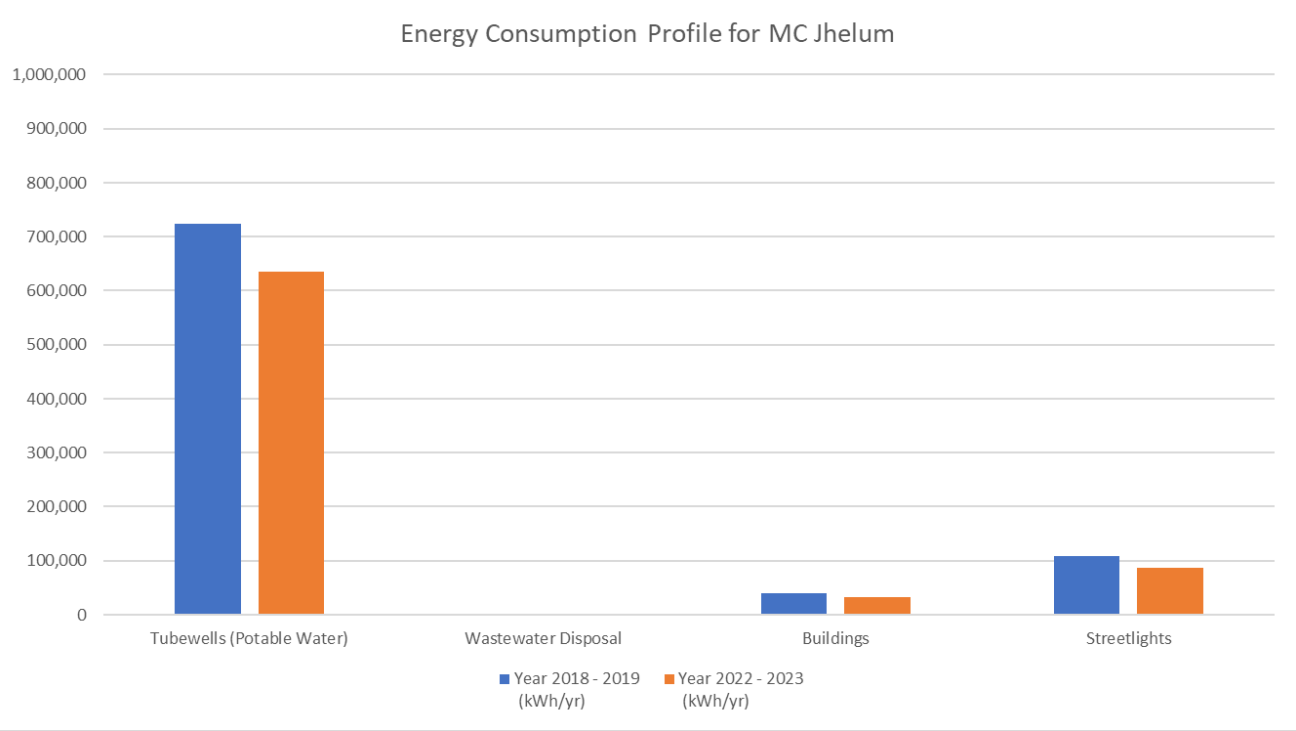
1.5.4 Vehicles

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	3.70
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	79.18

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.



		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)	21	19	723,115	634,697	88,418	0.20 kWh/m3	0.18 kWh/m3	Replacement of 7 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 5 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	N/A	N/A	N/A	N/A	0	N/A	N/A	No performance could be carried out on disposal stations as these sites were non-operational during the both audits.
3	Buildings	3	5	39,931	31,852	8,079	13.72 kWh/m2	8.78 kWh/m2	Library old building and Graveyard were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these buildings have not been considered in the overall energy consumption and KPI calculations.
4	Streetlights	262	495	108,417	86,588	21,829	3,764 kWh/km	2,635 kWh/km	Based on the previous assessment, there were only 262 MC owned operational lights with an average consumption of 413kWh/light/annum, whereas, currently there are

		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
									495 operational lights with average energy consumption of 174kWh/light/annum. The MC has significantly improved its energy consumption per light fixture.

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
Replacement of Pumpset at (Chak Abdullah Shadab Road Pump No. 25 - Unique ID: 81706206)	6,598	4,026	1,128,002	1,060	296,916	46	3
Replacement of Pumpset at (Sahil Colony Pump No. 22 - Unique ID: 81706209)	25,798	4,151	1,163,000	4,143	1,160,930	12	13
Replacement of Pumpset at (Norani Masjid Pump No. 35 - Unique ID: 81706215)	22,017	4,026	1,128,002	3,536	990,757	14	11
Replacement of Pumpset at (Chak Bram Pump No. 35 - Unique ID: 81706216)	12,655	4,026	1,128,002	2,032	569,460	24	6
Replacement of Pumpset at (Mandi Mor Pump No. 30 Mujahidabad - Unique ID: 81706226)	15,672	4,026	1,128,002	2,517	705,227	19	8
Replacement of Pumpset at (Ramzan Bazar - Unique ID: 81706234)	9,300	4,026	1,128,002	1,494	418,517	32	5
Replacement of Pumpset at (Sheesha Ground - Unique ID: 81706236)	11,016	4,026	1,128,002	1,769	495,703	27	6
Replacement/Installation of Capacitors	Not Quantifiable	1,050	294,210	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	84,837	23,771,365	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	40,071	1,951	546,790	6,435	1,803,199	4	20
Total:	**143,127**	**116,143**	**32,543,377**	**22,986**	**6,440,709**		**72**

Table 7: Medium Priority Measures

Medium 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
Replacement of existing MC operated non efficient streetlights with LEDs	117,717	27,152	7,608,089	18,905	5,297,260	17	69
Total:	**117,717**	**27,152**	**7,608,089**	**18,905**	**5,297,260**	**17**	**69**

Table 8: 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	38,036	27,000	7,565,400	0	0	0	Not Quantifiable
Total:	**38,036**	**27,000**	**7,565,400**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Jhelum MC has twenty-five (25) tubewells for groundwater, all of which are manually operated. Out of these, 19 pumpsets were found to be in working condition.

The MC has one (1) disposal station having two (2) pumps. Both pumpsets are currently non-functional and their site is under-construction. The pumps are used to dispose the wastewater to the nearby drain. There are eleven (11) dewatering sets in the MC and all 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 eighteen (18) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake assessment of the following pumpsets as no flow could be detected due to high turbulence and rusty conditions of the inner surface of the delivery pipe.
   1. Peer Azmat Darbar Pump No. 17 (Unique ID: 81706217)
   2. Karim Pura Pump (Unique ID: 81706214)
   3. Ehsan Road Pump No. 34 (Unique ID: 81706220)
   4. R.O School Pump No. 32 (Unique ID: 81706229)
   5. Asasya Road Pump No. 24 (Unique ID: 81706235)
   6. Pump No. 2 Tehsil Road Near Post Office (Unique ID: 81806241)

(iv) Undertake assessment of the following pumpsets due to non-functional motors
   1. Near Al-Meraj Flour Mill (Unique ID: 81706222)
   2. Kashmir Colony Pump No. 19 (Unique ID: 81706223)
   3. Mandi Mor Pump No. 33 (Unique ID: 81706227)

(v) Undertake assessment of the following pumpsets due to non-availability of electrical supply
   1. Kamela Slaughter (Unique ID: 81706231)
   2. Salman Pass Pump No. 3 (Unique ID: 81806239)
   3. Pump No. 27 Jubille Ghatt Bagh Mohallah (Unique ID: 81806242)

(vi) Undertake assessment of the following disposal stations as these pumps were non-functional and site is under-construction

1. Altaf Park Disposal (Unique ID: 81806240-A)
2. Altaf Park Disposal (Unique ID: 81806240-B)

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 9: 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	81706234	Ramzan Bazar	28-14416-7951400	Turbine	KSB	2008	Siemens	2008	32.93434	73.726801
2	81706235	Asasya Road Pump No. 24	28-14416-7951800	Turbine	KSB	2007	Siemens	2007	32.933062	73.728739
3	81806241	Pump No. 2 Tehsil Road Near Post Office	28-14412-7706700	Turbine	KSB	2020	Siemens	2020	32.925948	73.730648
4	81806242	Pump No. 27 Jubille Ghatt Bagh Mohallah	28-14416-7955000	Turbine	KSB	2008	Siemens	2008	32.926087	73.733474
5	81806243	Bagh Mohallah Kundan Ghat	28-14416-7955100	Turbine	KSB	2020	Siemens	2020	32.927132	73.734657
6	81706215	Norani Masjid Pump No. 35	28-14421-8022700-U	Turbine	KSB	2008	Siemens	2008	32.972243	73.702308
7	81706220	Ehsan Road Pump No. 34	28-14421-8022500-R	Turbine	KSB	2007	Siemens	2007	32.97475	73.692937
8	81806237	Municipal Stadium (Salman Parag No. 1)	28-14412-7707400	Turbine	KSB	2007	Siemens	2007	32.925156	73.728499
9	81707771	Kashmir Colony Pump No. 37	28-14412-7708402	Turbine	KSB	2020	Siemens	2020	32.98432	73.675713
10	81706217	Peer Azmat Darbar Pump No. 17	28-14421-8022600	Turbine	KSB	2008	Siemens	2008	32.975931	73.696895
11	81706216	Chak Bram Pump No. 35	28-14421-8023200-U	Turbine	KSB	2008	Siemens	2008	32.978339	73.700153
12	81706222	Near Al-Meraj Flour Mill	28-14421-8021600-U	Turbine	KSB	2007	N/A	2007	32.971425	73.699203
13	81706206	Chak Abdullah Shadab Road Pump No. 25	28-14416-7953800	Turbine	KSB	2008	Siemens	2008	32.937287	73.736385
14	81706208	Dist. Court Road Pump No. 6	28-14411-7643000	Turbine	KSB	2020	Siemens	2020	32.943196	73.741202
15	81706209	Sahil Colony Pump No. 22	28-14411-7643200	Turbine	KSB	2007	Siemens	2007	32.941549	73.741913
16	81706211	Bilal Town Pump No. 21	28-14411-7641500	Turbine	KSB	2007	Siemens	2007	32.953592	73.742032
17	81706212	Near Mehfooz CNG Pump No. 23	28-14411-7642900	Turbine	KSB	2007	Siemens	2007	32.94779	73.746007
18	81706214	Karim Pura Pump	28-14411-7642500	Turbine	KSB	2007	Siemens	2007	32.953908	73.724603
19	81706223	Kashmir Colony Pump No. 19	28-14412-7708400	Turbine	KSB	N/A	Siemens	N/A	32.98391	73.675454
20	81706226	Mandi Mor Pump No. 30 Mujahidabad	28-14416-7950500	Turbine	KSB	2007	Siemens	2007	32.942814	73.718296
21	81706227	Mandi Mor Pump No. 33	28-14416-7951100	Turbine	KSB	2008	Siemens	2008	32.943405	73.71774
22	81706229	R.O School Pump No. 32	28-14411-7641300	Turbine	KSB	2007	Siemens	2007	32.950728	73.71823
23	81706231	Kamela Slaughter	28-14411-7642400	Turbine	KSB	2008	Siemens	2008	32.94913	73.720142
24	81706236	Sheesha Ground	28-14412-7706800	Turbine	KSB	2007	Siemens	2007	32.931824	73.727389
25	81806239	Salman Pass Pump No. 3	28-14412-7707500	Turbine	KSB	2020	Siemens	2020	32.923025	73.728327

2.1.2 Disposal Works

Table 10: Inventory Table of Disposal Works

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Pump Capacity (Cusec)	Motor Manufacturer	Motor Capacity (Hp)	Latitude	Longitude
1	81806240-A	Altaf Park Disposal	27-14412-8441200	Centrifugal	KSB	4	Siemens	50	32.922931	73.726962
2	81806240-B	Altaf Park Disposal	27-14412-8441200	Centrifugal	KSB	4	Siemens	50	32.922931	73.726962

2.1.3 Filtration Units

Table 11: Inventory of Filtration Units

Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East
1	81806244	Bagh Mohallah	Centrifugal	1	Master Pumps	N/A	Master Motors	30.801216	73.443706
2	81806245	Karam Shah	Centrifugal	1	SONEX Pump	N/A	SONEX Motor	30.811097	73.444548
3	81808881	Shandar Chowk	Centrifugal	1	N/A	N/A	N/A	30.809176	73.440753
4	81808882	Sheesha Ground	Centrifugal	1	N/A	N/A	N/A	30.810702	73.443006

2.1.4 Dewatering Sets Details

Details of the MC Dewatering Sets are given below.

Table 12: Dewatering Sets' Details

Sr. No.	Unique Id	Location	Quantity	Latitude	Longitude
1	81806240 A	Plot 305, Naya Mohallah	1	32.92978	73.73141
2	81806240 B	Stadium Road (Workshop)	10	32.923283	73.727207

2.2 GIS Map of water pumps/Tubewells & wastewater disposals in Jhelum, 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.

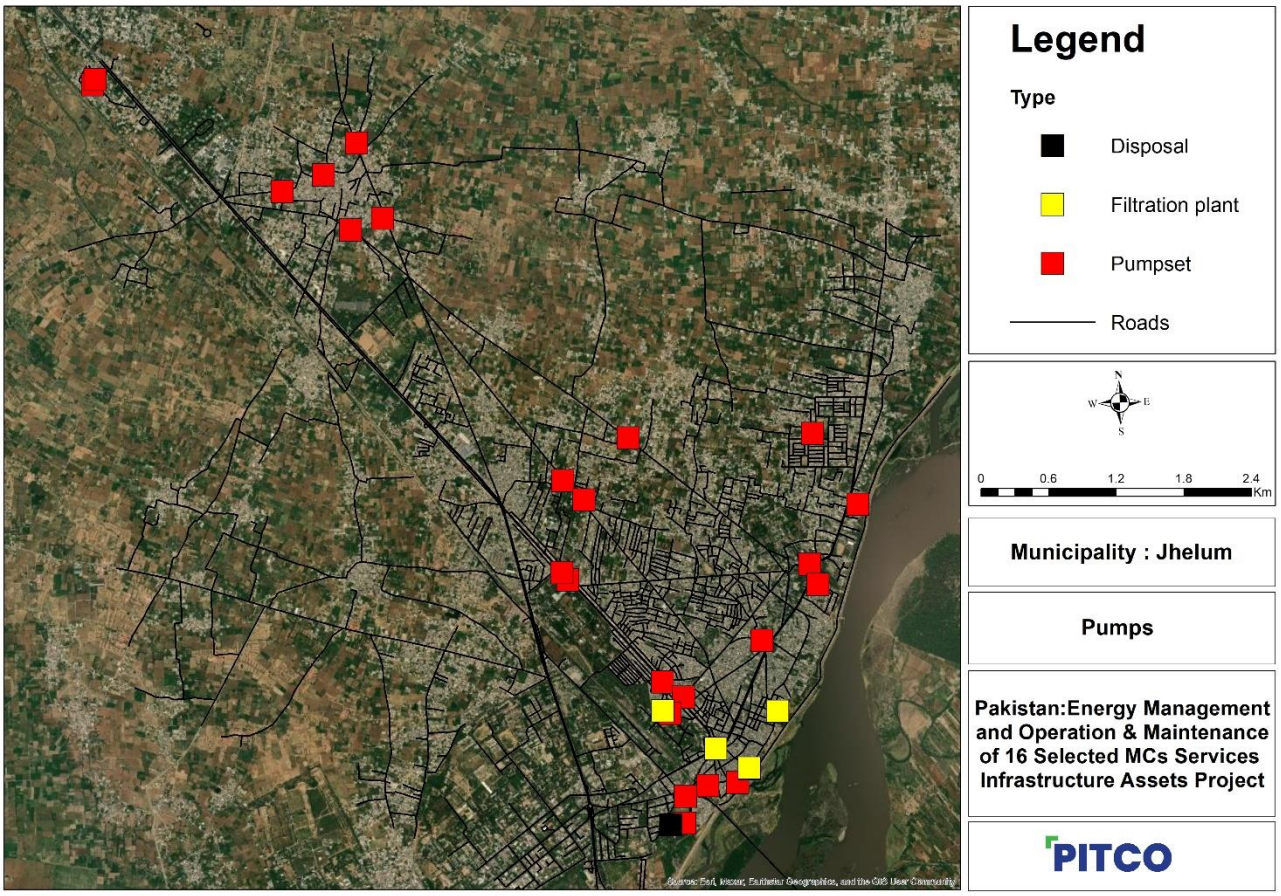


Figure 1: Map for Pumps and Disposal at MC Jhelum

2.3 Baseline Energy Consumption Trend

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

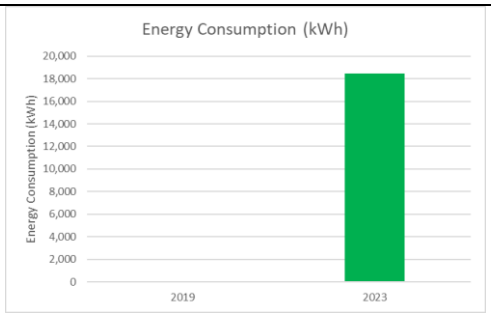
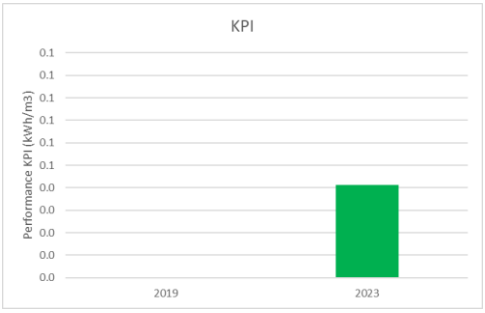
Table 13: Baseline Energy Consumption Trend

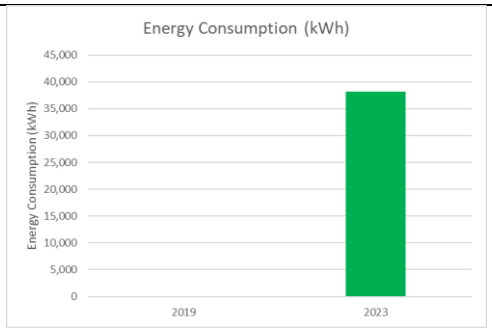
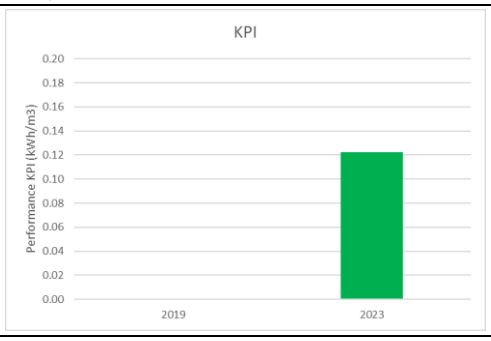
Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	634,697
Electrical energy used by Wastewater Disposal	kWh/y	6,056
Electrical energy used (Total)	kWh/y	640,753

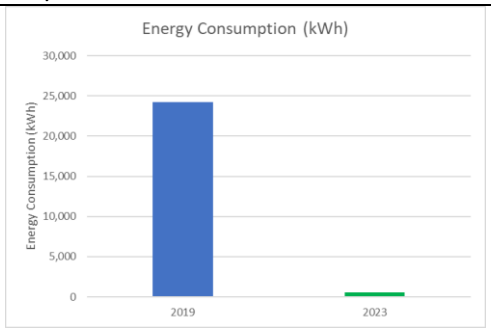
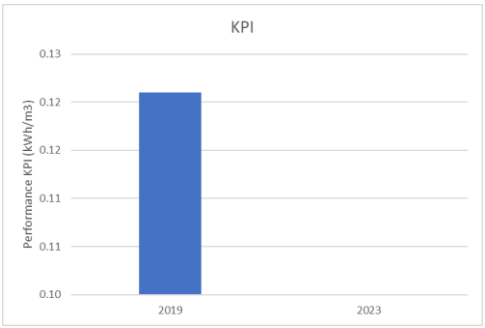
A comparison of current electricity consumption by the MC's water supply and disposal assets compared to results of the energy audit activity carried out in 2019, is presented in the following table:

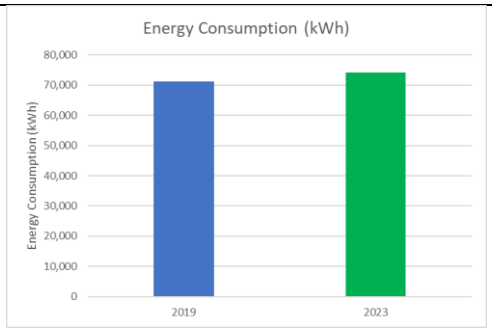
		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	21	19	723,115	634,697	88,418	0.20 kWh/m3	0.18 kWh/m3	Replacement of 7 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 5 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	N/A	N/A	N/A	N/A	0	N/A	N/A	No performance could be carried out on disposal stations as these sites were non-operational during the both audits.

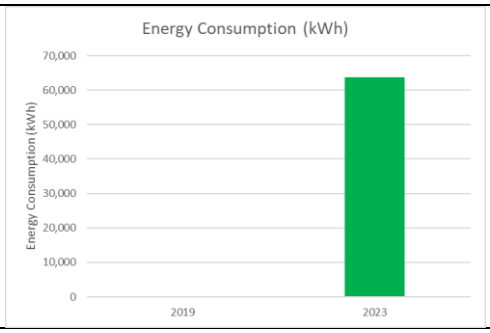
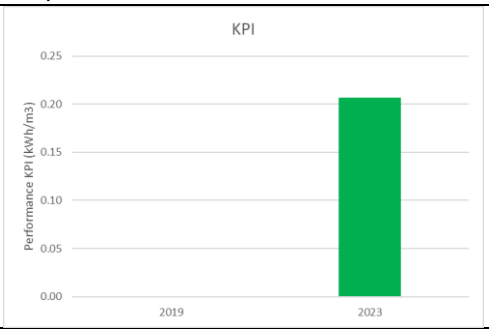
Replacement of 7 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken installation of 5 new pumpsets. A discussion on each newly installed asset is presented below:

Dist. Court Road Pump No. 6 - Unique ID (81706208)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	18,432 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.04 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No calculations of the KPI has been calculated for the previous audit, this site was non-functional due to non-availability of electrical supply and there were no billing details available for this pumpset.	

Kashmir Colony Pump No. 37 - Unique ID (81707771)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
N/A	38,148 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.12 kWh/m3
	
Comments:	
This is a new site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No billing and KPI comparison has been calculated for this site, as there was no baseline data available for this new site.	

Salman Pass Pump No. 3 - Unique ID (81806239)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
24,192 kWh	597 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.12 kWh/m3	N/A
	
Comments:	
A new pumpset has been installed at this site. This site was found to be non-operational due to unavailability of the electrical supply. As per the MC focal person, this site is non-functional since the last year therefore, no billing details are available for the current year. Based on the assessment of 2019 audit, it was recommended to replace this inefficient pumpset with an efficient pumpset.	

Pump No. 2 Tehsil Road Near Post Office - Unique ID (81806241)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
71,202 kWh	74,247 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	N/A
	
Comments:	
A new pumpset has been installed at this site. No KPIs have been calculated for this site, as no flow could be detected due to the excessive air and high turbulence in the delivery lines in the recent audit whereas, no flow was detected due to was extremely rusty condition of the delivery pipe in the previous audit..	

Bagh Mohallah Kundan Ghat - Unique ID (81806243)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	63,652 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.21 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No calculations of the KPI has been calculated for the previous audit, this site was non-functional abandoned by the MC and there were no billing details available for this pumpset.	

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.

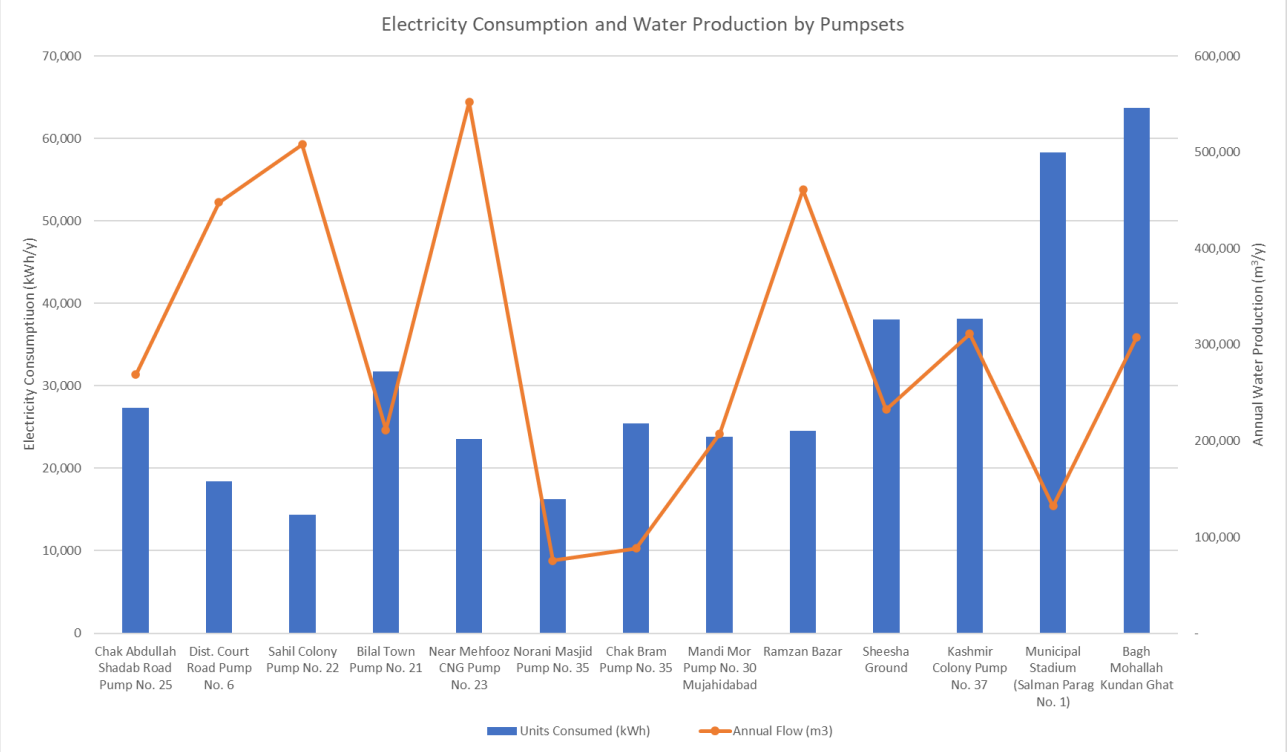


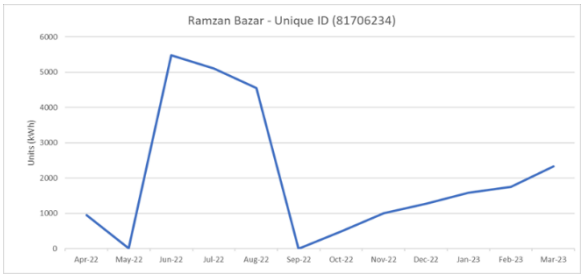
Figure 2: Electricity Consumption and Water Production by Pumpsets

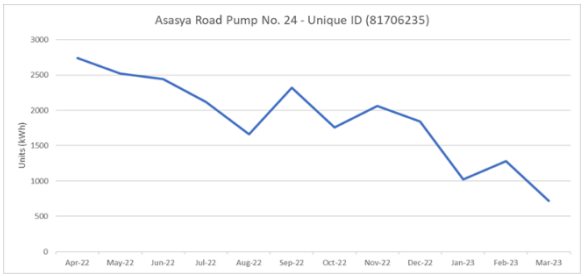
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets.

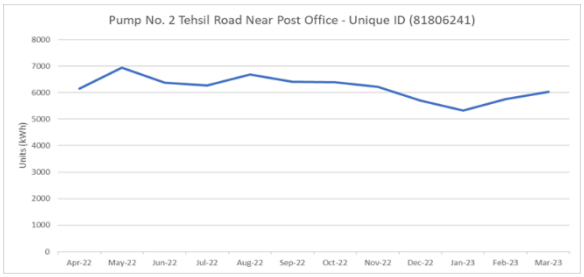
Furthermore, only those pumpsets have been included in the above graph for which pump performance could be carried out and complete billing details were available.

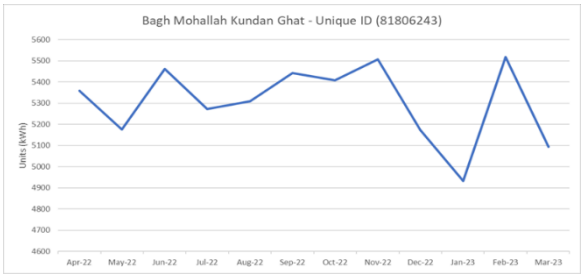
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

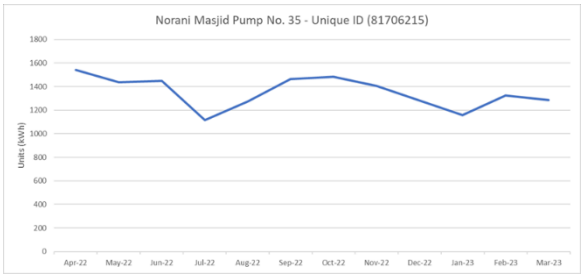
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

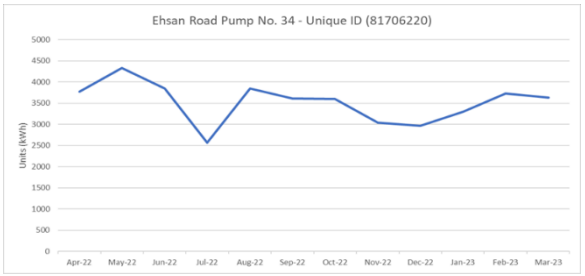


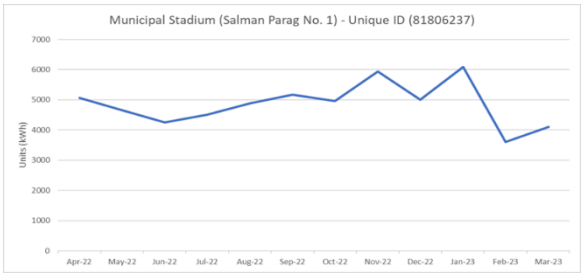


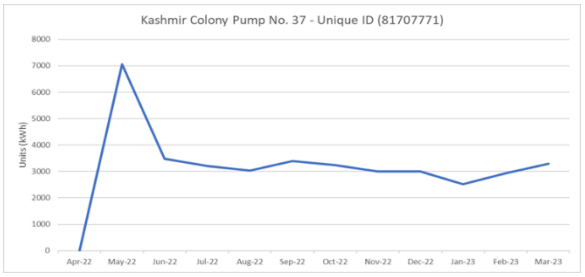


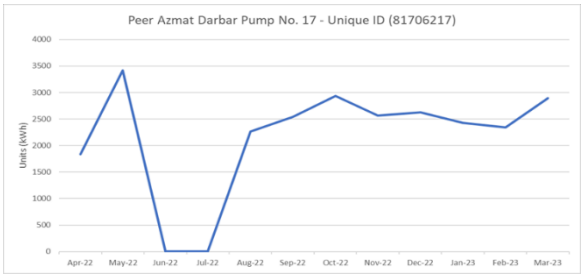


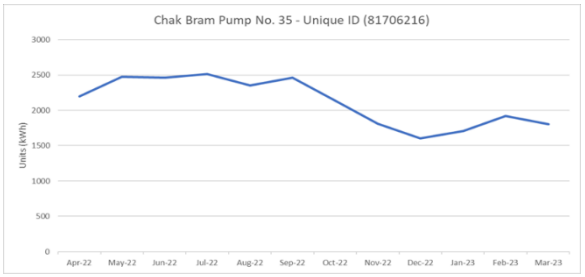


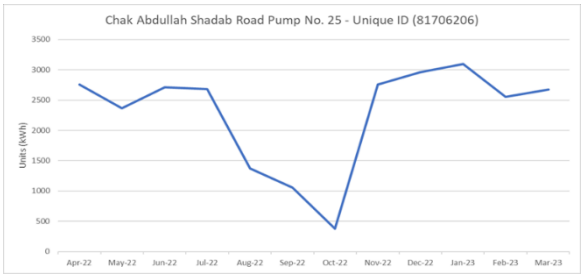


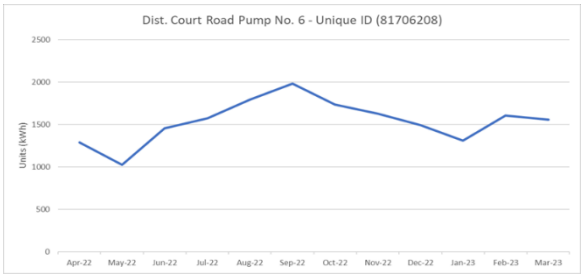


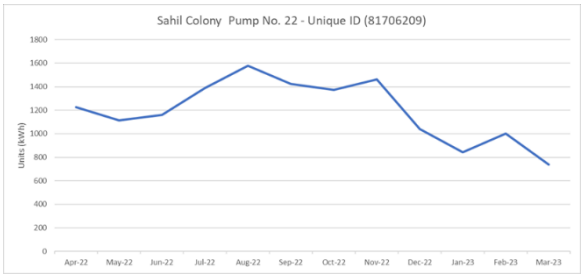


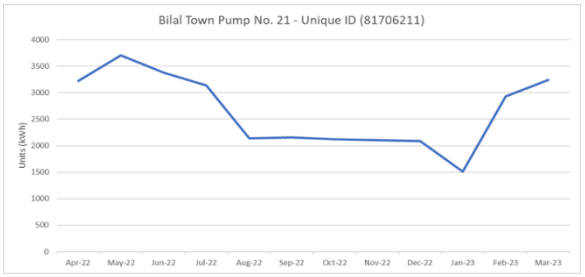


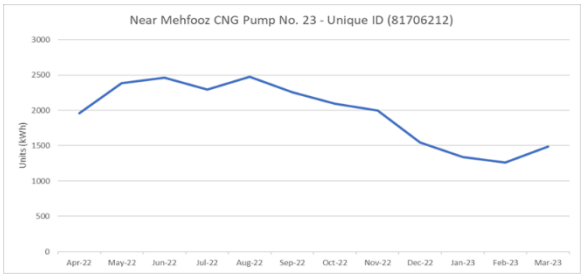


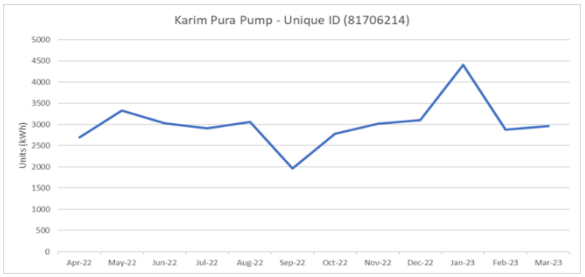


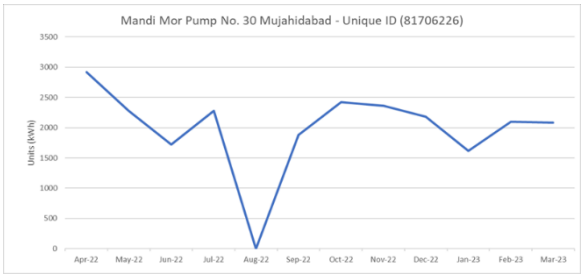


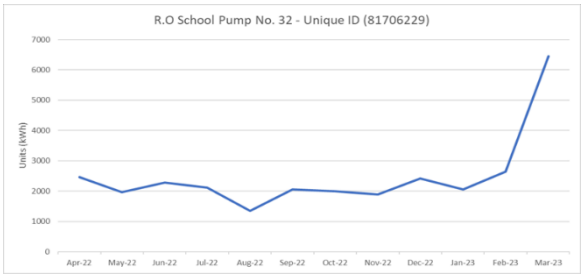


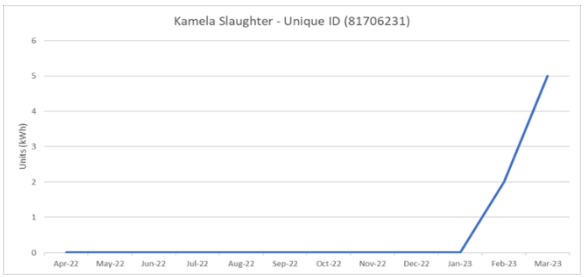


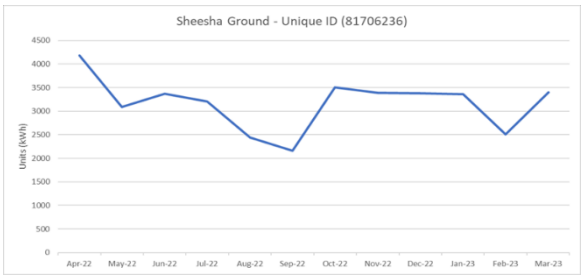












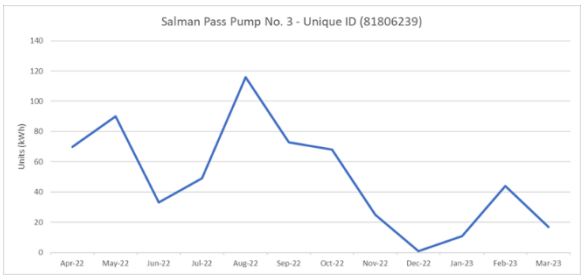


Figure 3: Energy Consumption Trend for Water Pumps

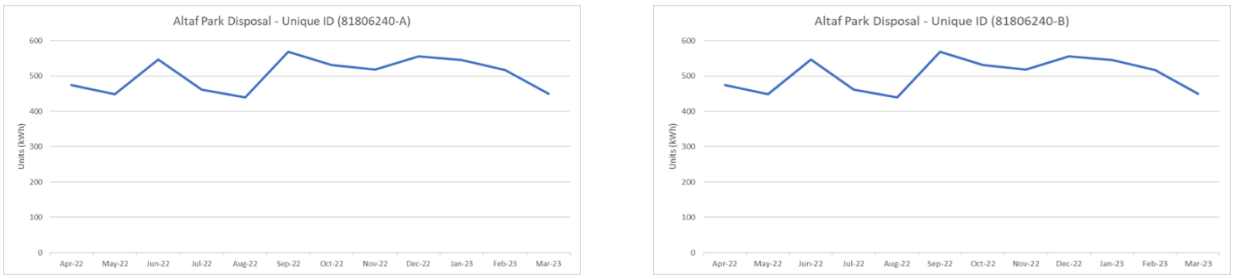


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Jhelum MC has twenty-five (25) tubewells for groundwater, all of which are manually operated. Performance evaluation of pumpsets could be carried out at only 13 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 14: Matrix of Pumpset Assessment and Billing Data Availability

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
1	81706217	Peer Azmat Darbar Pump No. 17	Yes	No
2	81706206	Chak Abdullah Shadab Road Pump No. 25	Yes	Yes
3	81706208	Dist. Court Road Pump No. 6	Yes	Yes
4	81706209	Sahil Colony Pump No. 22	Yes	Yes
5	81706211	Bilal Town Pump No. 21	Yes	Yes
6	81706212	Near Mehfooz CNG Pump No. 23	Yes	Yes
7	81706214	Karim Pura Pump	Yes	No
8	81706215	Norani Masjid Pump No. 35	Yes	Yes
9	81706216	Chak Bram Pump No. 35	Yes	Yes
10	81706220	Ehsan Road Pump No. 34	Yes	No
11	81706222	Near Al-Meraj Flour Mill	Yes	No
12	81706223	Kashmir Colony Pump No. 19	Yes	No
13	81706226	Mandi Mor Pump No. 30 Mujahidabad	Yes	Yes
14	81706227	Mandi Mor Pump No. 33	Yes	No
15	81706229	R.O School Pump No. 32	Yes	No
16	81706231	Kamela Slaughter	Yes	No
17	81706234	Ramzan Bazar	Yes	Yes
18	81706235	Asasya Road Pump No. 24	Yes	No
19	81706236	Sheesha Ground	Yes	Yes
20	81707771	Kashmir Colony Pump No. 37	Yes	Yes
21	81806237	Municipal Stadium (Salman Parag No. 1)	Yes	Yes
22	81806239	Salman Pass Pump No. 3	Yes	No
23	81806241	Pump No. 2 Tehsil Road Near Post Office	Yes	No
24	81806242	Pump No. 27 Jubille Ghatt Bagh Mohallah	Yes	No
25	81806243	Bagh Mohallah Kundan Ghat	Yes	Yes

Table 15: 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	81706206	Chak Abdullah Shadab Road Pump No. 25	101.9	135.7	20.75	25.17	36%	0.78	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve is jammed. Previously, it was recommended to replace the pumpset.
2	81706208	Dist. Court Road Pump No. 6	101.9	135.6	34.58	25.67	59%	0.88	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, this site was non-functional due to non-availability of electrical supply.
3	81706209	Sahil Colony Pump No. 22	101.9	153.9	18.92	25.83	36%	0.81	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve is jammed. Previously, Previously, this site was non-functional.
4	81706211	Bilal Town Pump No. 21	101.9	106.7	39.24	23.17	58%	0.81	Efficiency of the pumpset is satisfactory. Sluice/gate valve is jammed. Previously, the efficiency of the pumpset was 63%.
5	81706212	Near Mehfooz CNG Pump No. 23	101.9	167.3	28.50	27.10	56%	0.78	Efficiency of the pumpset is satisfactory. Sluice/gate valve is jammed. Previously, the efficiency of the pumpset was 59%.
6	81706215	Norani Masjid Pump No. 35	101.9	32.7	25.32	14.80	18%	0.68	Efficiency of the pumpset is unsatisfactory. Gate/sluice valve is jammed. Previously, it was recommended to replace the pumpset.
7	81706216	Chak Bram Pump No. 35	101.9	48.6	25.32	14.80	27%	0.59	Efficiency of the pumpset is unsatisfactory. Gate/sluice valve is jammed. Previously, flow was not detected possibly due to the rusty conditions of the inner surface of the delivery pipe.
8	81706226	Mandi Mor Pump No. 30 Mujahidabad	101.9	104.7	21.97	24.77	30%	0.82	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve is jammed. Previously, it was recommended to replace the pumpset.
9	81706234	Ramzan Bazar	101.9	139.7	17.23	25.30	31%	0.82	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve is jammed. Previously, the efficiency of the pumpset was 56%.
10	81706236	Sheesha Ground	101.9	117.5	20.14	24.47	31%	0.77	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve is jammed. Previously, it was recommended to replace the pumpset.

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
11	81707771	Kashmir Colony Pump No. 37	101.9	94.4	46.72	24.70	57%	0.77	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory.
12	81806237	Municipal Stadium (Salman Parag No. 1)	101.9	114.3	37.73	24.10	57%	0.78	Efficiency of the pumpset is satisfactory. Sluice/gate valve is jammed. Efficiency of the pumpset was 62%.
13	81806243	Bagh Mohallah Kundan Ghat	101.9	93.3	48.26	24.40	59%	0.87	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Sluice/gate valve is jammed. Heavy leakage was observed in the foundation. Previously, this site was abandoned by the MC.

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 16: 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
81706206	283.37	50	6	6	30	-	50	Safe	ok	190	380	0.84	0.78	84%	Low PF
81706208	66.74	42	6	6	30	92	50	Safe	ok	200	400	0.84	0.88	86%	
81706209	152.79	41	6	6	30	-	50	Safe	ok	200	380	0.84	0.81	87%	
81706211	298.42	45	6	6	30	-	50	Safe	ok	200	380	0.84	0.81	78%	
81706212	1018.59	44	6	6	30	-	50	Safe	ok	200	380	0.84	0.78	91%	Low PF
81706215	159.15	40	6	8	30	-	50	Safe	ok	200	380	0.84	0.68	50%	Low PF
81706216	159.15	48	5	6	30	-	50	Safe	Not ok	-	380	0.84	0.59	50%	Low PF
81706226	530.52	36	6	6	30	-	50	Safe	ok	200	380	0.84	0.82	83%	
81706234	250.10	39	6	6	30	-	50	Safe	ok	200	380	0.84	0.82	85%	
81706236	115.75	39	6	6	30	-	50	Safe	ok	190	380	0.84	0.77	82%	Low PF
81707771	0.00	49	6	6	30	-	50	Safe	ok	200	400	0.84	0.77	83%	Low PF
81806237	159.15	66	3	4	30	-	50	Safe	ok	200	380	0.86	0.78	81%	Low PF
81806243	159.15	48	4	5	30	-	50	Safe	Not ok	-	400	0.84	0.87	82%	

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 17: Comparison of Pumpset Efficiency at Existing Conditions and Duty Point

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
1	81707771	Kashmir Colony Pump No. 37	102	29.828	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	94.36	46.7	Flow at Existing Operating Conditions is nearest to duty point	24.70	57%

2.4.3 Wastewater Disposal System

The MC has one (1) disposal station having two (2) pumps. Both pumpsets are currently non-functional and their site is under-construction.

Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are eleven (11) dewatering sets in the MC and all 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 18: Water Pumps and Wastewater Disposal System: Recommendations for improvement

Sr No.	Unique ID	Location	Comments	Recommendation
Pumps				
1	81706206	Chak Abdullah Shadab Road Pump No. 25	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
2	81706209	Sahil Colony Pump No. 22	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
3	81706212	Near Mehfooz CNG Pump No. 23	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
4	81706215	Norani Masjid Pump No. 35	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
5	81706216	Chak Bram Pump No. 35	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
6	81706226	Mandi Mor Pump No. 30 Mujahidabad	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
7	81706234	Ramzan Bazar	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
8	81706236	Sheesha Ground	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
9	81707771	Kashmir Colony Pump No. 37	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
10	81806237	Municipal Stadium (Salman Parag No. 1)	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
General Observations				
11	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
12	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 IESCO during the entire year are given in Annexure 1.
13	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.
14	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 Jhelum 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 19: Inventory Detail of Streetlights

	Streetlights	MC Operated	Privately Operated
Operational Street Lights	495	495	
Non Operational Street Lights	465	465	
Total	**960**	**960**	**0**

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.

Out of the total streetlights operated by MC, there are 194 light fixtures installed on PC, 357 fixtures are installed on steel structure, 112 fixtures are installed on tubular structure, 13 fixtures are installed on trees, 40 fixtures are installed on wires, and 169 fixtures are installed on walls. The streetlights' structural classification is tabulated below.

Table 20: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Tree	Wires	Wall	Ground	Grand Total
MC	194	357	112	13	40	25	169	**885**
Private								0

Streetlights of Jhelum MC are installed in main areas of the city. None of the streetlights are privately operated and all these streetlights are operated and maintained by the MC. Further details of streetlights along with their meter reference numbers in different areas of the MC are shown in table below.

Table 21: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	River Road Baba Khaki Shah	35	29-14416-0073950	1.19
2	Ground Chowk Pakistan	17	11-14416-1161200	0.43
3	Shamali Chowk Mohallah	19	29-14416-0031061	1.44
4	Council Morr	55	29-14411-0129758	2.07
5	Androon Niba Mohallah	60	29-14416-1526902	1.26
6	Civil Line Girja House	53	29-14416-0076871	1.37
7	Peera Gaib Graveyard Chowk	41	29-14416-1413601	0.20
8	Mohallah Islam Pura	23	03-14411-0290602	0.46
9	Islam Pura Road	51	28-14411-7642600	1.87
10	Ramzan Pura Road	21	29-14411-0129759	1.14
11	Commercial College Bilal Town	105	29-14411-0136223	5.22
12	Machine Muhallah No. 1	46	29-14412-0018990	1.09
13	Machine Muhallah No. 2	47	29-14412-0019000	1.14
14	Shadab Road Civil Line	28	29-14416-0037560	0.94
15	Near Girls College FC Office	16	29-14411-0108381	1.26

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
16	Abbas Pura Near Islamia College	18	29-14411-0112580	0.85
17	Karmab Market Machine Mohallah	12	01-14412-0037800	0.34
18	Mujahid Abad Road	16	29-14416-0009800	0.86
19	Shandar Chowk	31	01-14412-0160200	1.14
20	Bilal Town Near Haider SS	37	29-14411-0161662	1.22
21	Bilal Town Near Ayesha CR	39	29-14411-0139091	1.13
22	Tahlian Wala Data Road	26	29-14411-0161663	0.63
23	Salman Paris Old Bridge	59	29-14412-0035990	1.48
24	Fresco Bakery Civil Line	33	29-14416-0069260	1.67
25	Civil Line Near Masjid	21	29-14416-0030241	0.44
26	Normal School Near DC House	6	29-14411-0116000	0.21
27	Peera Gaib Near Habib Bank	34	29-14411-0044671	1.46
28	Graveyard Chowk Near Janazgah	11	29-14416-0025591	0.37

Out of the 960 surveyed lights in the MC, 495 lights were found to be operational. Details are given in the following table:

Table 22: Details of Operational Streetlights

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours[5]	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	18	151		12.0	11,905	-
LED	30	92		12.0	12,089	
LED	50	2		12.0	438	
LED	100	14		12.0	6,132	-
LED	120	86		12.0	45,202	-
LED	178	1		12.0	780	
CFL	20	2		12.0	175	
CFL	24	4		12.0	420	
CFL	45	1		12.0	197	
Tube Light	40	1		12.0	175	-
Incandescent Bulb	100	2		12.0	876	-
Mercury Bulb	125	27		12.0	14,783	
Sodium Light	200	9		12.0	7,884	
Sodium Light	250	103		12.0	112,785	
Total					**213,840**	**-**

[5] Based on Interview with Client.

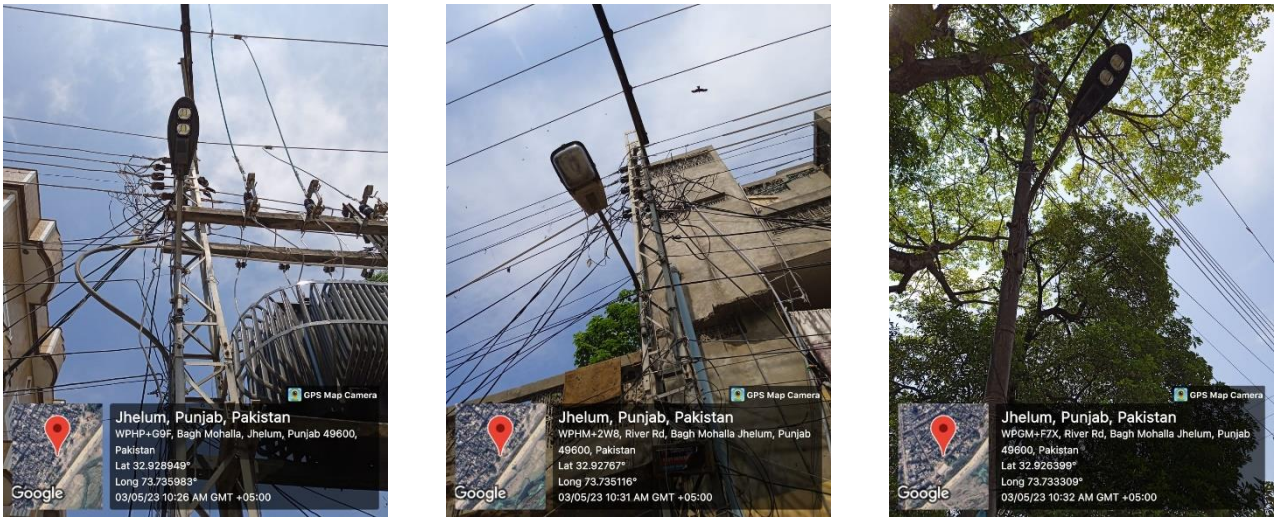


Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

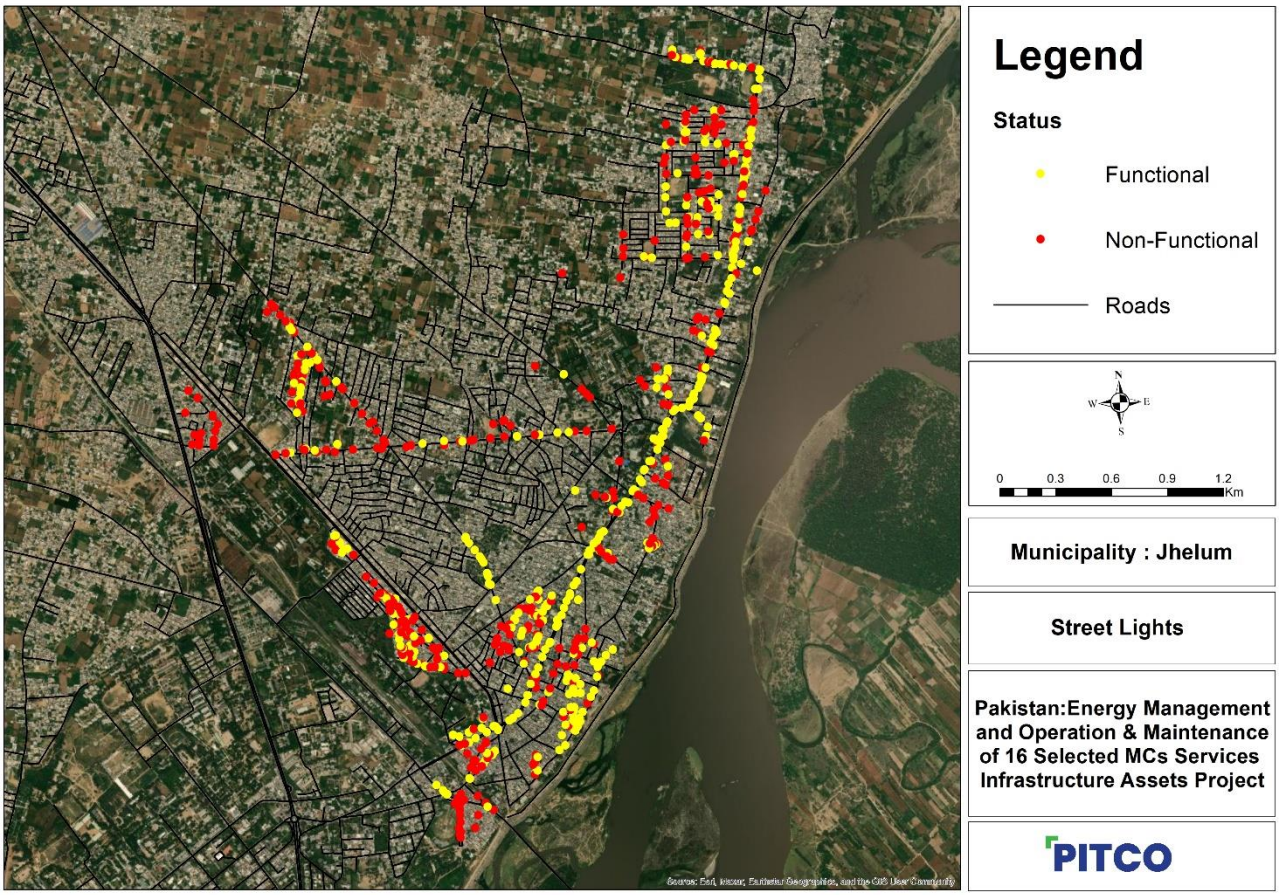


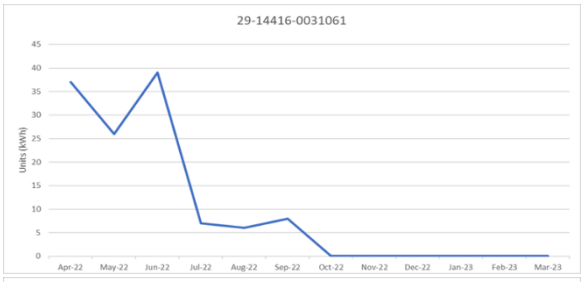
Figure 9: GIS Mapping of street lights in Jhelum MC

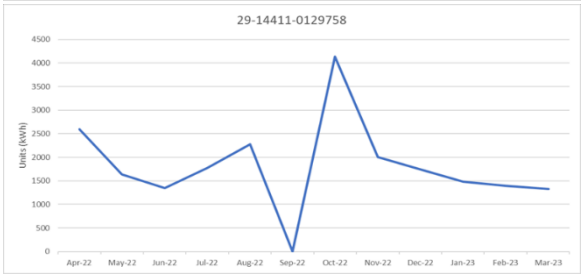
3.3 Baseline Energy Consumption Trend

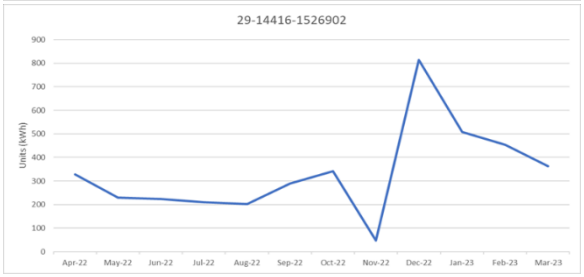
Details of energy consumption by the streetlights in the MC are given below.

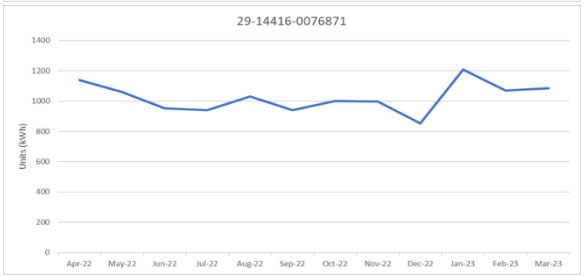
Table 23: Baseline Energy Consumption Trend

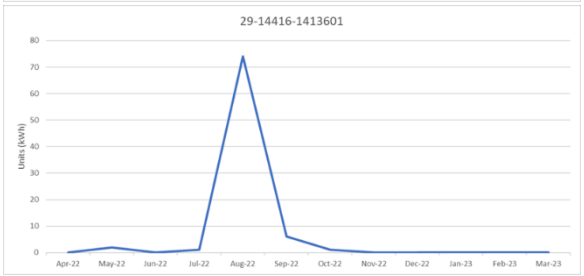
Particulars	Unit	Value
Electrical energy consumed	kWh/y	86,588
Total number of operational lights	No.	495

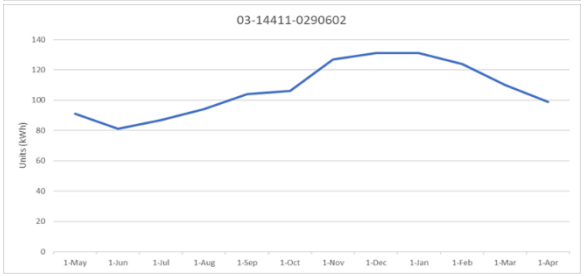


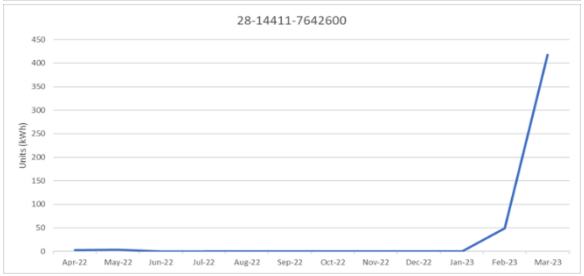


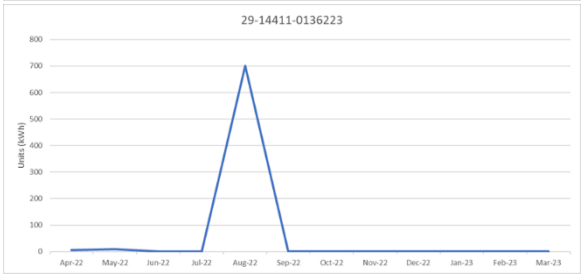


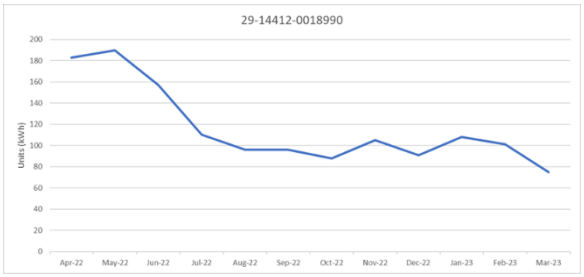








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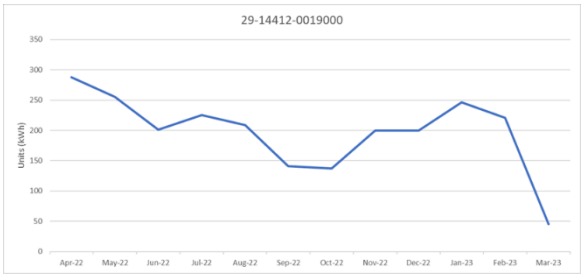
Units (kWh)
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23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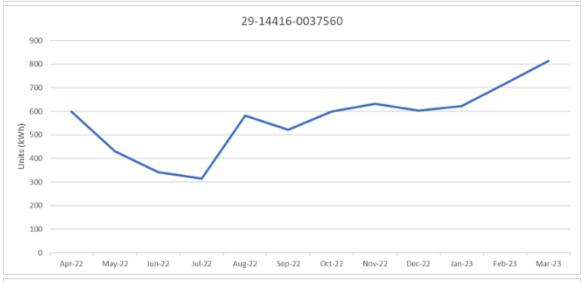
Mar-23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Sep-22
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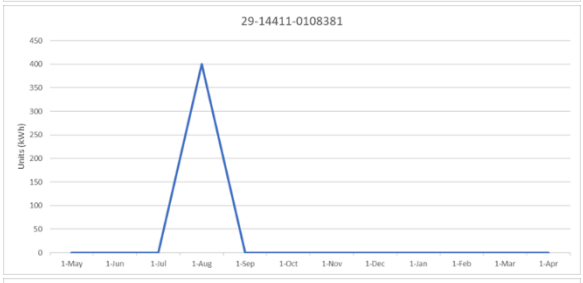
Dec-22
Jan-23
Feb-23
Mar-23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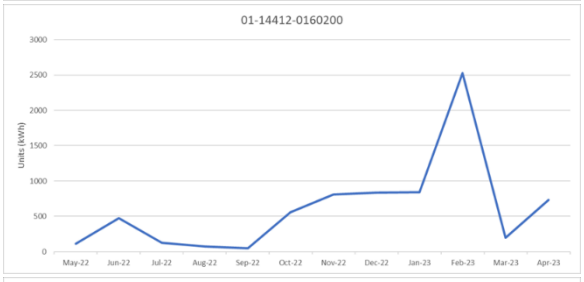
1-Feb
1-Mar
1-Apr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Feb-23
Mar-23
Apr-23


01-14412-0037800
Units (kWh)
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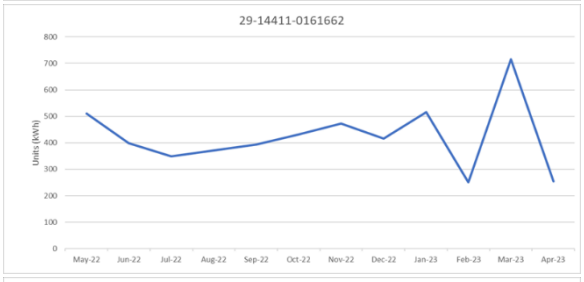
Apr-23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Apr-23


29-14411-0139091
Units (kWh)
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Aug-22
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Nov-22
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Jan-23
Feb-23
Mar-23
Apr-23


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Units (kWh)
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Jun-22
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Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23


29-14412-0035990
Units (kWh)
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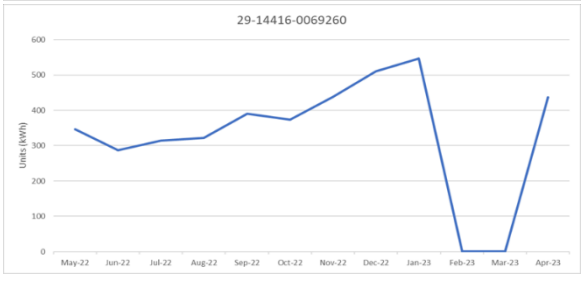
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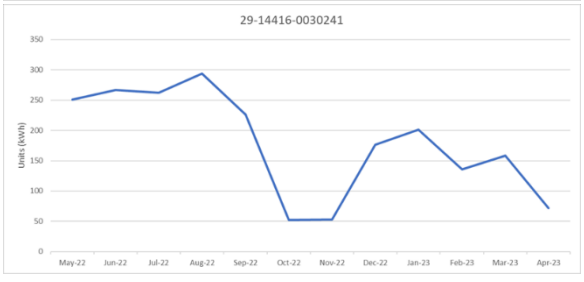
Apr-23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Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23
Apr-23

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	262	495	108,417	86,588	21,829	3,764 kWh/km	2,635 kWh/km	Based on the previous assessment, there were only 262 MC owned operational lights with an average consumption of 413kWh/light/annum, whereas, currently there are 495 operational lights with average energy consumption of 174kWh/light/annum. The MC has significantly improved its energy consumption per light fixture.

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 Jhelum.

3.5 Observations

- All Streetlights in Jhelum MC are operated by MC.
- Most of the operational streetlights are LEDs.
- Approximately 58% of the LED streetlights have a rating of 120 Watts or more.
- Jhelum 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 24: Streetlights - recommendations for improvement

Sr. No.	Area	Observations	Recommendations/ Remarks
1	Inventory	• All of the streetlights in Jhelum are MC operated. • Most of the operational streetlights are LEDs • Most of the streetlights are of high wattage	All 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. 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	Jhelum 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 maintenance related activities of the streetlights. Every streetlight pole should have a unique identification

Sr. No.	Area	Observations	Recommendations/ Remarks
			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 Jhelum MC is tabulated below.

Table 25: 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	JMF-9242	Tractor Trolley	Millat	MF-385	2007	4WD	Transport of Solid Waste	LM913570V513050N	0529/01	85HP
2	Unregistered Vehicle 1	Tractor	Millat	MF-385	2020	4WD	Back Hoe	LM9B570V575583F	2536325	85HP
3	JMF-9246	Tractor	Millat	MF-385	2006	4WD	Transport of Solid Waste	LM9B570V513411N	0547/09	85HP
4	JMD-1359	Tractor Trolley	Millat	MF-375	2003	4WD	Transport of Solid Waste	LM9B570V503817J	148	75HP
5	JMC-2675	Tractor Trolley	Millat	MF-240	2009	2WD	Transport of Solid Waste	1867305M4	MTL 15018	50Hp
6	GAA-460	Tractor	Millat	MF-240	2009	2WD	Mechanical Sweeper	50631	40454/17/9	50Hp
7	JMF-9248	Tractor	Al-Ghazi	SN-304	2005	2WD	Lifter	C50900545A	S50082	35Hp
8	JMF-9245	Tractor Trolley	Millat	MF-385	2007	4WD	Transport of Solid Waste	M9B570V512999N	0548/03	85HP
9	JMF-9247	Tractor Front loader	Millat	MF-385	2007	4WD	Front Loader	LM9D570V512891N	0459/02	85HP
10	JMC-718	Tractor	Millat	MF-375	2007	4WD	Water Bowser	L097041U505633	489/21	75Hp
11	JMF-9243	Tractor Front loader	Millat	MF-385	2007	4WD	Front loader	LM9B570V513268N	54221	85HP
12	JMF-9244	Tractor Trolley	Millat	MF-385	2007	4WD	Transport of Solid Waste	570V512897N	0488/11	85HP
13	JMB-6528	Tractor Trolley	Millat	MF-375	1994	4WD	Transport of Solid Waste	LD97041V503570	405/05	75HP
14	GAA-459	Truck	Nissan	PKBCH211G	2007	4WD	Suction Machine	97490	PKBCH211G-00593-P	4400
15	JMB-7850	Jeep Potohar	Suzuki	Potohar	N/A	4WD	No Task Assigned	N/A	N/A	1000
16	JM-2219	Mini-Truck	N/A	N/A	N/A	4WD	No Task Assigned	N/A	N/A	N/A
17	Unregistered Vehicle 2	Truck Compactor	Hino	300 Series	2022	4WD	Transport of Solid Waste	WGM50267	JHHYCKOF104600218	4009
18	Unregistered Vehicle 3	Truck Compactor	Hino	300 Series	2022	4WD	Transport of Solid Waste	4JGM50265	JHHYCKOF804600216	4009
19	TMA-2012	Pickup	Suzuki	Ravi	2012	2WD	Dengue Brigade	221066	PK32573	796
20	JMB-2763	Truck	Mazda	Titan-3500	1990	4WD	Loading & Unloading	105701	201334	4300
21	JMB-5474	Jeep	Suzuki	Potohar	1992	4WD	Transport of Staff	701639	717492	1000
22	JMB-4273	Jeep	Suzuki	Potohar	2002	4WD	Transport of Staff	107791	330216	1000
23	JMA-913	Truck	Bedford	N/A	1980	4WD	Firefighting	CS10648	CJQ-600157	5500
24	JME-1713	Truck	Hino	NR-300	2003	4WD	Firefighting	13638	16196	4009
25	Unregistered Vehicle 4	Rickshaw	Qingqi	CNE-150	2012	2WD	No Task Assigned	N/A	N/A	150
26	JMK-2056	Bike	Yamaha	YB100	2007	2WD	Transport of Staff	N/A	5HM-062774K	100
27	Unregistered Vehicle 5	Bike	Yamaha	YB100	2007	2WD	Transport of Staff	N/A	N/A	100
28	Unregistered Vehicle 6	Rickshaw	Qingqi	CNE-150	2012	2WD	No Task Assigned	N/A	5QM10042129082	150
29	JMC-9700	Car	Suzuki	Cultus	2002	2WD	Transport of Staff	812451	SF310PK955760	1000
30	Unregistered Vehicle 7	Truck	Nissan	PKBCH211G	2007	4WD	Jetting Machine	97494	PKBCH211G-00597-P	4400

4.2 Baseline Fuel Consumption Trend

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

Table 26: On-field fuel Consumption analysis of MC vehicles

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)				
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption
1	JMF-9242	1:08 PM	2:08 PM	1.76	1.76 Liters/hr	10:00 AM	1:08 PM		9.99	3.19 Liters/hr
2	Unregistered Vehicle 1	11:10 AM	12:10 PM	0.79	0.79 Liters/hr	9:12 AM	11:10 AM		6.73	3.42 Liters/hr
3	JMF-9246	2:00 PM	3:00 PM	1.53	1.53 Liters/hr	10:45 AM	2:00 PM		10	3.08 Liters/hr
4	JMD-1359	1:10 PM	2:10 PM	1.97	1.97 Liters/hr	10:07 AM	1:10 PM		14	4.59 Liters/hr
5	JMF-9245	10:55 AM	11:55 AM	1	1 Liters/hr	9:05 AM	10:55 AM		7.99	4.36 Liters/hr
6	JMF-9247	10:05 AM	11:05 AM	2.84	2.84 Liters/hr	8:35 AM	10:05 AM		7.89	5.26 Liters/hr
7	JMC-718	10:00 AM	11:00 AM	1.43	1.43 Liters/hr	8:32 AM	10:00 AM		3.61	2.46 Liters/hr
8	JMF-9243	12:20 PM	1:20 PM	2.77	2.77 Liters/hr	10:30 AM	12:20 PM		12	6.55 Liters/hr
9	JMF-9244	12:10 PM	1:10 PM	2	2 Liters/hr	10:36 AM	12:10 PM		10.56	6.74 Liters/hr
10	JMB-6528	11:53 AM	12:55 PM	1	0.97 Liters/hr	9:22 AM	12:53 PM		9.64	2.74 Liters/hr
11	GAA-459	11:16 AM	12:16 PM	1.57	1.57 Liters/hr	9:38 AM	11:16 AM		6.44	3.94 Liters/hr
12	Unregistered Vehicle 2	10:10 AM	11:10 AM	2	2 Liters/hr	8:25 AM	10:10 AM		1.98	1.13 Liters/hr
13	Unregistered Vehicle 3	11:05 AM	12:05 PM	2	2 Liters/hr	8:20 AM	11:05 AM	160	8	0.05 Liters/km

Table 27: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	JMF-9242	4.0
2	Unregistered Vehicle 1	3.0
3	JMF-9246	4.0
4	JMD-1359	4.0
5	GAA-460	3.0
6	JMF-9248	2.5
7	JMF-9245	4.0
8	JMF-9247	4.0
9	JMC-718	4.0
10	JMF-9243	4.0
11	JMF-9244	4.0
12	JMB-6528	4.0
13	GAA-459	0.37

The logbooks of remaining vehicles are not available in MC.

The MC made 19 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 1.72 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 4.21 liters/hour.

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 during the first phase of the in 2019 are not being used by the MCs for recording fuel consumption.

Table 28: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	86,328
Annual Cost of Fuel (Diesel)	PKR/y	25,294,104
Annual Consumption of Fuel (Petrol)	Liter/y	0
Annual Cost of Fuel (Petrol)	PKR/y	0

4.3 Maintenance Log of Vehicles

No record was available for the maintenance and repairing (if any) of the vehicles that are in use of the MC. Purchase record of newly bought vehicle is available with MC. Pictures of some of the vehicles owned by Jhelum MC are given below.

Figure 11: MC Vehicles

4.4 Observations and Recommendations

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

MC Jhelum has bought enough new vehicles to meet their daily demand. Based on the logbook data, the consultant cannot make any recommendation for replacement of old vehicles. 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.

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 5 MC owned buildings in the MC. 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.

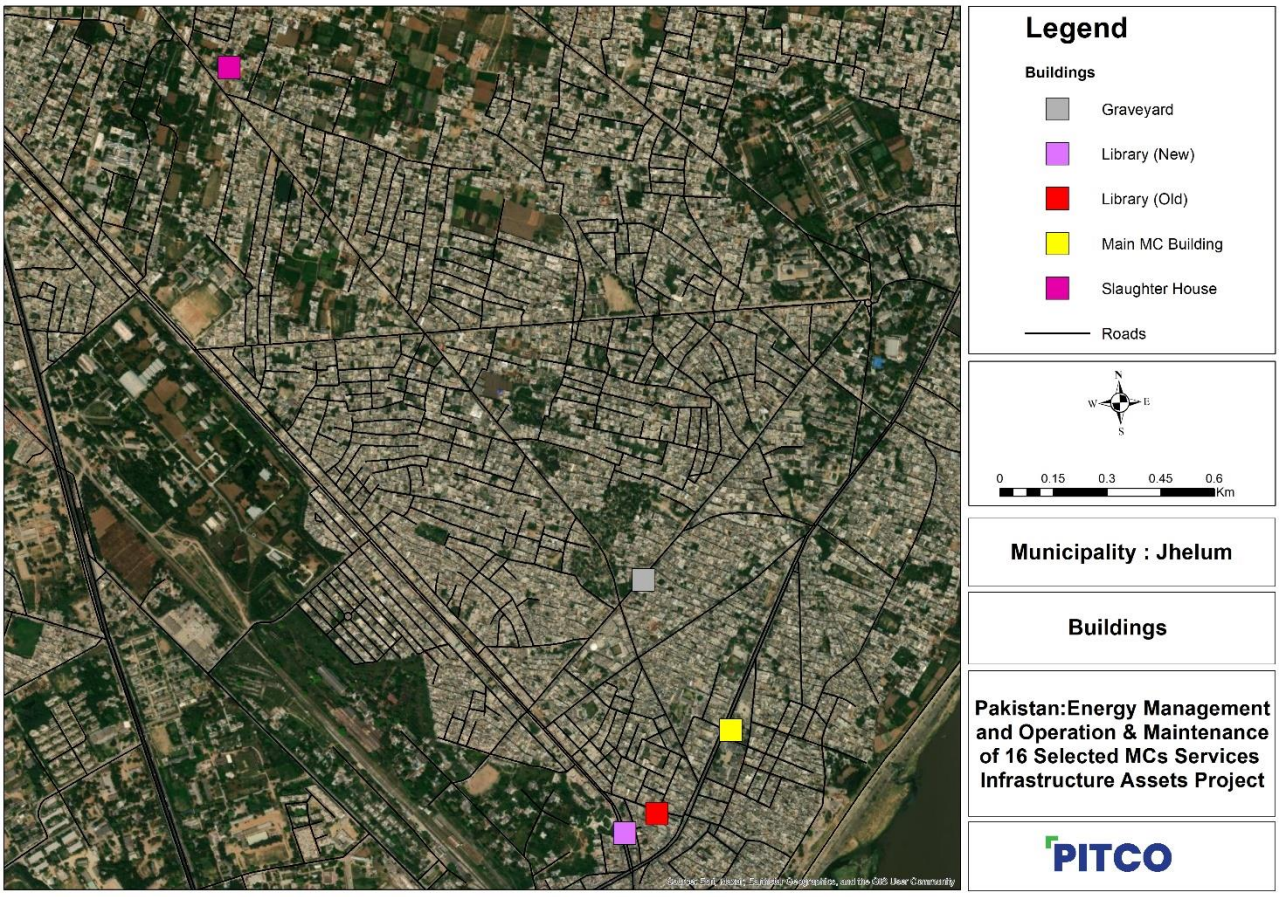

Figure 12: Map for Buildings

5.2 Building Details

Details of the MC buildings are given below.

Table 29: Buildings' Details

Sr. No.	Address	GPS	Unique ID	Ownership	Age of Building	Condition of Building	Total Area (m2)	Insulation of Building	Number of Floors
1	Library (Old)	N:32.930115 E:73.732110	81806265	MC	N/A	Satisfactory	1,501	No Proper Insulation	1
2	Library (New)	N:32.929665 E:73.731125	81806265-1	MC	N/A	Satisfactory	2250.9	No Proper Insulation	1
3	Slaughter House	N:32.949312 E:73.720366	81706230	MC	37	Satisfactory	N/A	No Proper Insulation	1
4	Main MC Building	N:32.932129 E:73.734428	81706205	Mc	37	Satisfactory	1,375	No Proper Insulation	1
5	Graveyard	N:32.935991 E:73.732019	81706205-1	MC	N/A	Satisfactory	500	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 30: Number of Heating Units in MC Buildings

Sr. No.	Name of Room	Type of Heating Equipment	Equipment Count	Capacity in Watts	Daily operating hours[6]	No. of months used per year	Operating days per year	Annual Energy consumption (kWh/year)
Main MC Building								
1	**Mosque Outside**	Electric Heater (Geyser)	1	2000	2	4	104	416
2	**Audit Office**	Electric Heater	1	1000	2	4	104	208
3	**MOP Office**	Electric Heater	1	1000	2	4	104	208
	Total							**832**

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

Table 31: Number of Cooling Units in Office Buildings of the MC

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Library (Old)								
1	**Main Hall**	Ceiling Fan	12	80	4	8	208	799
2	**Librarian Room**	Ceiling Fan	2	80	5	8	208	166
3	**Record Room**	Ceiling Fan	2	80	3	8	208	100
Library (New)								
1	**Main Hall**	Ceiling Fan	4	80	4	8	208	266
2	**Computer Room**	Ceiling Fan	1	80	6	8	208	100
Main MC Building								
1	**Mosque Inside**	Ceiling Fan	6	80	4	8	208	399
2	**Mosque Inside**	Split AC	1	1800	2	6	156	562
3	**Mosque Inside**	Bracket Fan	3	50	4	8	208	125
4	**Mosque Inside**	Inverter	1	1452	2	6	156	453
5	**Store**	Ceiling Fan	2	80	3	8	208	100
6	**Fire Brigade office**	Air Cooler	1	125	8	6	156	156
7	**Incharge Fire Brigade**	Ceiling Fan	1	80	8	8	208	133
8	**Electrician Room**	Ceiling Fan	2	80	8	8	208	266
9	**Kitchen**	Ceiling Fan	1	80	3	8	208	50
10	**Administration P.A**	Bracket Fan	1	50	7	8	208	73
11	**MOF Office**	Bracket Fan	1	50	7	8	208	73
12	**MOF Office**	Split AC	1	1800	5	5	130	1,170
13	**One window Cell MOP Branch**	Bracket Fan	2	50	7	8	208	146
14	**One window Cell MOP Branch**	Split AC	1	1650	5	5	130	1,073
15	**One window Cell MOP Branch**	Exhaust Fan	2	30	4	12	312	75
16	**Administration Office**	Bracket Fan	4	50	4	8	208	166
17	**Administration Office**	Inverter	1	1452	4	5	130	755
18	**Administration Office**	Exhaust Fan	1	30	4	8	208	25
19	**Outside Administrative**	Ceiling Fan	3	80	7	8	208	349
20	**Cashier Officer**	Ceiling Fan	1	80	8	8	208	133
21	**Cashier Officer**	Exhaust Fan	1	30	7	8	208	44
22	**Record Branch**	Ceiling Fan	4	80	7	8	208	466
23	**Record Branch**	Bracket Fan	1	50	7	8	208	73
24	**Record Branch**	Pedestal Fan	1	125	7	8	208	182
25	**Secretary Unit 2**	Ceiling Fan	1	80	8	8	208	133
26	**Clerk Office**	Bracket Fan	1	50	7	8	208	73
27	**Clerk Office**	Exhaust Fan	1	30	7	8	208	44
28	**Chief Sanitary Inspector**	Ceiling Fan	1	80	6	8	208	100
29	**Chief Sanitary Inspector**	Split AC	1	1800	4	5	130	936
30	**Union Office**	Ceiling Fan	1	80	8	8	208	133

[7] 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[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
31	**Gallery 1**	Ceiling Fan	1	80	8	8	208	133
32	**Gallery 1**	Bracket Fan	1	50	8	8	208	83
33	**Account Branch**	Ceiling Fan	3	80	8	8	208	399
34	**Account Branch**	Window AC	1	5000	4	5	130	2,600
35	**Account Branch**	Exhaust Fan	1	30	8	8	208	50
36	**Meeting Hall**	Bracket Fan	5	50	2	8	208	104
37	**MOR office**	Ceiling Fan	1	80	6	8	208	100
38	**MOR office**	Split AC	1	1800	4	5	130	936
39	**MOR office**	Bracket Fan	1	50	6	8	208	62
40	**MOR office**	Exhaust Fan	1	30	6	8	208	37
41	**MOI office**	Bracket Fan	2	50	8	8	208	166
42	**MOI office**	Inverter	1	1452	4	5	130	755
43	**MOI office**	Exhaust Fan	1	30	8	8	208	50
44	**Kitchen**	Bracket Fan	1	50	6	8	208	62
45	**Audit office**	Ceiling Fan	2	80	7	8	208	233
46	**Audit office**	Split AC	1	1800	4	5	130	936
47	**Audit office**	Exhaust Fan	1	30	7	8	208	44
48	**Encroachment Inspector**	Ceiling Fan	1	80	7	8	208	116
49	**Encroachment Inspector**	Exhaust Fan	1	30	7	8	208	44
50	**Kiraya Dokanat**	Ceiling Fan	1	80	8	8	208	133
51	**MOS office**	Bracket Fan	1	50	8	8	208	83
52	**MOS office**	Window AC	1	5000	4	5	130	2,600
53	**MOS office**	Exhaust Fan	1	30	8	8	208	50
54	**Sub-Engineer office**	Exhaust Fan	1	30	6	8	208	37
55	**Sub-Engineer office**	Window AC	1	5000	3	5	130	1,950
56	**MOP office**	Bracket Fan	1	50	7	8	208	73
57	**MOP office**	Exhaust Fan	2	30	7	8	208	87
58	**Gallery 2**	Ceiling Fan	1	80	8	8	208	133
59	**Head Clerk office**	Ceiling Fan	2	80	8	8	208	266
60	**Head Clerk office**	Bracket Fan	1	50	8	8	208	83
61	**Head Clerk office**	Exhaust Fan	1	30	7	8	208	44
62	**Water Supply Recovery**	Ceiling Fan	1	80	8	8	208	133
63	**Building Branch**	Ceiling Fan	2	80	8	8	208	266
64	**Computer Operator CO**	Bracket Fan	2	50	8	8	208	166
65	**Co Office**	Bracket Fan	1	50	5	8	208	52
66	**Co Office**	Inverter	1	1452	3	6	156	680
67	**Gallery 3**	Ceiling Fan	1	80	8	8	208	133
Graveyard								
1	**Main Hall**	Ceiling Fan	38	80	2	8	208	1,265
2	**Washroom**	Exhaust Fan	1	30	1	8	208	6
3	**Store**	Ceiling Fan	1	80	1	8	208	17
4	**Open Area**	Ceiling Fan	8	80	1	8	208	133

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
	Total						**Total Annual kWh**	**25,198**

Table 32: Number of Lighting Unit in Office Buildings of the MC

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Electricity consumption (kWh/year)
Library (Old)							
1	**Main Hall**	CFL	14	60	6	312	1,572
2	**Librarian Room**	CFL	2	60	6	312	225
3	**Librarian Room**	SMD	8	24	6	312	359
4	**Record Room**	CFL	1	24	3	312	22
5	**Record Room**	CFL	1	60	3	312	56
6	**Record Room**	LED	8	24	3	312	180
7	**Washroom**	CFL	2	24	3	312	45
8	**Outside Area**	CFL	5	24	10	312	374
9	**Outside Area**	LED	1	12	10	312	37
10	**Outside Area**	CFL	1	60	10	312	187
11	**Outside Area**	LED	2	50	12	312	374
Library (New)							
1	**Main Hall**	ILB	1	100	3	312	94
2	**Main Hall**	Tube Light	2	40	6	312	150
3	**Main Hall**	LED	2	12	6	312	45
4	**Washroom**	LED	2	12	2	312	15
5	**Computer Room**	Tube Light	1	40	6	312	75
6	**Outside Area**	LED	16	120	12	312	7,188
7	**Outside Area**	LED	1	12	12	312	45
Main MC Building							
1	**Mosque Inside**	LED	6	18	4	312	135
2	**Mosque Inside**	LED	5	12	1	312	19
3	**Mosque Inside**	LED	2	7	4	312	17
4	**Washroom**	LED	1	12	3	312	11
5	**Outside of Mosque**	Tube Light	1	40	10	312	125
6	**Outside of Mosque**	LED	1	12	8	312	30
7	**Store**	LED	2	12	4	312	30
8	**Fire Brigade Office**	ILB	1	200	0	312	0
9	**Fire Brigade Office**	Tube Light	1	40	14	312	175
10	**Fire Brigade Office**	LED	1	12	14	312	52
11	**Incharge Fire Brigade**	LED	2	12	18	312	135
12	**Electrician Room**	ILB	1	100	8	312	250

[8] "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[8]	Operating days per year	Annual Electricity consumption (kWh/year)
13	**Electrician Room**	LED	3	12	8	312	90
14	**Administration PA**	LED	2	12	8	312	60
15	**MOF office**	LED	7	12	8	312	210
16	**MOF office**	Tube Light	1	40	8	312	100
17	**MOF office**	LED	2	30	8	312	150
18	**One Window MOP Branch**	Tube Light	2	40	6	312	150
19	**One Window MOP Branch**	LED	2	12	8	312	60
20	**One Window MOP Branch**	LED	6	12	8	312	180
21	**Administrative office**	SMD	20	12	8	312	599
22	**Administrative office**	LED	2	12	8	312	60
23	**Outside Administrative**	Tube Light	1	40	0	312	0
24	**Outside Administrative**	LED	1	12	12	312	45
25	**Outside Administrative**	Sodium Light	1	400	12	312	1,498
26	**Cashier Room**	Tube Light	1	40	8	312	100
27	**Cashier Room**	LED	1	12	8	312	30
28	**Record Branch**	CFL	1	45	8	312	112
29	**Record Branch**	LED	6	12	8	312	180
30	**Record Branch**	LED	1	30	8	312	75
31	**Record Branch**	LED	1	18	8	312	45
32	**Secretary Unit 2**	Tube Light	1	40	8	312	100
33	**Secretary Unit 2**	CFL	1	85	8	312	212
34	**Secretary Unit 2**	LED	1	12	8	312	30
35	**Clerk office**	Tube Light	1	40	8	312	100
36	**Clerk office**	LED	6	12	8	312	180
37	**Chief Sanitary Inspector**	Tube Light	1	40	8	312	100
38	**Chief Sanitary Inspector**	LED	2	30	8	312	150
39	**Union Office**	CFL	1	24	8	312	60
40	**Gallery 1**	LED	1	12	12	312	45
41	**Gallery 1**	Sodium Light	1	400	12	312	1,498
42	**Account Branch**	Tube Light	2	40	8	312	200
43	**Account Branch**	LED	3	30	8	312	225
44	**Account Branch**	LED	1	12	8	312	30
45	**Meeting Hall**	LED	24	12	2	312	180
46	**MOR office**	LED	8	12	8	312	240
47	**MOI office**	Tube Light	1	40	8	312	100
48	**MOI office**	LED	2	30	8	312	150
49	**MOI office**	LED	6	12	8	312	180
50	**Kitchen**	Tube Light	1	40	8	312	100
51	**Audit Office**	LED	13	12	8	312	389
52	**Encroachment Inspector**	LED	1	24	8	312	60
53	**Kiraya Dokanat**	Tube Light	1	40	8	312	100
54	**Kiraya Dokanat**	LED	1	24	8	312	60
55	**Kiraya Dokanat**	LED	1	18	8	312	45

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Electricity consumption (kWh/year)
56	**Kiraya Dokanat**	LED	1	12	8	312	30
57	**MOS Office**	Tube Light	1	40	8	312	100
58	**MOS Office**	LED	4	12	8	312	120
59	**MOS Office**	LED	1	30	8	312	75
60	**Sub-Engineer office**	Tube Light	2	40	0	312	0
61	**Sub-Engineer office**	LED	4	12	6	312	90
62	**Sub-Engineer office**	LED	1	18	6	312	34
63	**MOR office**	LED	7	12	7	312	183
64	**Gallery 2**	ILB	1	100	8	312	250
65	**Gallery 2**	Tube Light	1	40	8	312	100
66	**Gallery 2**	Mercury Light	1	125	0	312	0
67	**Head office Clerk**	LED	5	12	8	312	150
68	**Water Supply Recovery**	Tube Light	1	40	0	312	0
69	**Water Supply Recovery**	LED	1	30	8	312	75
70	**Building branch**	Tube Light	1	40	0	312	0
71	**Building branch**	LED	2	12	8	312	60
72	**Computer operator**	LED	4	7	8	312	70
73	**Computer operator**	LED	1	12	8	312	30
74	**Co-office**	Tube Light	2	40	0	312	0
75	**Co-office**	CFL	1	24	8	312	60
76	**Co-office**	LED	2	30	8	312	150
77	**Co-office**	LED	8	12	6	312	180
78	**Gallery 3**	ILB	1	100	8	312	250
79	**Gallery 3**	Tube Light	1	40	0	312	0
			Graveyard				
1	**Outside**	LED	1	30	12	312	112
2	**Outside**	LED	2	40	12	312	300
3	**Main Hall**	LED	5	40	1	312	62
4	**Main Hall**	LED	5	30	1	312	47
5	**Wazu Area**	LED	3	30	1	312	28
6	**Wazu Area**	LED	1	40	1	312	12
7	**Washroom**	LED	1	30	1	312	9
8	**Store**	LED	1	12	1	312	4
9	**Open Area**	LED	5	12	1	312	19
10	**Open Area**	CFL	3	24	1	312	22
11	**Open Area**	LED	1	30	1	312	9
	Total						**22,925**

5.3 Baseline Energy Consumption Trend

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

Table 33: Energy consumption in Office Buildings

SI No.	Description	Unit	Value[9]
1	Annual Electricity Consumption	kWh	37,865
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[9] Based on Utility Bills

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	3	5	39,931	31,852	8,079	13.72 kWh/m2	8.78 kWh/m2	Library old building and Graveyard were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these buildings have 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 34: Cooling Equipment Comparison

Building Name	Initial Audit (2019) Type of Cooling Equipment	Count	Proposed Replacements	Recent Audit (2023) Count
MC Office Jhelum	Bracket Fan	28	0	29
MC Office Jhelum	Ceiling Fan	41	0	39
MC Office Jhelum	Pedestal Fan	1	0	1
MC Office Jhelum	Air cooler	1	0	1
MC Office Jhelum	Split AC	6	0	6
MC Office Jhelum	Inverter	-	-	4
MC Office Jhelum	Window AC	4	4	3
MC Office Jhelum	Exhaust Fan	-	-	15
Library	Ceiling Fan	16	0	5

Table 35: Lighting Equipment Comparison

Building Name	Initial Audit (2019) Type of Cooling Equipment	Count	Proposed Replacements	Recent Audit (2023) Count
MC Office Jhelum	Tube Light	50	50	24
MC Office Jhelum	LED	121	0	165
MC Office Jhelum	CFL	55	55	4
MC Office Jhelum	Incandescent light Bulb	1	1	4
MC Office Jhelum	SMD	-	-	20
MC Office Jhelum	Sodium light	-	-	2
MC Office Jhelum	Mercury light	-	-	1
Library	Incandescent light Bulb	20	20	1
Library	LED	22	0	21
Library	Tube Light	-	-	3

Table 36: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh
MC Office Jhelum	36,621	25,990
Library	3,310	5,862
Overall	**39,931**	**31,852**

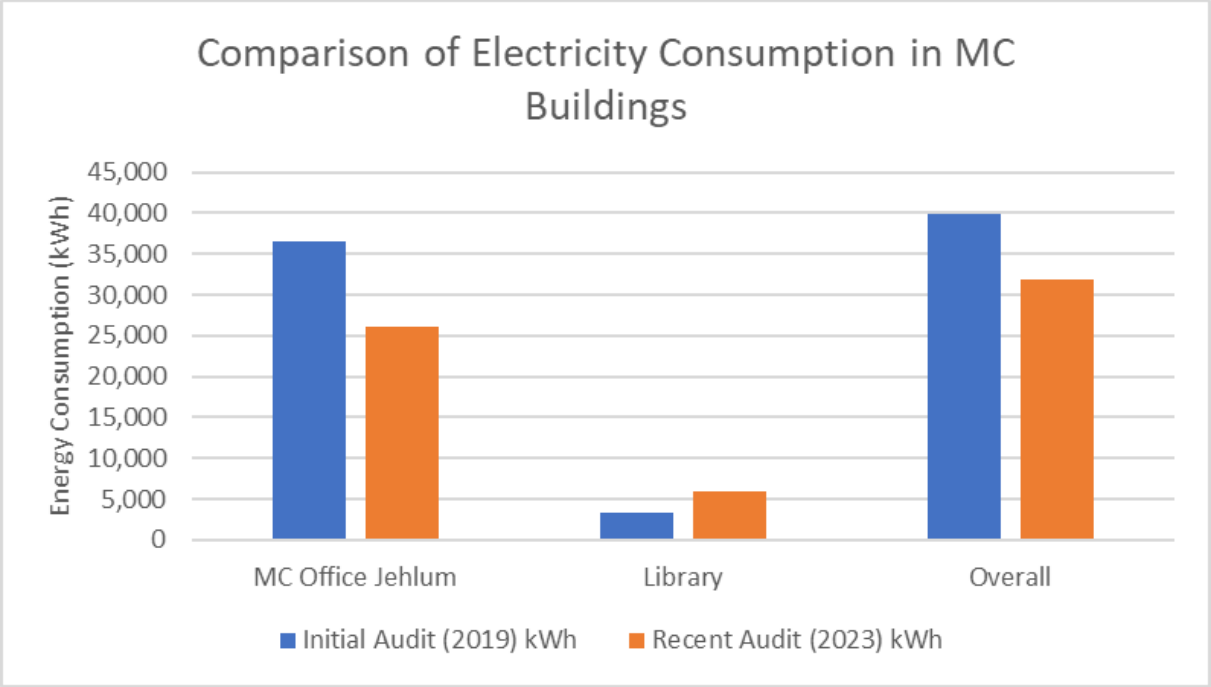

Figure 13:Comparison of Electricity Consumption in MC Buildings

5.4 Maintenance Logs of Buildings

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

6 Solar Assessment for MC Jhelum

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 Jhelum is 100% dependent on the Grid. IESCO is the distribution company which is responsible for providing electricity to the site.

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

MC Main Office Building has four main electrical connections. Three out of four electrical meters have 220V single phase electrical connections, whereas one electrical meter has 400V Three Phase connection. Moreover, Slaughterhouse, Library (New), Library (Old) and Graveyard also has single phase 220V electrical connections. 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 only. However, if the system requirement of any site with single-phase connection exceeds above 5kW based on the historical electricity bill, the Consultant has provided the detailed assessment of available solar system capacity. Metering details of each building is presented below.

Table 37: Metering details at MC Jhelum

Sr. No	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Library (Old)	81806265	07144160742600	1	A-3a (66)
2	Library (New)	81806265-1	01144120153100	1	A-3a (66)
3	Slaughter House	81706230	04144110448500	1	A-2a (04)
4	Graveyard	81706205-1	15144161622600	1	A-1a (01)
5	Main MC Building	81706205	11144161202200	3	A-3a (66)
			11144161202000	4	A-3a (66)
			11144161201900	1	A-2a (04)
			11144161200400	7	A-3a (66)

6.1 Main MC Office Building

The project site i.e. Main MC Office Building is located near Civil Lines Shamali Mohalla, Jhelum, Punjab, Pakistan while the geographical co-ordinates of location are 32.932129°N (latitude) and 73.734428°E (longitude).

Figure 14: Front View Of Main MC Office Building

Figure 15: Aerial View of MC Office Main building

6.1.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Main MC Office Building is 25,990 kWh. 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 1: Solar System Requirement

Sr No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	11144161202200 (1ϕ)	7,857	655	1,097[10]	6
2	11144161202000 (1ϕ)	2,555	213	311[11]	2
3	11144161201900 (1ϕ)	9,798	817	1,512[12]	7
4	11144161200400 (3ϕ)	5,780	482	1,074[13]	16
Total					**31**

Note: The Consultant has observed that Main MC Office Building has four different electrical connections, whereas two single phase connections (11144161202200 & 11144161201900) have system requirement of more than 5 kW. Therefore, the Consultant has estimated the load assessment of the total energy consumption of MC Building. Moreover, based on the analysis of the historical billings it is identified that the total system requirement for this site is **31 kW**. It is highly recommended to replace the single-phase connections that are mentioned above to three-phase connection before the installation of solar system as estimated by the Consultant.

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Office Building is 14,800 ft^2 whereas, the total area of rooftop available for the solar installation is 8,798 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.

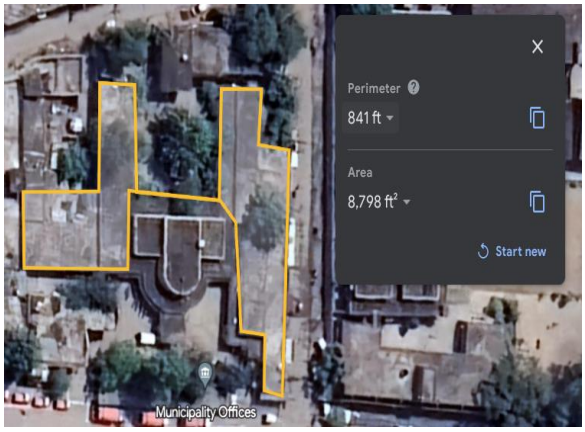

Figure 16: Top View of Main MC Office building

[10] This energy consumption peak is from the month of June, 2022.
[11] This energy consumption peak is from the month of September, 2022.
[12] This energy consumption peak is from the month of September, 2022.
[13] This energy consumption peak is from the month of August, 2022.

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

Figure 17: Location for Installation-A

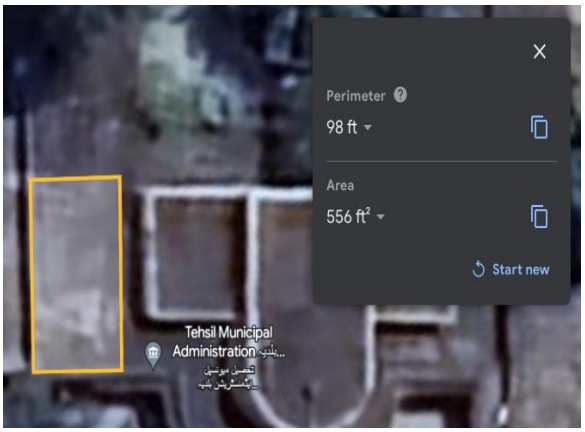

Figure 18: Location for Installation-B

Figure 19: : Location for Installation-C

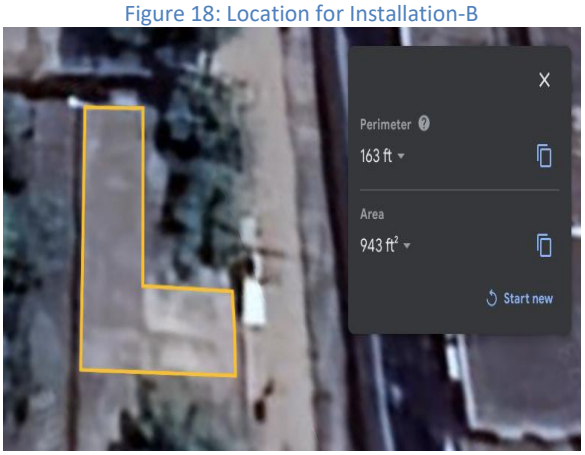

Figure 20: Location for Installation-D

Table 38:System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Location – D	Total
Area availability (ft²)	966	556	1,515	943	3,980
Solar system capacity (kW)	9	5	15	9	38

6.2 Library (Old)

The project site i.e. Library (Old) Stand is located near Iqbal Library Road, Machine Mohalla No.3 Naya Mohalla, Jhelum, Punjab, Pakistan while the geographical co-ordinates of location are 32.930115 °N (latitude) and 73.732110°E (longitude).

Figure 21: Front view of Library

Figure 22: Aerial view of Library

6.2.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption of Library (Old) is 3,102 kWh with the peak electricity consumption of 309 kWh in January 2023. 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

Sr No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	07144160742600	3,102	259	309	2
Total					**2**

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

6.3 Library (New)

The project site i.e. Library (New) is located near Old G.T Road, Model Colony, Jhelum, Punjab, Pakistan while the geographical co-ordinates of location are 32.929665°N (latitude) and 73.731125°E (longitude).

Figure 23: Front view of Library

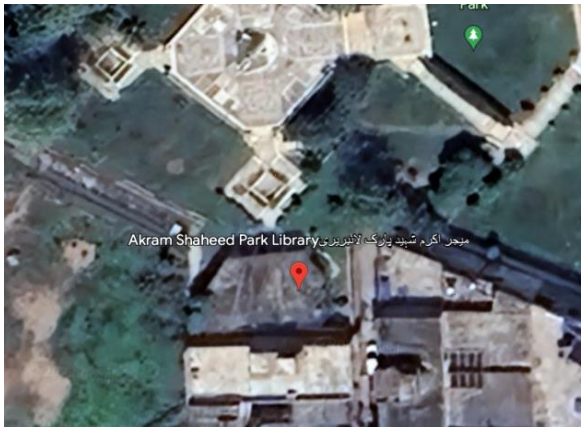

Figure 24:Aerial view of Library

6.3.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption of Library (New) 5,862 kWh with the peak electricity consumption of 1,020 kWh in December 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 40:Solar System Requirement

Sr No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	01144120153100	5,862	499	1,020	4
Total Solar System Requirement (kW)					**4**

Note: Based on the analysis of the historical billings it is identified that the system requirement for this site is **4 kW** with a single-phase connection furthermore as building is connected to the national grid through a single-phase electricity connection, therefore, it is not recommended to install the solar system at this site.

6.4 Slaughterhouse

The project site i.e. Slaughterhouse is located near Islampura Road, Islampura Mohalla Islampura, Jhelum, Punjab, Pakistan while the geographical co-ordinates of location are 32.949312°N (latitude) and 73.720366°E (longitude).

Figure 25: Aerial view of the Slaughterhouse

6.4.1 Solar System Requirement

Note: As per the information received from the MC focal person, slaughter house building is the property of MC Jhelum, but the operations and maintenance of slaughterhouse is managed by the tenants therefore the Consultant has not done the solar assessment for this site.

6.5 Graveyard

The project site i.e. Graveyard is located Dhoke Jumma, Jhelum, Punjab, Pakistan while the geographical co-ordinates of location are 32.936312°N (latitude) and 73.731936°E (longitude).

Figure 26: Front view of Graveyard

Figure 27: Aerial view of Graveyard

6.5.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption Graveyard is 2,911 kWh with the peak electricity consumption of 369 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 41:Solar System Requirement

Sr No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	15144161622600	2,911	243	369	2
Total Solar System Requirement (kW)					**2**

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

6.6 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.

6.6.1 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.

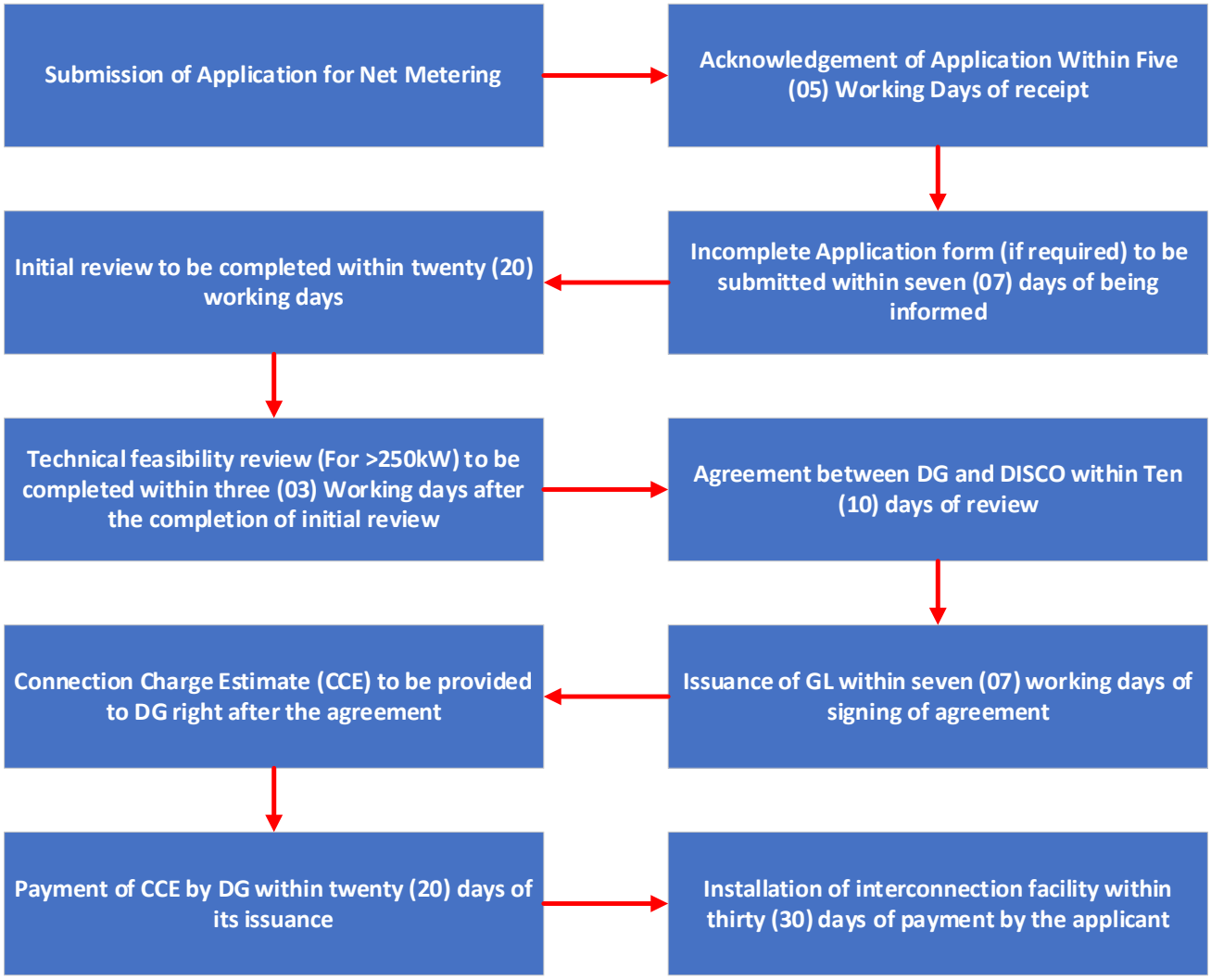

Figure 28:Pakistan Net Metering Application Process

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

Replacement of Pumpset at (Chak Abdullah Shadab Road Pump No. 25 - Unique ID: 81706206)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 36%.

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	190
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	136
Measured Head	m	20.7
Measured Motor Power	kW	25.17
Pump Efficiency	%	36%
Existing Operational Hours	h	6.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	35
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	8.0
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	49,830
Energy Required by Proposed Pump	kWh/y	43,232
Saving Potential	kWh/y	6,598
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,060
Investment	US $	4,026
Simple Payback Period	months	46

7.1.2 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Sahil Colony Pump No. 22 - Unique ID: 81706209)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 36%.

Recommended Action

Replacement of Pump with new PECO 10WC 3-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	200
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	154
Measured Head	m	18.9
Measured Motor Power	kW	25.83
Pump Efficiency	%	36%
Existing Operational Hours	h	10.0
Proposed Pump Flow	m^3/h	153
Proposed Head	m	35
Power Consumption of Proposed Pump	kW	17.9
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	10.1
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	85,250
Energy Required by Proposed Pump	kWh/y	59,452
Saving Potential	kWh/y	25,798
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	4,143
Investment	US $	4,151
Simple Payback Period	months	12

7.1.3 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Norani Masjid Pump No. 35 - Unique ID: 81706215)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 18%.

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 44: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	200
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	33
Measured Head	m	25.3
Measured Motor Power	kW	14.80
Pump Efficiency	%	18%
Existing Operational Hours	h	7.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	35
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	2.2
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	34,188
Energy Required by Proposed Pump	kWh/y	12,171
Saving Potential	kWh/y	22,017
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,536
Investment	US $	4,026
Simple Payback Period	months	14

7.1.4 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Chak Bram Pump No. 35 - Unique ID: 81706216)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 27%.

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 45: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	49
Measured Head	m	25.3
Measured Motor Power	kW	14.80
Pump Efficiency	%	27%
Existing Operational Hours	h	5.5
Proposed Pump Flow	m^3/h	102
Proposed Head	m	35
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	2.6
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	26,862
Energy Required by Proposed Pump	kWh/y	14,207
Saving Potential	kWh/y	12,655
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,032
Investment	US $	4,026
Simple Payback Period	months	24

7.1.5 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Mandi Mor Pump No. 30 Mujahidabad - Unique ID: 81706226)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 30%.

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 46: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	200
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	105
Measured Head	m	22.0
Measured Motor Power	kW	24.77
Pump Efficiency	%	30%
Existing Operational Hours	h	6.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	35
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	6.2
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	49,038
Energy Required by Proposed Pump	kWh/y	33,366
Saving Potential	kWh/y	15,672
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,517
Investment	US $	4,026
Simple Payback Period	months	19

7.1.6 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Ramzan Bazar - Unique ID: 81706234)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 31%.

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 47: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	200
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	140
Measured Head	m	17.2
Measured Motor Power	kW	25.30
Pump Efficiency	%	31%
Existing Operational Hours	h	10.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	35
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	13.7
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	83,490
Energy Required by Proposed Pump	kWh/y	74,190
Saving Potential	kWh/y	9,300
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,494
Investment	US $	4,026
Simple Payback Period	months	32

7.1.7 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Sheesha Ground - Unique ID: 81706236)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 31%.

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 48: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	190
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	117
Measured Head	m	20.1
Measured Motor Power	kW	24.47
Pump Efficiency	%	31%
Existing Operational Hours	h	6.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	35
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	6.9
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	48,444
Energy Required by Proposed Pump	kWh/y	37,428
Saving Potential	kWh/y	11,016
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,769
Investment	US $	4,026
Simple Payback Period	months	27

7.1.8 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 49: Financial Analysis of installation of capacitors for improvement of Power Factor

Sr. No.	Location	Unique ID	PF kVAR on each phase	Quantity	Unit Cost (USD)	Total (USD)
1	Chak Abdullah Shadab Road Pump No. 25	81706206	2.5	3.0	50	150
2	Near Mehfooz CNG Pump No. 23	81706212	2.5	3.0	50	150
3	Norani Masjid Pump No. 35	81706215	2.5	3.0	50	150
4	Chak Bram Pump No. 35	81706216	5.0	3.0	50	150
5	Sheesha Ground	81706236	2.5	3.0	50	150
6	Kashmir Colony Pump No. 37	81707771	2.5	3.0	50	150
7	Municipal Stadium (Salman Parag No. 1)	81806237	2.5	3.0	50	150
Total						**1050**

7.1.9 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 thirty (30) 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 50: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	3,803,576
Annual Water consumption (post-implementation)	m^3/y	3,765,541
Annual Water saving per year	m^3/y	38,036
Estimate of Investment (including the cost of the server)	US$	27,000

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 960 streetlights are being operated by the municipality. Out of these, 465 were found to be non-operational. It was also observed that all of streetlights are manually operated.

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 will 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 29: 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 51: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	465
Number of non-functional streetlights (>20 feet)	#	0
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	465

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	23,743,365
Proposed number of photocell switches	#	28
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	28,000
Upfront investment cost	PKR	23,771,365
Upfront investment cost	US$	84,837
Annual Operating Electricity unit	kWh/yr	61,101
Annual Operating Cost	PKR/yr	2,749,545
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	349,129
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

7.2.2 Medium Priority Measure: Replacement of existing MC operated inefficient streetlights with LEDs

Project

Replacement of inefficient streetlights (i.e. tube lights, CFL, Mercury light, sodium light, etc.) operated by municipality with LEDs along with photocell switches and energy meters.

Study & Investigation

During the assessment it was observed that there are 960 streetlights operated by municipality out of which 495 are operational. 346 of the operational streetlights were LEDs so they are not recommended for replacement.

Out of the 149 operational non-LED streetlights none are installed at a height of 20 feet or more.

Recommended Action

It is recommended to replace above mentioned streetlights with LEDs. 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.

Saving Assessment

LED lamps will have less maintenance issues as compared to conventional tube lights and energy savers (CFLs), because LED has higher 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).

Table 52: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	149
Number of functional streetlights (>20 feet)	#	0
Wattage of proposed LED lights	Watt	50

Parameters	Unit	Value
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	149
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Upfront investment cost	PKR	7,608,089
Upfront investment cost	US$	27,152
Annual Operating Electricity unit	kWh/yr	19,579
Annual Electricity Consumption of Existing Lights	kWh/yr	137,295
Financial Savings	US$/yr	18,905
Payback	months	17

7.3 Energy Efficiency Measures for Buildings

7.3.1 High Priority Energy Efficiency Measure: 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 53: 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)
Library (Old)											
1	CFL	14	60	840	2,097	LED Bulb 13 Watts	13	182	454	350	4,900
2	CFL	2	60	120	300	LED Bulb 13 Watts	13	26	65	350	700
3	CFL	1	24	24	60	LED Bulb 8 Watts	8	8	20	330	330
4	CFL	1	60	60	150	LED Bulb 13 Watts	13	13	32	350	350
5	CFL	2	24	48	120	LED Bulb 8 Watts	8	16	40	330	660
6	CFL	5	24	120	300	LED Bulb 8 Watts	8	40	100	330	1,650
7	CFL	1	60	60	150	LED Bulb 13 Watts	13	13	32	350	350
Library (New)											
8	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
9	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
10	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
Main MC Building											
11	Window AC	1	5000	5000	12,480	Inverter 1.5 ton	1,452	1,452	692	143,000	143,000
12	Window AC	1	5000	5000	12,480	Inverter 1.5 ton	1,452	1,452	692	143,000	143,000
13	Window AC	1	5000	5000	12,480	Inverter 1.5 ton	1,452	1,452	692	143,000	143,000
14	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
15	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
16	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
17	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
18	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
19	Sodium Light	1	400	400	998	Flood LED 200 Watt	400	400	998	25,000	25,000
20	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
21	CFL	1	45	45	112	LED Bulb 13 Watts	13	13	32	350	350
22	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
23	CFL	1	85	85	212	LED Bulb 13 Watts	13	13	32	350	350
24	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
25	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
26	CFL	1	24	24	60	LED Bulb 8 Watts	8	8	20	330	330
27	Sodium Light	1	400	400	998	Flood LED 200 Watt	400	400	998	25,000	25,000
28	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
29	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
30	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
31	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
32	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
33	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350

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)
34	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
35	CFL	1	24	24	60	LED Bulb 8 Watts	8	8	20	330	330
36	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
Graveyard											
37	CFL	3	24	72	180	LED Bulb 8 Watts	8	24	60	330	990
	Total										**546,790**

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 54: 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	days/year	130
Average Operational Hours for Building Cooling Equipment	Hours/day	3.7
Energy consumption of inefficient Equipment	kWh/yr	46,131
Energy consumption of Proposed Equipment	kWh/yr	6,060
Energy Savings	kWh/yr	40,071
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	6,435
Upfront Investment (including change in fixtures)	USD	1,951
Payback Period	Months	4

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, 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

8.1.2 Investment Estimate (including Material Specification/Quantities) for PECO 10 WC /3 Stages, 30hp Motor

	Pump Size	10 WC /3 Stages			
Capacity		152.9 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		0
			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	4	stages with flow type impellers			
Column assembly of	5	inshces I.D with flanged joins	each 10 ft length	0	Sets
			and one top set	1	feet length
			column shaft dia	30	mm
Discharge Head Inch	6				with prelubrication tank
Electric Motor vertical hollow shaft 30 HP/4 Pole					included
DWT 10 WC					included
Discharge head 6 " with top shaft					included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	965,290
Sales Tax @ 17%	Rs:	197,710
Total Cost of Pumpset	Rs:	1,163,000

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 30W	30	4200 Lm	140 Lm/Watt	465	51,061	23,743,365
2	Accessories	Photocell switch				28	1,000	28,000
Lumpsum Price (PKR)								**23,771,365**
Lumpsum Price (USD)								**84,837**

8.2.2 Investment Estimate (including Material Specification/Quantities) for Medium Priority EE Measure: Replacement of existing MC operated inefficient streetlights with LEDs

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	149	51,061	7,608,089

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
Lumpsum Price (PKR)								7,608,089
Lumpsum Price (USD)								27,152

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	LED Bulb 13 Watts	13	24	312	350	8,400
2	LED Bulb 8 Watts	8	13	104	330	4,290
3	LED Rod 20 Watts	20	19	380	2,900	55,100
4	Flood LED 200 Watt	400	2	800	25,000	50,000
5	Inverter 1.5 ton	1,452	3	4,356	143,000	429,000
Lumpsum Price (PKR)						**546,790**
Lumpsum Price (USD)						**1,951**

9 Summary of Energy Efficiency Measures

MC Jhelum's annual energy consumption is 1,636,172 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$ 41,891** with an estimated investment of **US$ 170,296**
- Reduce electricity consumption by approx. **260,844 kWh**
- Reduce GHG Emissions by **143 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of IESCO

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