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Kamoke Municipal Committee

Energy Audit Report

June 2023

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ACKNOWLEDGEMENT

PITCO express their sincere gratitude to the World Bank & Punjab Municipal Development Fund Company (PMDFC) team for their role in guiding and steering Energy Management and Operation & Maintenance of 16 Selected MCs Services Infrastructure Assets Project Under Punjab Cities Program (PCP). The consultant is grateful to the World Bank-Pakistan for vesting its confidence in the team for carrying out this prominent assignment for the assessment of the existing audits and for identification of energy efficiency interventions and for their full-fledged cooperation and support throughout the study.

The Consultant is also grateful to entire Kamoke 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 Kamoke MC Background

The city of Kamoke is located at 31.9765° N, 74.2220° E. Kamoke MC has a total area of 1,254 Acres and the total population of Kamoke City is 230,000 according to latest census conducted in 2017.

According to 1981 Census Kamoke is the largest Town of District Gujranwala and its population was 88,182 and according to 1998 Census, the population of Urban Area Kamoke is 152,246 (approximately) and according to latest census conducted in 2017, the population of Kamoke City is 230,000. There is a total area of 1,254 Acres within the Municipal Committee limits. In 2001, Municipal Committee Kamoke was notified as Tehsil Municipal Administration consisting of 24 Union Council (16 Rural & 08 Urban) and T.M.A. Kamoke was again converted into Municipal Committee w.e.f. 01-01-2017 which is an administrative subdivision of the District and the City is itself subdivided into 36 Urban Wards.

The Administration consists of Administrator, Chief Officer and 3 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 Kamoke MC has the following management.

Sr. No.	Name of Officer	Designation
1	Mr. Fazal Abbas	Administrator
2	Ms. Sofia Ashiq	Chief Officer
3	Mr. Asif Farzand*	Municipal Officer (Infrastructure)
4	Mr. Rana Mudassar	Municipal Officer (Regulation)
5	Ms. Asma Azeem	Municipal Officer (Finance)

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

1.4.1 Baseline Energy Consumption of Kamoke

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	214,625
Electrical energy used by Wastewater Disposal[2]	kWh/year	141,600
Electrical energy used in Buildings[3]	kWh/year	104,107
Electrical energy used by Streetlights[4]	kWh/year	41,954
Diesel used by Vehicles	liter/year	55,440
Petrol used by Vehicles	liter/year	26,208

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)	0.09
2	Energy Density of Wastewater Disposal	(kWh/m^3)	0.01
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)	4.15
5	Energy Cost on Wastewater Disposal	(PKR/m^3)	0.62
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)	13,810
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	392
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	40,011

[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
		PKR/Lighting Equipment	46,040
4	Average cost of installation of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	1,254
		PKR/Lighting Equipment	370
5	Average annual maintenance costs	(PKR)	24,394
6	Average daily duration of operation	(Hour)	12.0
7	Average energy costs per kilometer of lit roads	(PKR/km)	621,435
8	Average energy costs per light pole/fixture	(PKR/ fixture)	17,644
9	Number and percentage of failed public lights		82%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	13.11
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.88
3	Average Energy Cost of Heating	(PKR/m^2)	40
4	Average Energy Cost of Cooling	(PKR/m^2)	226
5	Average Energy Cost of Lighting	(PKR/m^2)	151

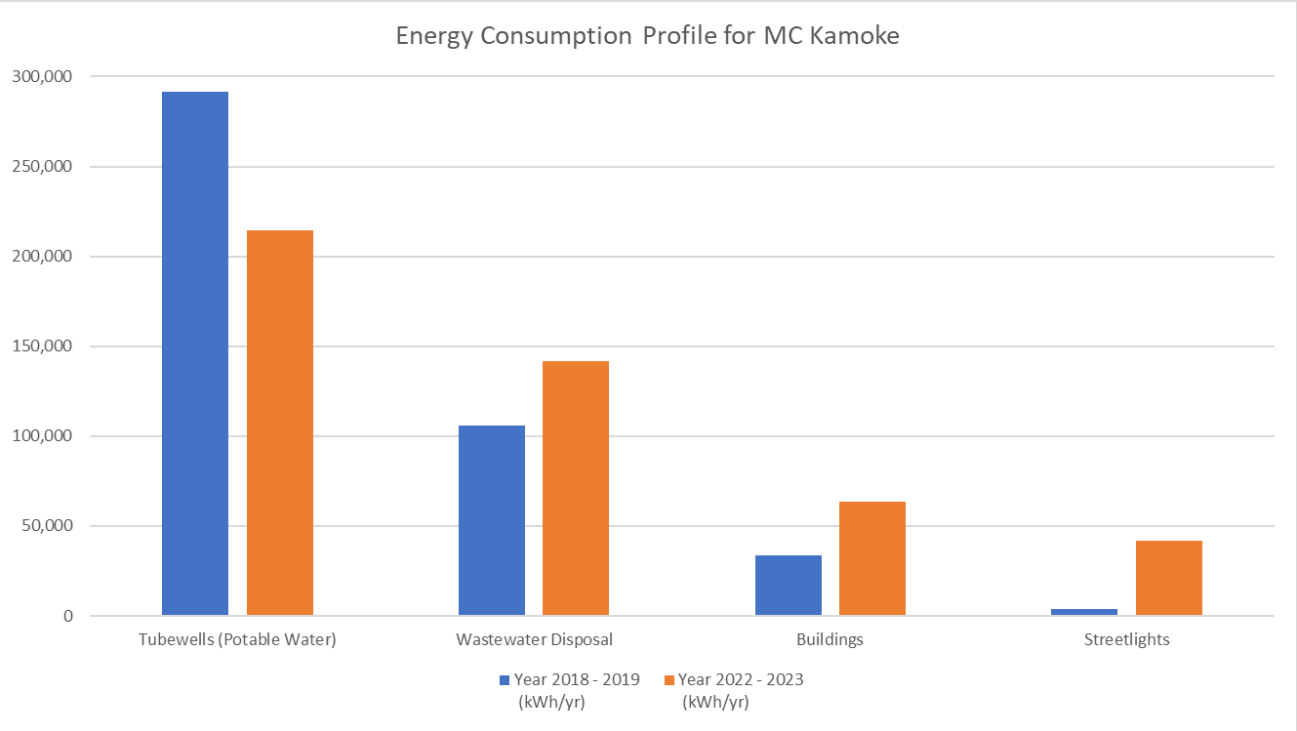
1.5.4 Vehicles

Table 5: KPIs for Vehicles

Sr. No	Description	Unit	KPI
1	Fuel consumption for staff transport vehicles	Liter/km	0.20
2	Fuel consumption for solid/liquid waste transport	Liter/km	0.27
3	Expenditure on fuel for staff transport vehicles	PKR/km	59
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	79

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)	4	3	291,603	214,625	76,978	0.24 kWh/m3	0.09 kWh/m3	Replacement of 3 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 1 pump 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	5	6	105,760	141,600	-35,840	0.014 kWh/m3	0.013 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal has improved as well. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.
3	Buildings	1	3	33,560	63,540	-29,980	6.03 kWh/m2	11.42 kWh/m2	Stadium Waqeel Khan and Library building 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. Electricity units (kWh) are increased

		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
									due to a significant increase in electric appliances in MC Office buildings.
4	Streetlights	0	66	3,737	41,954	-38,217	0	13,810 kWh/km	A baseline comparison for streetlights cannot be carried out in this MC as there were no operational lights in MC Kamoke during the 2019 audit.

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/Installation of Capacitors	Not Quantifiable	1,275	357,255	Not Quantifiable	Months	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	55,279	15,489,286	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	2,855	581	162,730	459	128,494	15	1
Total:	**2,855**	**57,135**	**16,009,271**	**459**	**128,494**		**1**

Table 7: Low Priority Measures

Low Priority Energy Efficiency Measure	Water Savings m^3/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Installation of Flow meters integrated with a centralized DCS system	12,112	14,000	3,922,800	0	0	0	Not Quantifiable
Total:	**12,112**	**14,000**	**3,922,800**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Kamoke MC has six (6) tubewells for groundwater, all of which are manually operated. Out of these, three (3) pumpsets were found to be in working condition.

The MC has one (1) disposal station having eight (8) pumps. Out of these 6 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are twelve (12) dewatering sets in the MC all of which 12 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 two (2) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake assessment of the following pumpset as no flow could be detected by the flowmeter possibly due to excessively turbulent flow
   1. Water Tank Mandiala (Unique ID: 5290426)

(iv) Undertake assessment of the following pumpsets as the sites have been abandoned by the MC
   1. Sharif Pura (Unique ID: 5300424)
   2. Pak town W.S # 007 (Unique ID: 5300432)
   3. Line Park Rasool Nagar (Unique ID: 5290425-1)

(v) Undertake assessment of the following disposal pumpsets as the sites are under maintenance
   1. Disposal Works Ghania (Unique ID: 5290427-A)
   2. Disposal Works Ghania (Unique ID: 5290427-F)

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

2.1 Inventory for water and wastewater pumping equipment

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

2.1.1 Tubewells

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

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	Year of Motor Manufacturing	Latitude	Longitude
1	5290425	Mohallah Rasool Nagar Pani Wali Tanki	28-12142-1662301	Turbine	KSB	2020	Siemens	2020	31.980677	74.231745
2	5290425-1	Line Park Rasool Nagar	27-12142-1264000	Turbine	N/A	N/A	General Electrical	N/A	31.98008	74.231052
3	5290426	Water Tank Mandiala Road	28-12142-0004300	Turbine	KSB	2006	Siemens	2006	31.973391	74.22337
4	5290428	Girls College	30-12141-1339900	Turbine	Beco	1996	Beco	1996	31.980008	74.220869
5	5300424	Sharif Pura	01-12141-0008103	Turbine	Peco	N/A	Peco	N/A	31.962602	74.219477
6	5300432	Pak Town	27-12141-2288400	Turbine	Grundfos	N/A	Grundfos	N/A	31.989809	74.21119

2.1.2 Disposal Works

Table 9: 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	5290427-A	Ghania	28-12141-0586400	Centrifugal	KSB	10	KSB	75	31.956074	74.221332
2	5290427-B	Ghania	28-12141-0586400	Centrifugal	KSB	10	KSB	75	31.956074	74.221322
3	5290427-C	Ghania	28-12141-0586400	Centrifugal	KSB	10	KSB	75	31.956074	74.221322
4	5290427-D	Ghania	28-12141-0586400	Centrifugal	KSB	10	KSB	75	31.956074	74.221322
5	5290427-E	Ghania	28-12141-0586400	Centrifugal	KSB	10	KSB	75	31.956074	74.221322
6	5290427-F	Ghania	28-12141-0586400	Centrifugal	KSB	10	KSB	75	31.956074	74.221322
7	5290427-G	Ghania	28-12141-0586400	Centrifugal	KSB	10	KSB	75	31.956074	74.221322
8	5290427-H	Ghania	28-12141-0586400	Centrifugal	KSB	10	KSB	75	31.956074	74.221322

2.1.3 Dewatering Sets

Table 10: Inventory of Dewatering Sets

Sr. No.	Unique ID	Location	Quantity	Latitude	Longitude
1	5300434-A	Aimnabad Road	1	31.979428	74.226800
2	5300434-B	Rafique Kot	1	31.974044	74.214650
3	5300434-C	Service Road	1	31.972036	74.222678
4	5300434-D	Madiala Road	9	31.973517	74.223342

2.1.4 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	5290430	Girls College	Water Supplied from Govt. Girls College Pumpset Unique ID (5290428)					31.98009	74.220848
2	5300431	Habib Pura	Centrifugal	1	Shalimar	2010	KSB	31.977351	74.208102
3	5300433	Sharif Pura	No Data Available since pump is stolen					31.9626	74.219466
4	5300429	Allah Wali Masjid Tiba Muhammad Nagar Mughal Chowk	Centrifugal	1	Lasanti		Lasanti	31.970511	74.23224

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

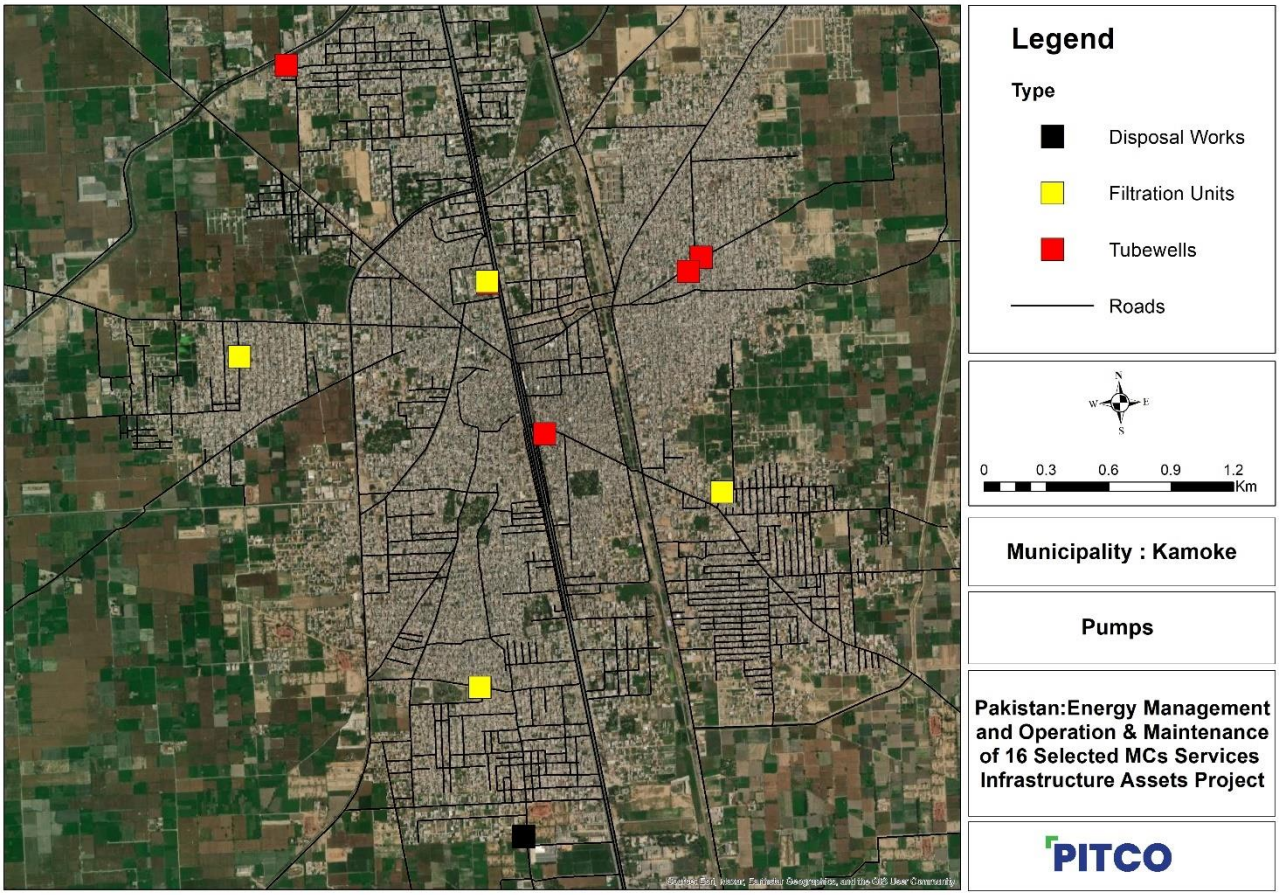


Figure 1: Map for Pumps and Disposal at MC Kamoke

2.3 Baseline Energy Consumption Trend

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

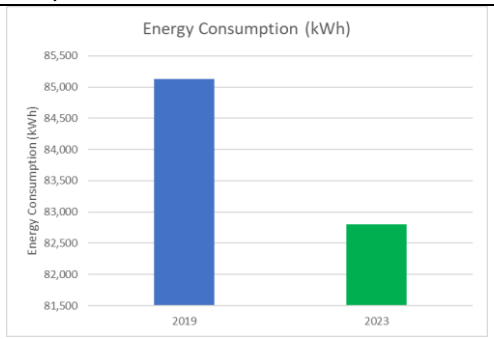
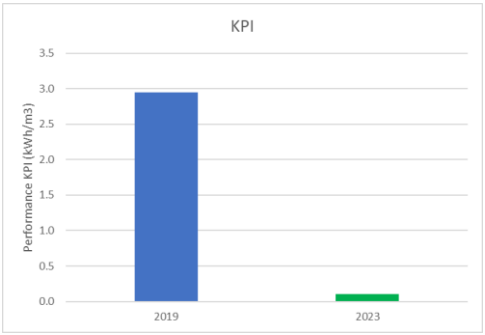
Table 12: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	214,625
Electrical energy used by Wastewater Disposal	kWh/y	141,600
Electrical energy used (Total)	kWh/y	356,225

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)	4	3	291,603	214,625	76,978	0.24 kWh/m3	0.09 kWh/m3	Replacement of 3 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 1 pump 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	5	6	105,760	141,600	-35,840	0.014 kWh/m3	0.013 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal has improved as well. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.

Replacement of 3 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 1 pumpset. A discussion on the newly installed asset is presented below:

Mohallah Rasool Nagar - Unique ID (5290425)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
85,133 kWh	82,800 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
2.95 kWh/m3	0.10 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of new pumpset and bore was recommended due to the low efficiency. Annual energy consumption of this pumpset in 2019 was 85,133 kWh whereas, annual energy consumption of this pumpset of current year is 82,800 kWh with an annual energy savings of 2,333 kWh. Although there is very small savings of energy consumption of this site, the corresponding water supply to the MC from this pumpset has increased significantly. As seen from the KPI, the new pumpset is performing efficiently.	

2.4 Observations and Recommendations

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

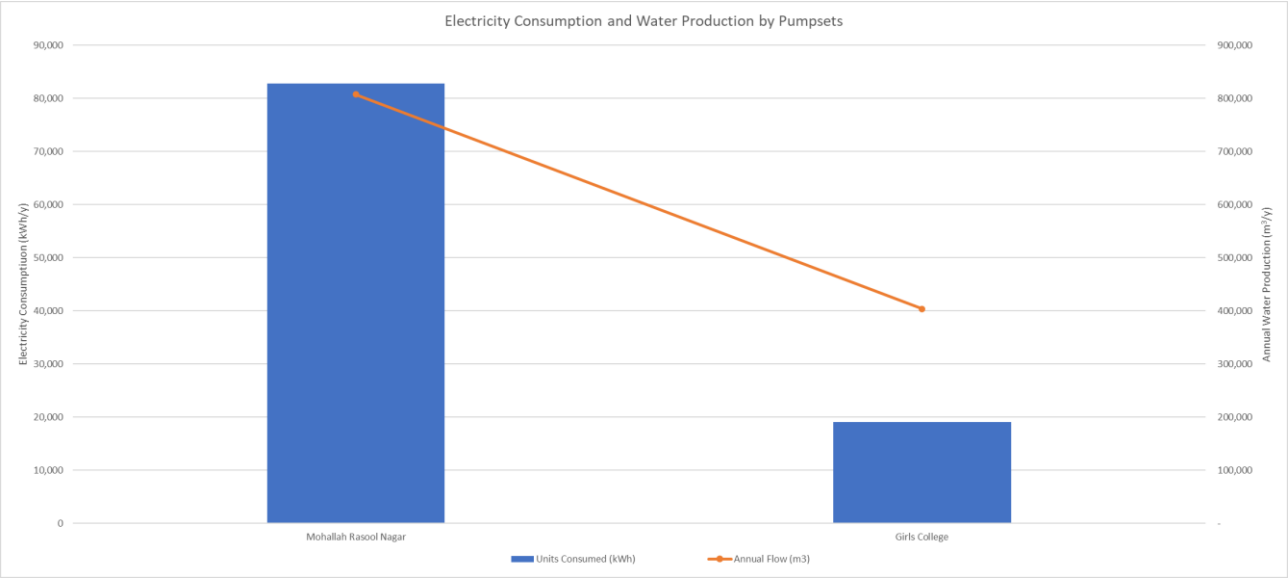


Figure 2: Electricity Consumption and Water Production by Pumpsets

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

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

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

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

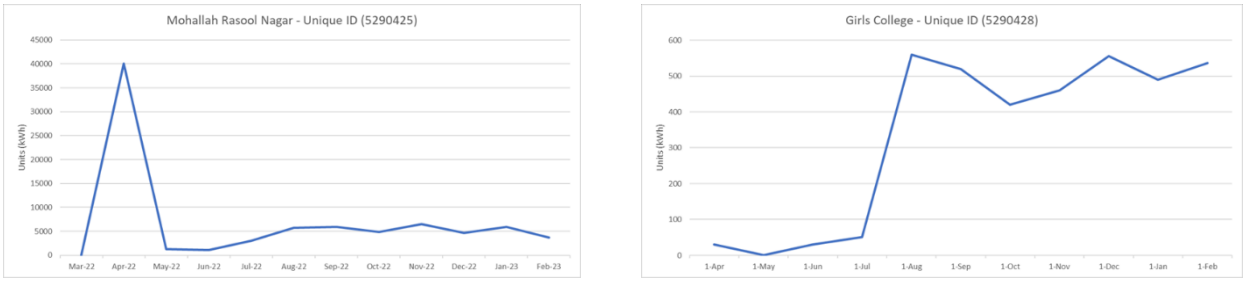


Figure 3: Energy Consumption Trend for Water Pumps

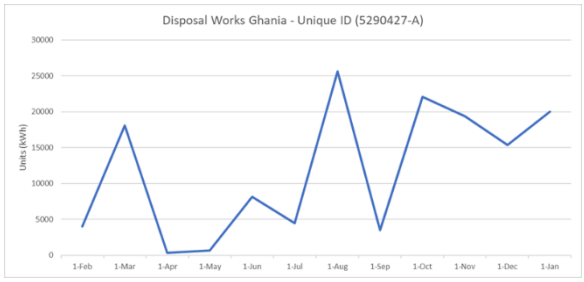


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Kamoke MC has six (6) tubewells for groundwater, all of which are manually operated. Out of these, three (3) pumpsets were found to be in working condition.

Performance evaluation of pumpsets could be carried out at only 2 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 13: Matrix of Pumpset Assessment and Billing Data Availability

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
1	5290425	Mohallah Rasool Nagar	Yes	Yes
2	5290426	Water Tank Mandiala	Yes	No
3	5290428	Girls College	Yes	Yes
4	5300424	Sharif Pura	Yes	No
5	5300432	Pak town W.S # 007	Yes	No
6	5290425-1	Line Park Rasool Nagar	Yes	No
7	5290427-A	Disposal Works Ghania	Yes	No
8	5290427-B	Disposal Works Ghania	Yes	Yes
9	5290427-C	Disposal Works Ghania	Yes	Yes
10	5290427-D	Disposal Works Ghania	Yes	Yes
11	5290427-E	Disposal Works Ghania	Yes	Yes
12	5290427-F	Disposal Works Ghania	Yes	No
13	5290427-G	Disposal Works Ghania	Yes	Yes
14	5290427-H	Disposal Works Ghania	Yes	Yes

Table 14: 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	5290425	Mohallah Rasool Nagar	203.9	276.1	25.23	37.53	59%	0.90	New pumpset has been installed at this site. The efficiency of the pumpset is satisfactory. Previously, it was recommended to replace the pumpset due to lower efficiency value of 10%.
2	5290428	Girls College	203.9	153.0	26.25	22.43	57%	0.83	Efficiency of the pumpset is satisfactory. Previously, it was recommended to install capacitor bank due to the lower power factor value. Efficiency of the pumpset was satisfactory.

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 15: 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
5290425	1644.60	53	12.00	12.00	45	93	100	Safe	ok	150	400	0.87	0.90	84%	High Vibrations
5290428	430.82	34	8.00	8.00	45	-	100	Safe	Ok	-	-	-	0.83	50%	

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

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
1	5290425	Mohallah Rasool Nagar	204	44.76	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	276.08	25.2	Flow at Existing Operating Conditions	37.53	59%
2	205.12	34.4	Flow nearest to duty point	36.60	62%

2.4.3 Wastewater Disposal System

The MC has one (1) disposal station having eight (8) pumps for suction of wastewater from collecting tanks to main sewage drain. All these pumps are manual and run as per requirement.

The performance analysis carried out for these pumps is discussed in the table below. Pumps with an efficiency of 40% or higher are deemed satisfactory in terms of performance while those below this value are recommended for replacement.

Table 17: Disposal Performance Parameters

Sr No	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	PITCO Comments
1	5290427-A	Disposal Works Ghania	1,019.4	-	3.66			This pumpset is under maintenance. Previously, this pumpset was non-functional.
2	5290427-B	Disposal Works Ghania	1,019.4	1,517.2	3.66	33.50	53%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 41%.
3	5290427-C	Disposal Works Ghania	1,019.4	1,172.7	3.66	33.80	41%	Efficiency of the pumpset is satisfactory. Previously, this pumpset was non-functional.
4	5290427-D	Disposal Works Ghania	1,019.4	1,283.9	3.66	33.50	45%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 42%.
5	5290427-E	Disposal Works Ghania	1,019.4	1,279.3	3.66	32.40	46%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 40%.
6	5290427-F	Disposal Works Ghania	1,019.4	-	3.66			This pumpset is under maintenance. Previously, this pumpset was non-functional.
7	5290427-G	Disposal Works Ghania	1,019.4	1,025.1	3.66	31.10	39%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, the efficiency of the pumpset was 58%.
8	5290427-H	Disposal Works Ghania	1,019.4	1,175.9	3.66	26.50	52%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 40%.



Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are twelve (12) dewatering sets in the MC all of which 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	5290427-B	Disposal Works Ghania	The power factor at the site is below 0.8.	A 7.5 kVAr capacitor should be installed on each phase.
2	5290427-C	Disposal Works Ghania	The power factor at the site is below 0.8.	A 7.5 kVAr capacitor should be installed on each phase.
3	5290427-D	Disposal Works Ghania	The power factor at the site is below 0.8.	A 7.5 kVAr capacitor should be installed on each phase.
4	5290427-E	Disposal Works Ghania	The power factor at the site is below 0.8.	A 7.5 kVAr capacitor should be installed on each phase.
5	5290427-G	Disposal Works Ghania	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
6	5290427-H	Disposal Works Ghania	The power factor at the site is below 0.8.	A 7.5 kVAr capacitor should be installed on each phase.
General Observations				
7	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
8	General	Operating Time	Pumps should not be run during Peak electricity consumption hours.	Operational hours of pump should be scheduled keeping in mind the varying peak hours across the year to avoid peak charges. Peak hours for LESCO during the entire year are given in Annexure 1.
9	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.
10	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 Kamoke 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	66	66	
Non-Operational Street Lights	302	302	
Total	**368**	**368**	**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 2 light fixtures installed on PC, 78 fixtures are installed on steel structure, 22 fixtures are installed on walls, and 5 fixtures are installed on gates. The streetlights' structural classification is tabulated below.

Table 20: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Wall	Gate	Grand Total
MC	2	78	22	5	**107**
Private					0

Streetlights of Kamoke MC are installed in main areas of the city. None of the streetlights are privately operated but 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	Ladies Park	63	27121421730800	0.852
2	Street Light corner lady park	14	01121420022604 U	0.015
3	Underpass road	202	02121420078300U	1.365
4	Underpass Sharqi	7	24121420629506 U	0.209
5	Sabzi Mandi	7	24121420508903 U	0.096
6	GT-Road Underpass Ghazali	7	02121410690703 U	0.244
7	City Chowk	68	10121411042301 U	0.258

Out of the 368 surveyed lights in the MC, 66 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	6	4		12.0	105	0
LED	12	10		12.0	526	0
LED	60	4		12.0	1,051	0
LED	100	1		12.0	438	0
LED	120	47		12.0	24,703	0
Total					**26,823**	

Figure 8: Pictures of Streetlights

[5] Based on Interview with Client.

3.2 GIS Map

GIS and yellow points denote functional streetlights.

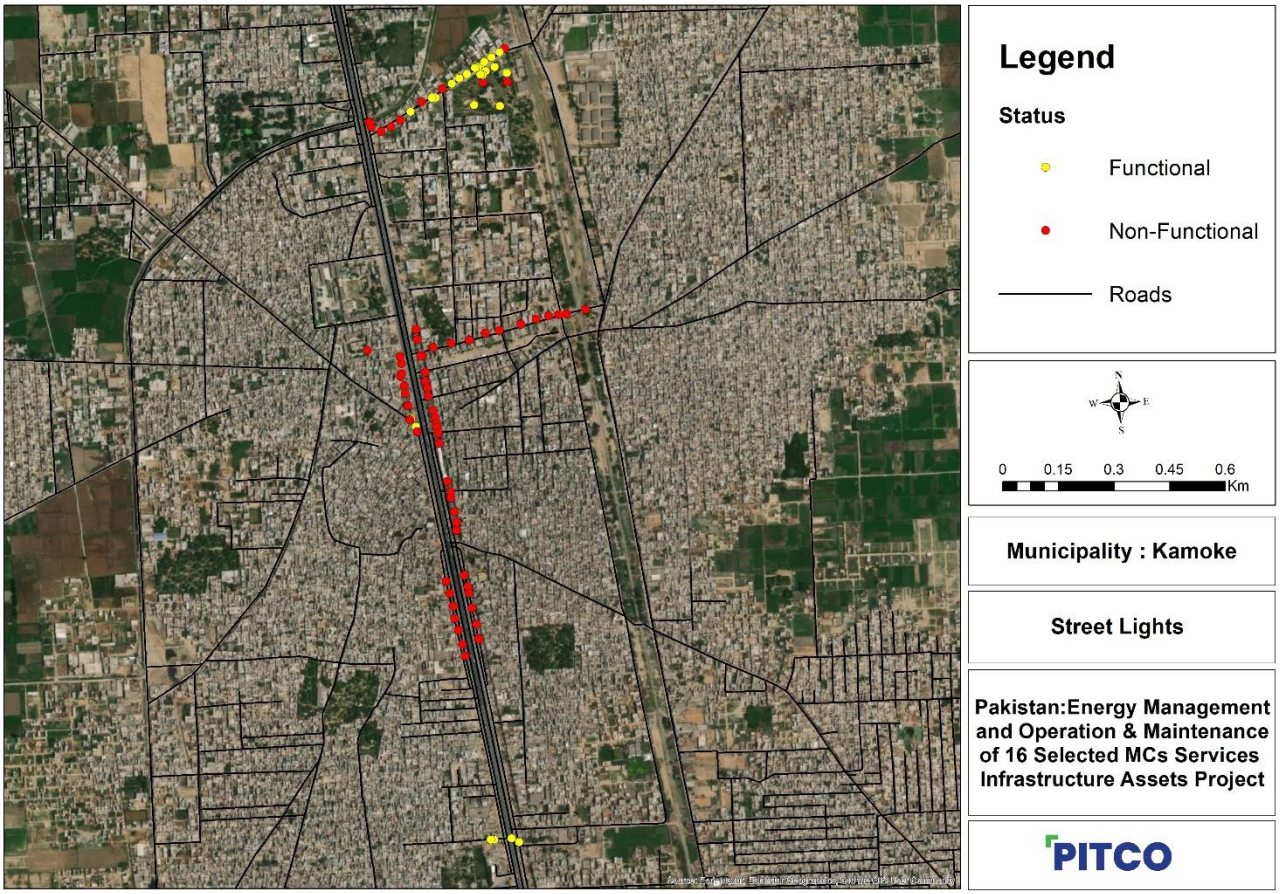


Figure 9: GIS Mapping of street lights in Kamoke MC

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	41,954
Total number of operational lights	No.	66

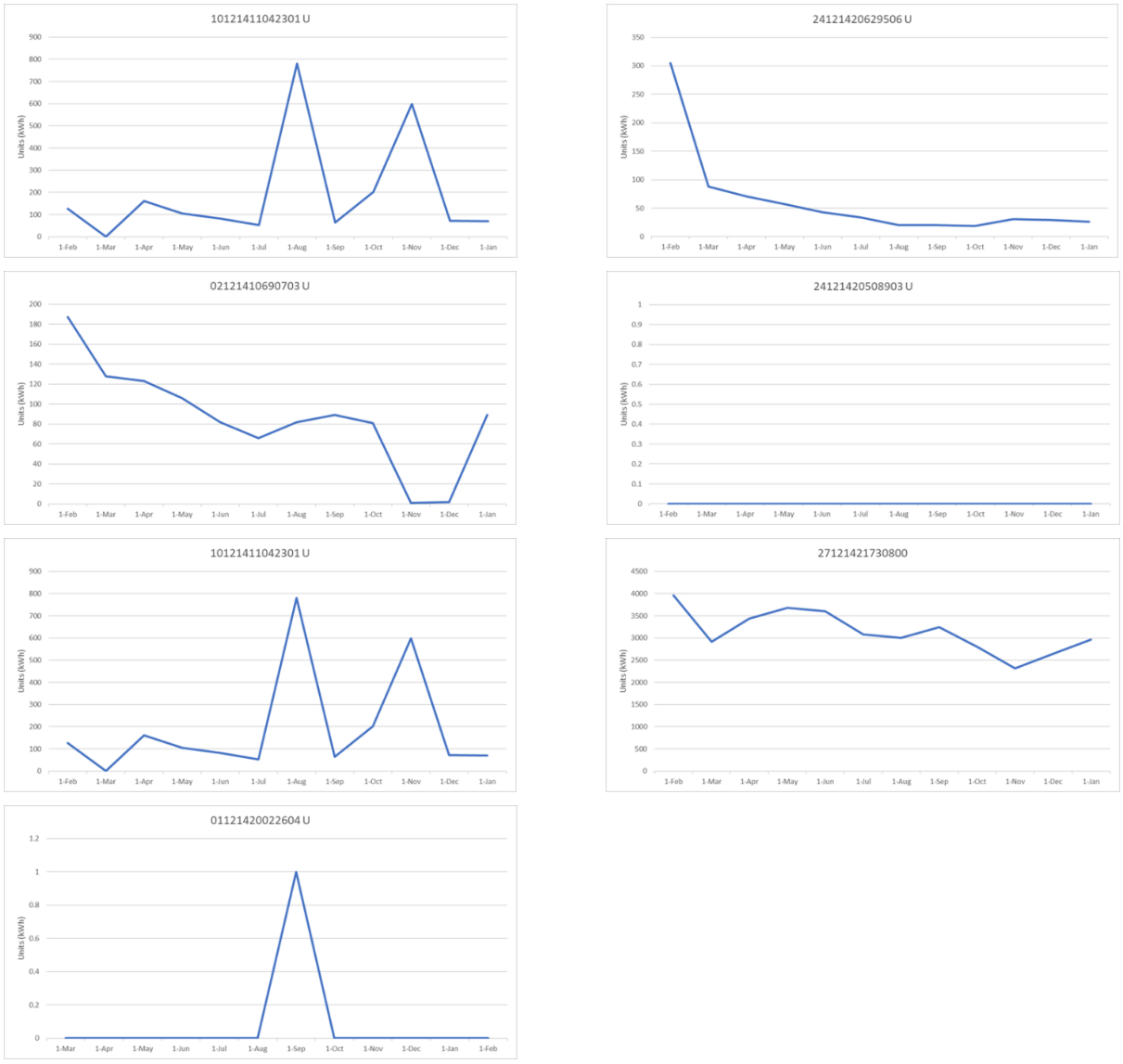


Figure 10: Energy Consumption trend of Streetlights

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	0	66	3,737	41,954	-38,217	0	13,810 kWh/km	A baseline comparison for streetlights cannot be carried out in this MC as there were no operational lights in MC Kamoke during the 2019 audit.

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 Kamoke.

3.5 Observations

- All Streetlights in Kamoke MC are operated by MC.
- All operational streetlights are LEDs.
- Approximately 71% of the LED streetlights have a rating of 120 Watts.
- Kamoke 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 Kamoke are MC operated. • All of the operational streetlights are LEDs • Most of the streetlights are of high wattage • There are no Sodium lights, tube lights and incandescent bulbs installed in the MC	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	Kamoke 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 Kamoke 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	Unregistered Vehicle 1	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386051	490716	796
2	Unregistered Vehicle 2	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386061	490718	796
3	Unregistered Vehicle 3	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386055	490717	796
4	Unregistered Vehicle 4	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386067	490724	796
5	Unregistered Vehicle 5	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386064	490730	796
6	Unregistered Vehicle 6	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386058	490720	796
7	Unregistered Vehicle 7	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386049	490722	796
8	Unregistered Vehicle 8	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386057	490721	796
9	Unregistered Vehicle 9	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386060	490723	796
10	Unregistered Vehicle 10	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386053	490725	796
11	Unregistered Vehicle 11	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	381728	486391	796
12	Unregistered Vehicle 12	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386065	490728	796
13	Unregistered Vehicle 13	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386066	490731	796
14	Unregistered Vehicle 14	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386062	490727	796
15	Unregistered Vehicle 15	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386063	490729	796
16	Unregistered Vehicle 16	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386132	490719	796
17	Unregistered Vehicle 17	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386052	490726	796
18	Unregistered Vehicle 18	Truck	Hino	NR300	2022	4WD	Transport of Solid Waste	WGM50165	JHHKCKOF604600148	4009
19	Unregistered Vehicle 19	Truck	Hino	NR300	2022	4WD	Transport of Solid Waste	WGM50162	JHHKCKOF004600145	4009
20	Unregistered Vehicle 20	Truck	Hino	NR300	2022	4WD	Transport of Solid Waste	WGM50166	JHHKCKOF804600149	4009
21	Unregistered Vehicle 21	Truck	Hino	NR300	2022	4WD	Transport of Solid Waste	WGM50167	JHHKCKOF404600150	4009
22	Unregistered Vehicle 22	Truck	Hino	NR300	2022	4WD	Transport of Solid Waste	WGM50155	JHHKCKOF504600142	4009
23	Unregistered Vehicle 23	Truck	Hino	NR300	2022	4WD	Transport of Solid Waste	WGM50153	JHHKCKOF104600140	4009
24	Unregistered Vehicle 24	Truck Jetting	Isuzu	FTR	2018	4WD	Suction	6HH1-02510P	JALFTR33K-7000123	3400
25	Unregistered Vehicle 25	Firefighting	Hino	N/A	1991	4WD	Firefighting, Fire brigade	157111370	2223	3400
26	Unregistered Vehicle 26	Sucker	Mitsubishi Fuso	Canter	2013	4WD	Suction	4D 34-N18009	MMC-04-CN00276	4200
27	GBA - 936	Tractor Front loader	Millat	MF-385	2022	4WD	Loading	85400/02/22	506753-H	85HP
28	GBA - 931	Tractor Trolley	Millat	MF-385	2022	4WD	Transport of Solid Waste	89622/24/22	603728-H	85HP
29	GBA - 934	Front Loader	Millat	MF-385	2022	4WD	Transport of Solid Waste	85402/01/22	506722-H	85HP
30	GAJ - 1945	Tractor Mechanical Sweeper	Millat	MF-240	2012	2WD	Mechanical Sweeper	622164	42013/31/12	50HP
31	GAJ-19-46	Tractor Front loader	Millat	MF-385	2006	4WD	Loading	511118-M	0462/22	85HP
32	GAJ-19-43	Tractor Front loader	Millat	MF-385	2019	4WD	Loading	503821-E	84726-01-19	85HP
33	GBA - 933	Tractor Trolley	Millat	MF-240	2022	2WD	Transport of Solid Waste	758372-H	44800/14/22	50HP

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)
34	Unregistered Vehicle 27	Tractor, Bowser	Ford	Ford 4600	1981	2WD	Water Browser	E-153599	13-724854	60Hp
35	Unregistered Vehicle 28	Tractor Trolley	Millat	MF-240	2019	2WD	Transport of Solid Waste	739834-F	44025/6/20	50HP
36	Unregistered Vehicle 29	Tractor Front loader + Back Hoe	Millat	MF-385	2019	4WD	Loading	565424-F	88216-11	85Hp
37	GAH - 140	Car	Suzuki	Potohar	1985	2WD	Transport of Staff	102673	316914	1000
38	SAB - 4055	Jeep	Suzuki	Potohar	N/A	2WD	Transport of Staff	N/A	738770	1000
39	GAO - 2020	Car	Suzuki	Cultus	2002	2WD	Transport of Staff	811946	954932	1000
40	Unregistered Vehicle 30	Mini Truck	Master	Forland	2012	2WD	Encroachment Branch	41000BU0153 88878	MMC0206883	4200
41	Unregistered Vehicle 31	Rickshaw	Stahlco Motors	Commando	2012	2WD	N/A	C12-0023E	C12-0023C	200
42	Unregistered Vehicle 32	Rickshaw	Stahlco Motors	Commando	2012	2WD	N/A	E12-0019E	E12-0019C	200
43	Unregistered Vehicle 33	Rickshaw	Stahlco Motors	Commando	2012	2WD	N/A	E12-0020E	E12-0020C	200
44	Unregistered Vehicle 34	Rickshaw	Stahlco Motors	Commando	2012	2WD	N/A	E12-009E	E12-009C	200
45	Unregistered Vehicle 35	Rickshaw	Stahlco Motors	Commando	2019	2WD	N/A	N/A	N/A	150
46	Unregistered Vehicle 36	Rickshaw	Tez Raftar	TR150	2019	2WD	N/A	N/A	N/A	150
47	GAM - 6143	Tractor Trolley	Millat	MF-375	2006	2WD	Transport of Solid Waste	508228	0598-12	75HP
48	GAJ-19-47	Tractor Trolley	Millat	MF-240	2006	2WD	Transport of Solid Waste	533013-M	934167	50HP
49	Unregistered Vehicle 37	Tractor Trolley	Millat	MF-240	2001	2WD	Transport of Solid Waste	561351-F	0944-74	50HP
50	Unregistered Vehicle 38	Truck	Mitsubishi Fuso	Canter	2012	4WD	Transport of Solid Waste	M98860	MMC-04-CN00178	4200
51	Unregistered Vehicle 39	Truck	Mitsubishi Fuso	Canter	2012	4WD	Transport of Solid Waste	M99616	MMC-04-CN00182	4200
52	Unregistered Vehicle 40	Rickshaw	Stahlco Motors	Commando	2019	2WD	N/A	N/A	N/A	150
53	GAJ-19-44	Fronton Loader	Millat	MF-385	2011	4WD	Transport of Solid Waste	521217	80535711	85HP

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	Unregistered Vehicle 10	11:20 AM	12:20 AM	1.45	0.11 Liters/hr	9:20 AM	11:00 AM		3.18	1.91 Liters/hr
2	Unregistered Vehicle 18	11:22 AM	12:22 AM	2.5	0.19 Liters/hr	9:20 AM	11:00 AM		9.5	5.7 Liters/hr
3	Unregistered Vehicle 24	10:04 AM	11:04 AM	1.07	1.07 Liters/hr	8:50 AM	10:00 AM		10	8.57 Liters/hr
4	Unregistered Vehicle 25	9:52 AM	10:52 AM	3	3 Liters/hr	8:50 AM	9:50 AM		6.64	6.64 Liters/hr
5	Unregistered Vehicle 26	9:58 AM	10:58 AM	3.5	3.5 Liters/hr	8:56 AM	9:57 AM		9	8.85 Liters/hr
6	GBA - 934	9:40 AM	10:50 AM	3.63	3.11 Liters/hr	8:30 AM	9:35 AM		12.9	11.91 Liters/hr
7	GAJ - 1945	9:54 AM	10:54 AM	3.79	3.79 Liters/hr	8:50 AM	9:50 AM		8	8 Liters/hr
8	Unregistered Vehicle 27	9:52 AM	10:52 AM	2.31	2.31 Liters/hr	8:50 AM	9:50 AM		7	7 Liters/hr
9	Unregistered Vehicle 28	10:58 AM	12:00 PM	2.65	2.56 Liters/hr	9:52 AM	10:55 AM		6.17	5.88 Liters/hr

Table 27: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	Unregistered Vehicle 2	4.17
2	Unregistered Vehicle 3	5.00
3	Unregistered Vehicle 4	4.55
4	Unregistered Vehicle 5	4.55
5	Unregistered Vehicle 8	4.77
6	Unregistered Vehicle 10	4.75
7	Unregistered Vehicle 11	4.64
8	Unregistered Vehicle 13	4.67
9	Unregistered Vehicle 15	5.36
10	Unregistered Vehicle 16	3.17
11	Unregistered Vehicle 17	4.79
12	Unregistered Vehicle 18	4.00
13	Unregistered Vehicle 19	4.00
14	Unregistered Vehicle 20	4.00
15	Unregistered Vehicle 21	4.14
16	Unregistered Vehicle 22	4.00
17	Unregistered Vehicle 23	3.88
18	GBA - 931	2.77
19	GBA - 933	3.07
20	Unregistered Vehicle 28	2.94
21	SAB - 4055	4.99
22	GAO - 2020	4.98
23	GAM - 6143	2.67
24	Unregistered Vehicle 37	4.00

The logbooks of remaining vehicles are not available in MC.

The MC made 24 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 2.18 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 7.16 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	31,116
Annual Cost of Fuel (Diesel)	PKR/y	9,116,988
Annual Consumption of Fuel (Petrol)	Liter/y	10,368
Annual Cost of Fuel (Petrol)	PKR/y	2,820,096

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 Kamoke 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 Kamoke 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 three 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.

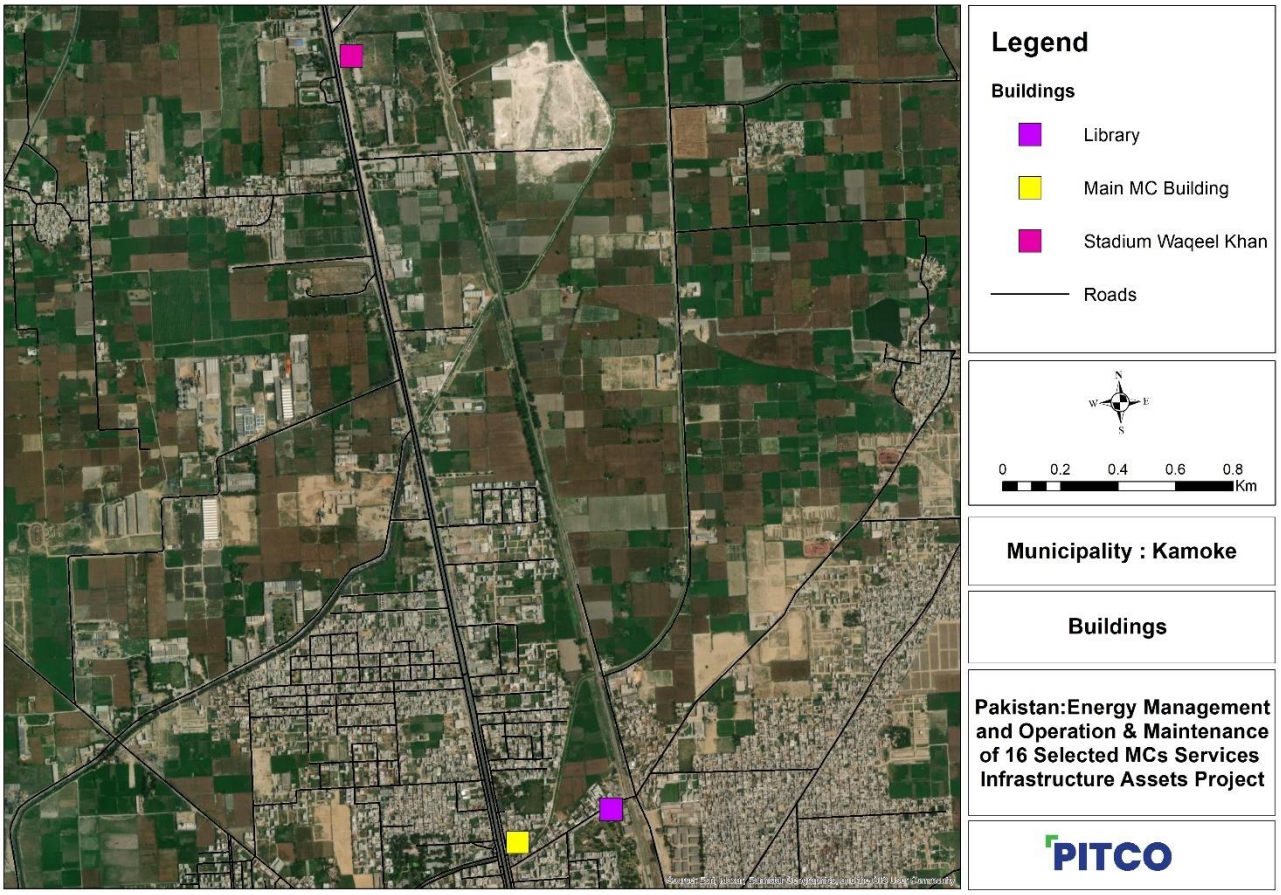


Figure 12: Map for Buildings

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	Main MC Building	N:31.984524 E:74.221200	20805335	MC	29	Satisfactory	1,000	No Proper Insulation	1
2	Stadium Waqeel Khan	N:32.009231 E:74.216524	20805335-1	MC	N/A	Satisfactory	1500	No Proper Insulation	1
3	Library	N:31.985399 E:74.224690	20805335-2	MC	N/A	Satisfactory	875	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/Location	Type of Heating Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[6]	Operating months per year	Operating days per year	Annual Electricity consumption (kWh/year)	Total Energy Consumption (kWh/year)
Main MC Building									
1	**Masjid outside**	Electric heater	1	1000	24	3	78	1,872	1,872
2	**Administration office**	Electric heater	1	1000	8	3	78	624	624
3	**Co-Office**	Electric heater	1	1000	2	3	78	156	156
4	**MOI Branch**	Electric heater	1	1000	3	3	78	234	234
5	**Audit Branch**	Electric heater	1	1000	4	3	78	312	312
Stadium Waqeel Khan									
1	**Washroom**	Geysers	1	2000	8	3	78	1,248	1,248
2	**Washroom 2**	Geysers	1	2000	7	3	78	1,092	1,092
	Total								**5,538**

[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 hour[7]s	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Main MC Building								
1	Masjid Main Hall	Ceiling Fan	1	80	8	7	182	116
112	Masjid Main Hall	Split AC	1	1800	8	6	156	2,246
3	Masjid Main Hall	Bracket Fan	1	50	8	7	182	73
4	Outside Masjid	Ceiling Fan	2	80	8	7	182	233
5	Superintendent office	Ceiling Fan	1	80	8	7	182	116
6	Superintendent office	Split AC	1	1650	8	6	156	2,059
7	Superintendent office	Bracket Fan	1	50	8	7	182	73
8	Account Branch	Ceiling Fan	1	80	8	7	182	116
9	Account Branch	Split AC	1	1800	8	6	156	2,246
10	Account Branch	Bracket Fan	1	50	8	7	182	73
11	MOP office	Ceiling Fan	1	80	8	7	182	116
12	MOP office	Inverter	1	1150	8	6	156	1,435
13	Record Room	Ceiling Fan	1	80	8	7	182	116
14	Record Room	Bracket Fan	1	50	8	7	182	73
15	MOF Office	Ceiling Fan	1	80	8	7	182	116
16	MOF Office	Split AC	1	1800	8	6	156	2,246
17	MOF Office	Exhaust Fan	1	30	8	7	182	44
18	Computer Room	Ceiling Fan	1	80	8	7	182	116
19	Computer Room	Split AC	1	1800	8	6	156	2,246
20	Engineering Branch	Ceiling Fan	1	80	8	7	182	116
21	Engineering Branch	Bracket Fan	2	50	8	7	182	146
22	Gallery 1	Ceiling Fan	1	80	8	7	182	116
23	One Window Operation	Ceiling Fan	1	80	8	7	182	116
24	Meeting Hall	Bracket Fan	7	50	2	7	182	127
25	Audit Room	Ceiling Fan	1	80	8	7	182	116
26	Audit Room	Inverter	1	1452	8	6	156	1,812
27	Administrative office	Ceiling Fan	3	80	12	8	208	599
28	Administrative office	Inverter	1	1150	7	6	156	1,256
29	Administrative office	Split AC	1	2700	7	6	156	2,948
30	Telephone Exchange	Ceiling Fan	1	80	8	8	208	133
31	Co-office	Ceiling Fan	1	80	8	8	208	133
32	Co-office	Split AC	1	1800	3	3	78	421
33	MOI Branch	Ceiling Fan	1	80	8	8	208	133
34	MOI Branch	Split AC	1	1800	4	6	156	1,123
35	MOR Branch	Ceiling Fan	1	80	8	8	208	133
36	MOR Branch	Split AC	1	1800	4	6	156	1,123
37	MOR Branch	Exhaust Fan	1	30	1	12	312	9

[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 hour's	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
38	**Gallery 2**	Ceiling Fan	3	80	6	8	208	300
39	**Sanitary Supervisor**	Ceiling Fan	2	80	8	8	208	266
40	**MOR Operator**	Ceiling Fan	1	80	20	8	208	333
41	**MOR Operator**	Exhaust Fan	1	30	1	8	208	6
42	**MOR Operator**	Pedestal Fan	1	125	10	8	208	260
43	**Store**	Ceiling Fan	5	80	2	8	208	166
44	**ACR Open Area**	Ceiling Fan	2	80	2	8	208	67
45	**ACR Open Area**	Split AC	1	0	2	6	156	0
46	**ACR Kitchen**	Ceiling Fan	1	80	1	8	208	17
47	**ACR Kitchen**	Exhaust Fan	1	30	4	8	208	25
48	**ACR Guest Room**	Exhaust Fan	1	30	2	8	208	12
49	**ACR Guest Room**	Split AC	1	1800	2	6	156	562
50	**ACR Store Room**	Ceiling Fan	1	80	2	8	208	33
51	**ACR Store Room**	Ceiling Fan	1	80	12	8	208	200
52	**ACR Rest Room**	Inverter	1	1452	12	6	156	2,718
			Stadium Waqeel Khan					
1	**Store**	Ceiling Fan	1	80	2	7	182	29
2	**Sports Officer Office**	Ceiling Fan	1	80	7	7	182	102
3	**Dressing Room**	Ceiling Fan	2	80	2	7	182	58
4	**Washroom**	Exhaust Fan	1	30	3	7	182	16
5	**Dressing Room 2**	Ceiling Fan	2	80	2	7	182	58
6	**Supervisor Office**	Ceiling Fan	1	80	8	7	182	116
7	**Open Area**	Ceiling Fan	3	80	4	7	182	175
			Library					
1	**Open Area**	Ceiling Fan	4	80	7	7	182	408
2	**Study Room**	Ceiling Fan	1	80	8	7	182	116
3	**Reading Hall**	Ceiling Fan	4	80	8	7	182	466
4	**Computer Section**	Ceiling Fan	2	80	8	7	182	233
5	**Librarian Room**	Ceiling Fan	1	80	8	7	182	116
6	**Meeting Hall**	Ceiling Fan	7	80	2	7	182	204
7	**Store Hall**	Ceiling Fan	4	80	1	7	182	58
8	**Store Hall**	Split AC	1	0	0	0	0	0
	Total							31,548

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

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating days per year	Annual Energy consumption (kWh/year)
			Main MC Building				
1	**Masjid Main Hall**	Tubelight	2	40	10	312	250

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating days per year	Annual Energy consumption (kWh/year)
2	**Masjid Main Hall**	LED	1	12	10	312	37
3	**Masjid Main Hall**	LED	4	30	10	312	374
4	**Masjid Outside**	LED	2	18	10	312	112
5	**Masjid Outside**	LED	2	50	10	312	312
6	**Masjid Outside**	LED	1	30	10	312	94
7	**MC Outside**	LED	2	30	12	312	225
8	**MC Outside**	LED	8	100	12	312	2,995
9	**MC Outside**	LED	1	50	12	312	187
10	**MC Outside**	LED	2	50	12	312	374
11	**Superintendent Office**	Tubelight	2	40	8	312	200
12	**Superintendent Office**	LED	2	50	8	312	250
13	**Account Branch**	LED	2	50	8	312	250
14	**Account Branch**	LED	1	30	8	312	75
15	**MOP Office**	LED	5	30	8	312	374
16	**Store / Record Room**	Tubelight	1	40	8	312	100
17	**Washroom**	Tubelight	1	40	0	312	0
18	**Washroom**	LED	1	12	24	312	90
19	**Record Room**	CFL	1	50	8	312	125
20	**Record Room**	LED	1	50	8	312	125
21	**MOF Office**	LED	3	50	8	312	374
22	**MOF Office**	LED	3	24	8	312	180
23	**MOF Office**	LED	1	12	8	312	30
24	**Computer Room**	LED	4	30	8	312	300
25	**Engineering Room**	LED	2	40	8	312	200
26	**Engineering Room**	LED	1	12	8	312	30
27	**Gallery 1**	Tubelight	2	40	0	312	0
28	**Gallery 1**	LED	3	40	8	312	300
29	**One Window Operation**	LED	2	50	8	312	250
30	**One Window Operation**	LED	3	13	8	312	97
31	**Meeting Hall**	Tubelight Panel	8	72	2	312	359
32	**Meeting Hall**	LED	4	13	2	312	32
33	**Meeting Hall**	Tubelight	16	40	2	312	399
34	**Open Area**	Tubelight	1	40	0	312	0
35	**Open Area**	LED	2	30	8	312	150
36	**Open Area**	LED	1	18	8	312	45
37	**Administrative Office**	Tubelight Panel	5	72	0	312	0
38	**Administrative Office**	LED	15	13	12	312	730
39	**Administrative Office**	LED	7	7	12	312	183
40	**Administrative Office**	LED	1	50	12	312	187
41	**Telephone Exchange**	Tubelight	1	40	0	312	0
42	**Telephone Exchange**	LED	1	18	8	312	45
43	**C.O office**	Tubelight	2	40	8	312	200
44	**C.O office**	LED	13	13	8	312	422

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating days per year	Annual Energy consumption (kWh/year)
45	MOI Branch	LED	1	50	7	312	109
46	MOI Branch	LED	2	30	8	312	150
47	MOI Branch	LED	1	12	8	312	30
48	MOR Branch	LED	16	13	8	312	519
49	Gallery 2	Tubelight	2	40	0	312	0
50	Gallery 2	LED	2	50	8	312	250
51	Sanitary Supervisor Office	LED	1	12	8	312	30
52	Sanitary Supervisor Office	LED	1	30	8	312	75
53	Kitchen	LED	2	12	8	312	60
54	Kitchen	LED	1	50	8	312	125
55	MOR Operator	Tubelight	2	40	8	312	200
56	MOR Operator	LED	2	50	8	312	250
57	MOR Operator	LED	2	12	8	312	60
58	Store	LED	6	12	2	312	45
59	Store	LED	1	50	2	312	31
60	Store	LED	1	30	2	312	19
61	ACR Outside	LED	1	30	10	312	94
62	ACR Outside	LED	3	100	10	312	936
63	ACR Outside	LED	2	50	10	312	312
64	ACR Open Area	LED	1	30	8	312	75
65	ACR Open Area	LED	2	50	8	312	250
66	ACR Kitchen	LED	1	30	4	312	37
67	ACR Guest Room	LED	2	12	1	312	7
68	ACR Guest Room	LED	1	35	1	312	11
69	ACR Guest Room	LED	1	50	1	312	16
70	ACR Store	LED	2	12	2	312	15
71	ACR Rest Room	LED	2	35	10	312	218
72	ACR Rest Room	LED	1	50	2	312	31
73	ACR Rest Room	LED	1	7	2	312	4
74	ACR Garraj	LED	1	30	10	312	94
75	ACR Audit Room	LED	3	40	8	312	300
76	ACR Audit Room	LED	1	35	8	312	87
77	ACR Audit Room	LED	1	12	8	312	30
			Stadium Waqeel Khan				
1	Outside	Tubelight	1	40	0	312	0
2	Outside	LED	2	12	12	312	90
3	Outside	LED	6	12	10	312	225
4	Store	Tubelight	1	40	2	312	25
5	Store 2	CFL	1	24	2	312	15
6	Sport Officer Office	Tubelight	2	40	7	312	175
7	Dressing Room	Tubelight	2	40	3	312	75
8	Dressing Room	CFL	3	24	1	312	22
9	Washroom	Tubelight	1	40	2	312	25

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating days per year	Annual Energy consumption (kWh/year)
10	**Washroom**	CFL	1	24	2	312	15
11	**Dressing Room 2**	Tubelight	2	40	3	312	75
12	**Washroom**	Tubelight	1	40	3	312	37
13	**Washroom**	LED	1	13	8	312	32
14	**Supervisor Officer**	CFL	1	24	4	312	30
15	**Open Area**	Tubelight	4	40	10	312	499
16	**Ground**	LED	8	120	3	312	899
Library							
1	**Outside**	LED	8	50	12	312	1,498
2	**Outside**	LED	1	120	12	312	449
3	**Outside**	LED	1	12	12	312	45
4	**Open Area**	LED	17	7	8	312	297
5	**Open Area**	LED	1	12	8	312	30
6	**Study Room**	LED	3	7	7	312	46
7	**Reading Hall**	LED	21	7	7	312	321
8	**Computer Section**	LED	6	7	7	312	92
9	**Store**	LED	3	7	2	312	13
10	**Librarian Room**	LED	3	7	7	312	46
11	**Librarian Room**	LED	1	50	7	312	109
12	**Washroom**	LED	1	12	8	312	30
13	**Meeting Hall**	LED	63	7	2	312	275
14	**Store Hall**	LED	3	40	2	312	75
	Total						**21,094**

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[8]
1	Annual Electricity Consumption	kWh	104,107
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[8] 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	1	3	33,560	63,540	-29,980	6.03 kWh/m2	11.42 kWh/m2	Stadium Waqeel Khan and Library building 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. Electricity units (kWh) are increased due to a significant increase in electric appliances in MC Office buildings.

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-Owned Building	Ceiling Fans	28	0	36
MC-Owned Building	Split AC	8	0	11
MC-Owned Building	Inverter	1	0	4
MC-Owned Building	Window AC	2	2	0
MC-Owned Building	Bracket Fan	9	0	13
MC-Owned Building	Exhaust Fan	-	-	5
MC-Owned Building	Pedestal Fan	-	-	1

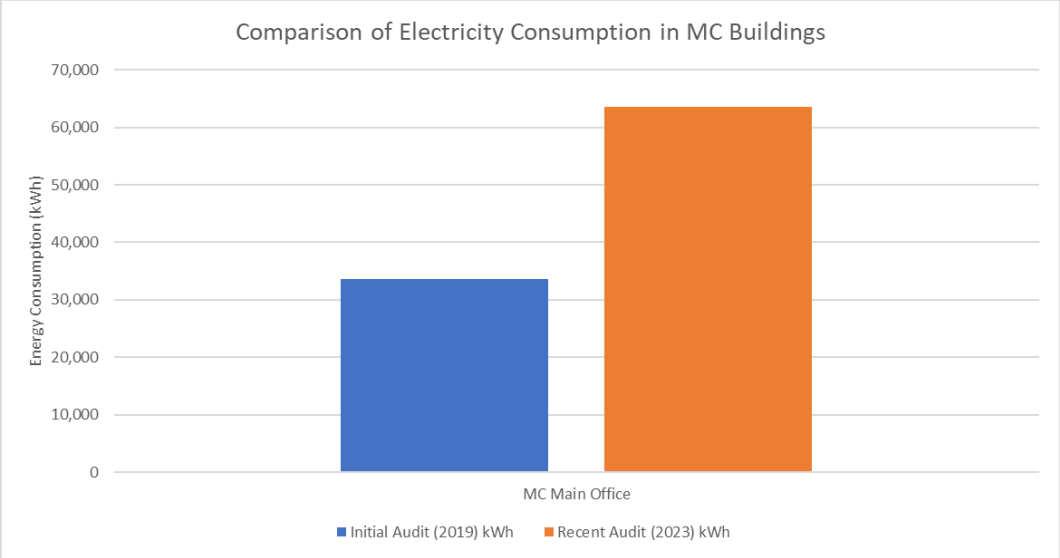
Table 35: Lighting Equipment Comparison

Building Name	Initial Audit (2019) Type of Cooling Equipment	Count	Proposed Replacements	Recent Audit (2023) Count
MC-Owned Building	CFL	16	16	1
MC-Owned Building	Tube Light	44	44	32
MC-Owned Building	LED	69	0	166
MC-Owned Building	Tube light Panel	-	-	13

Table 36: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh	Comment
MC Main Office	33,560	63,540	Stadium Waqeel Khan and Library building 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. Electricity units (kWh) are increased due to a significant increase in electric appliances in MC Office buildings.

1



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 Kamoke

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

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

MC Main Office Building, Stadium Waqeel Khan and Library has Three Phase 400V electrical connection. As Single-Phase connections are not eligible for net metering, therefore, the Consultant has only carried out detailed assessment of system size requirement for the three phase connection buildings 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 Kamoke

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Main MC Building	20805335	27121420022600	31	A-2c (06)T
2	Stadium Waqeel Khan	20805335-1	24121421729300	11	A-3a (66)
3	Library	20805335-2	27121421730800	68	A-2c (06)T

6.1 Main MC Office Building

The project site i.e. Main MC Office Building is located near NH 5, Pak Town, Kamoke, Gujranwala, Punjab, Pakistan while the geographical co-ordinates of location are 31.984524°N (latitude) and 74.221200°E (longitude).

Figure 13: Front View of Main MC Building

Figure 14: Aerial View of Main MC Building

6.1.1 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 Main MC Office Building is 63,540 kWh with the peak electricity consumption of 8,660 kWh

in September 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 2: Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
63,540	5,295	8,660	46

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Office Building is 59,890 ft^2 whereas, the total area of rooftop available for the solar installation is 13,818 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 15: Top View of Main MC Office building-Rest House

Figure 16: Top View of Main MC Office building-Offices Block

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

Figure 17: Location for Solar Installation-A

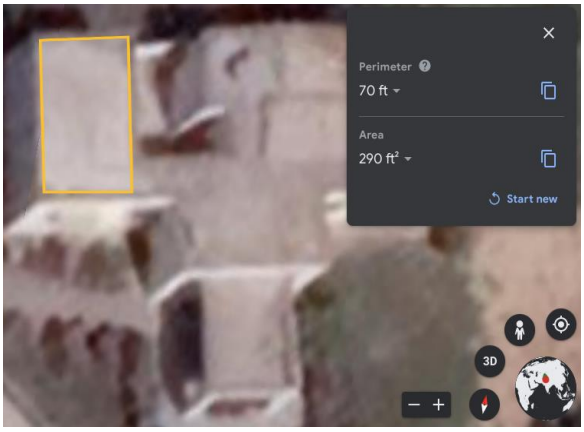


Figure 18: Location for Solar Installation-B

Figure 19: Location for Solar Installation-C

Figure 20: Location for Solar Installation-D

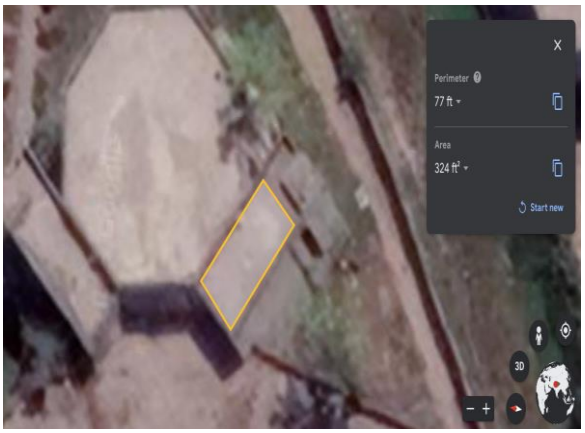


Figure 21: Location for Solar Installation-E

Figure 22: Location for Solar Installation-F

Table 3: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Location – D	Location – E	Location – F
Area availability (ft²)	880	290	1,920	373	324	5,988
Solar system capacity (kW)	9	3	19	4	3	60

6.2 Stadium Waqeel Khan

The project site i.e. Stadium Waqeel Khan is located near Kamoke, NH 5, Gujranwala, Punjab 52470, Pakistan while the geographical co-ordinates of location are 32.009231°N (latitude) and 74.216524°E (longitude).

Figure 23: Front view of Stadium Waqeel Khan

Figure 24: Aerial view of Stadium Waqeel Khan

6.2.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to February 2023, it is identified that the annual energy consumption of Stadium Waqeel Khan is 4,807 kWh with the peak electricity consumption of 750 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 4: Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
4,807	401	750	4

Note: Based on the analysis of the historical billings it is identified that the system requirement for this site is **4kW**. As per the National Electric Power Regulatory Authority (NEPRA) rules, net metering is only applicable for the solar system with minimum system size of 5kW or above, so it is not recommended to install the solar system at this site on priority basis.

6.3 Library

The project site i.e. Library is located Pak Town, Kāmoke, Gujranwala, Punjab, Pakistan while the geographical co-ordinates of location are 31.985399 °N (latitude) and 74.224690 °E (longitude).

Figure 25: Front view of Library

Figure 26: 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 35,760 kWh with the peak electricity consumption of 3,680 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 5: Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
35,760	2,980	3,680	21

6.3.2 Roof Assessment

As per the Consultant's assessment, the total area of the Library is 9,418 ft^2 whereas, the total area of rooftop available for the solar installation is 4,952 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.

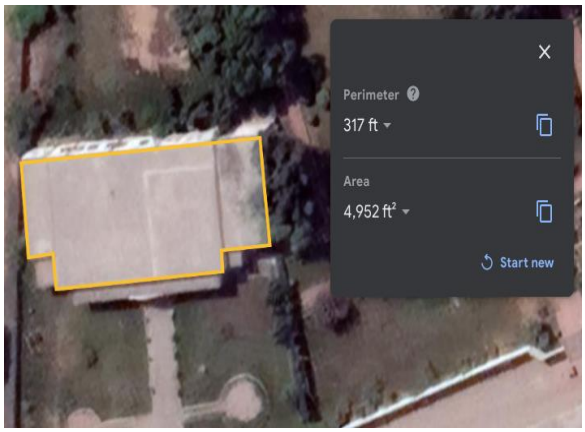


Figure 27: Top View of complete building

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

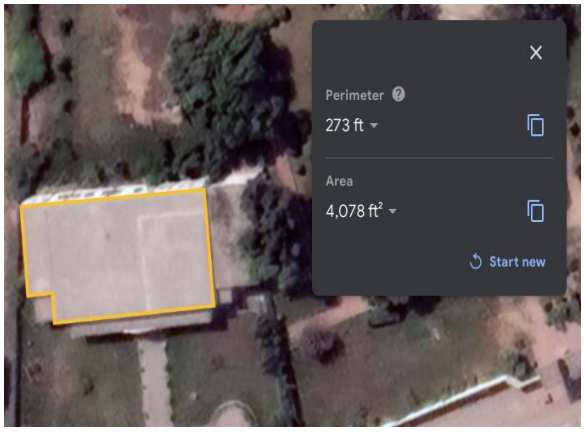


Figure 28: Location for Installation-A

Figure 29: Location for Installation-B

Table 6: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B
Area availability (ft²)	4,078	744
Solar system capacity (kW)	41	7

6.4 Net Metering Consideration

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

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

- Any three phase consumers (residential, commercial and industrial) will be considered eligible for the net metering system.
- Only plants installed and commissioned by AEDB registered vendors/consultants shall be eligible for net metering.
- Any empty space on the roof or facades of buildings, car parking, garages, factory or industrial buildings or sheds or similar buildings or at land within own premise of the consumer or any other suitable area where utility meter exists, is acceptable by the utility.
- Interconnection standards shall comply with the interconnection rules and standards set by the Utility or other relevant governing authority.
- 150% on the customer's sanctioned load is specified as the maximum permissible generator size (installed output DC capacity).
- The maximum output DC capacity of the installed RE system for Net Metering cannot be more than 1 MW.
- Load flow study for the facility having capacity up to 250kW is not required.
- The NOC by Electrical Inspector is not required for Net Metering of a system below 250 kW capacity.
    - In case the kWh supplied by Distribution Company exceed the kWh supplied by Distributed Generator, the Distributed Generator shall be billed for the net kWh in accordance with the Applicable Tariff.

- The tariff payable by the Distribution Company shall only be the off-peak rate of the respective consumer category of the respective month.

- The equipment installed for net metering shall be capable of accurately measuring the flow of electricity in two directions.
- The net meter shall conform to the specifications mentioned in Net metering regulation or approved by relevant authority (Utility or NEPRA).
- A Distributed Generator shall be responsible for all costs associated with Interconnection Facilities up to the Interconnection Point including metering installation
- A variation of ±5%in Voltage and ±1% in frequency is permissible to the nominal voltage and frequency respectively
- The Distributed Generator will furnish and install a manual disconnect device that has a visual break to isolate the Distributed Generation Facility from the Distribution facilities
- The grid connected inverters and generators shall comply with Underwriter Laboratories UL 1741 standard (Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources) which addresses the electrical interconnection design of various forms of generating equipment, IEEE 1547 2003, IEC 61215, EN
- The Distributed Generator shall not have any right to utilize Distribution Company's Interconnection Facilities for the sale of electricity to any other person.

6.4.1 Net-metering application procedure

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

- Any person who meets the requirements of a Distributed Generator as defined under the regulations 2(k) is eligible for submitting application. Regulation 2(k) states the definition of a Distributed Generator as "a Distribution Company's 3 Phase 400V or 11 kV consumer i.e: domestic, commercial or industrial and who owns and/or operates the Distributed Generation **Facility and** is responsible for the rights and regulations related to the agreement and licensed by the Authority under these regulations".
- Application to Distribution Company along with necessary documents shall be submitted by intending Distributed Generator.
- Within five working days of receiving an Application, the Distribution Company shall acknowledge its receipt and inform the Applicant whether the Application is completed in all respect. Provided that in case of any missing information or documents the Applicant shall provide the same to Distribution Company within seven working days of being informed by Distribution Company.
- Upon being satisfied that the Application is complete in all respect, the Distribution Company shall perform an initial review (20 days) to determine whether the Applicant qualifies for Interconnection Facility or may qualify subject to additional requirements.
- In case the initial review reveals that the proposed facility is not technically feasible, the Distribution Company shall return the Application and communicate the reasons to the Applicant within three working days after the completion of initial review.
- For connections up to 250 kW, no technical feasibility study is needed. Power Ministry, GOP has directed DISCOs to carry out relevant technical studies and approve the connections at sub-division level. If the DISCO is satisfied that the Applicant qualifies as a DG, then the DISCO and DG will enter into an agreement.

- The DISCO office will send the copy of the Agreement between DISCO and DG to NEPRA along with application for issuance of Generation License (GL). NEPRA will issue GL within forty (40) hours of submission of application by DISCOs.
- After the Agreement. DISCO will issue the Connection Charge Estimate, if any, to the Applicant for the proposed interconnection facility up to the interconnection point including net metering installation (it is the Applicant's choice to purchase Net Meter from DISCO or open market)
- The Applicant shall make the payment of Connection Charge Estimate within twenty days of its issuance.
- Within Thirty (30) days of payment by Applicant, the DISCO office will install and commission the proposed interconnection facility after the confirmation of GL license to the DG by NEPRA.

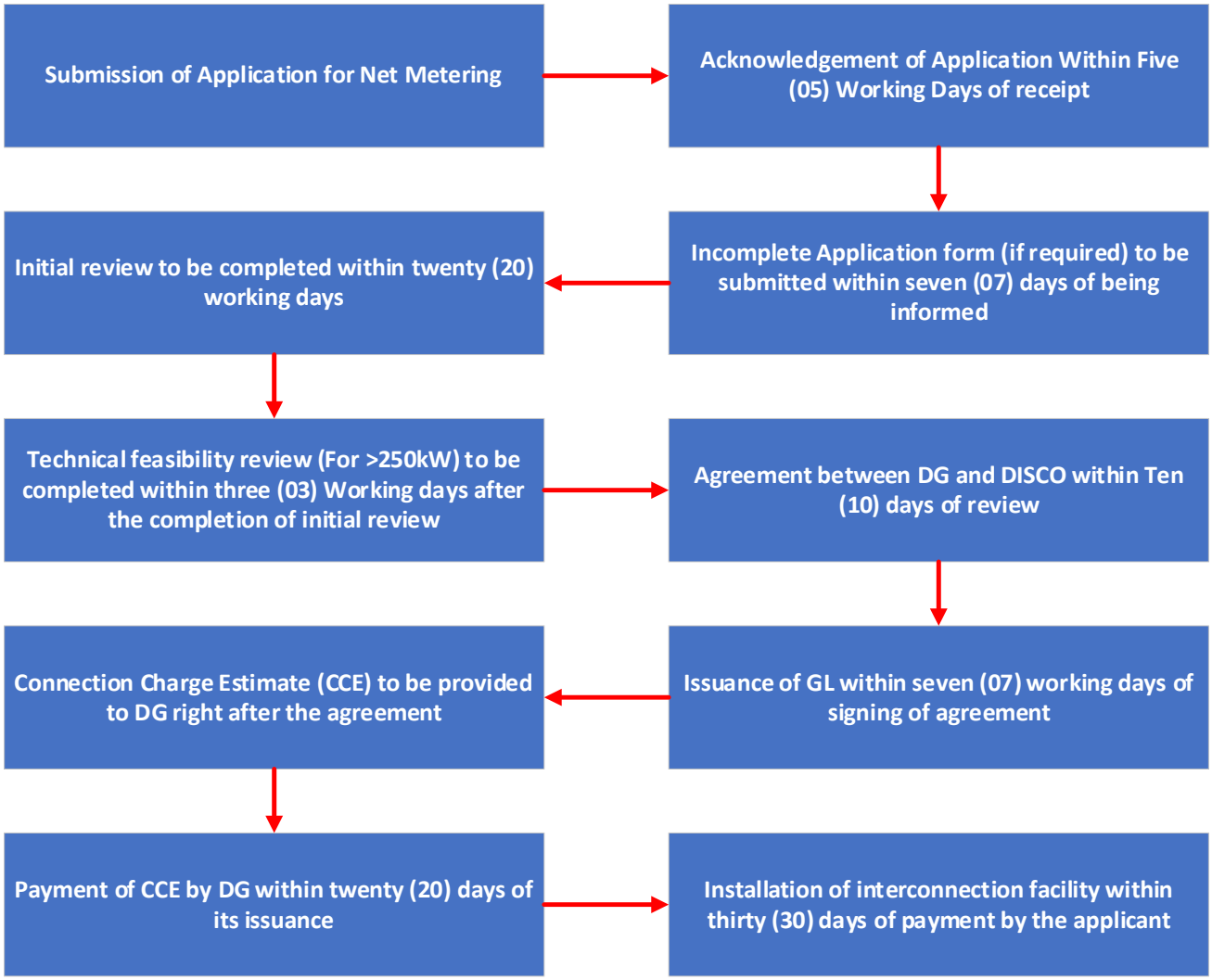


Figure 19: Pakistan Net Metering Application Process

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/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 38: 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	Disposal Works Ghania	5290427-B	7.5	3.0	75	225
2	Disposal Works Ghania	5290427-C	7.5	3.0	75	225
3	Disposal Works Ghania	5290427-D	7.5	3.0	75	225
4	Disposal Works Ghania	5290427-E	7.5	3.0	75	225
5	Disposal Works Ghania	5290427-G	5.0	3.0	50	150
6	Disposal Works Ghania	5290427-H	7.5	3.0	75	225
	Total					**1275**

7.1.2 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 fourteen (14) 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 39: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	1,312,118
Annual Water consumption (post-implementation)	m^3/y	1,298,997
Annual Water saving per year	m^3/y	13,121
Estimate of Investment (including the cost of the server)	US$	14,000

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 368 streetlights are being operated by the municipality. Out of these, 302 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 & 24-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 30: 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 40: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	302
Number of non-functional streetlights (>20 feet)	#	22
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	280

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	24
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	15,482,286
Proposed number of photocell switches	#	7
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	7,000
Upfront investment cost	PKR	15,489,286
Upfront investment cost	US$	55,279
Annual Operating Electricity unit	kWh/yr	34,252
Annual Operating Cost	PKR/yr	1,541,322
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	248,444
Monthly diesel cost for operating fork lifter for two days	PKR/month	20,000
Monthly cost of renting Fork Lifter for two days	PKR/month	80,000
Miscellaneous Cost	PKR/month	20,000
Monthly maintenance cost	PKR/month	120,000

7.3 Energy Efficiency Measures for Buildings

7.3.1 High Priority Energy Efficiency Measure: 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 41: 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	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
MC Building & Mosque											
1	Tubelight	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
2	Tubelight	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
3	Tubelight	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
4	CFL	1	50	50	125	LED Bulb 20 Watts	20	20	50	830	830
5	Tubelight Panel	8	72	576	1,438	LED Panel 36 Watts	36	288	719	6,200	49,600
6	Tubelight	16	40	640	1,597	LED Rod 20 Watts	20	320	799	2,900	46,400
7	Tubelight	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
8	Tubelight	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
Fire Brigade											
9	Tubelight	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
10	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
11	Tubelight	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
12	Tubelight	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
13	CFL	3	24	72	180	LED Bulb 13 Watts	13	39	97	350	1,050
14	Tubelight	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
15	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
16	Tubelight	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
17	Tubelight	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
18	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
19	Tubelight	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
	Total										**162,730**

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 42: 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
Energy consumption of inefficient Equipment	kWh/yr	5,716
Energy consumption of Proposed Equipment	kWh/yr	2,860
Energy Savings	kWh/yr	2,855
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	459
Upfront Investment (including change in fixtures)	USD	581
Payback Period	Months	15

8 Investment Estimate (including Material Specification/Quantities)

8.1 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.

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 50W	50	7000 Lm	140 Lm/Watt	22	53,873	1,185,206
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	280	51,061	14,297,080
3	Accessories	Photocell switch				7	1,000	7,000
Lumpsum Price (PKR)								**15,489,286**
Lumpsum Price (USD)								**55,279**

8.2 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.

8.2.1 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 Rod 20 Watts	20	38	760	2900	110200
2	LED Bulb 20 Watts	20	1	20	830	830
3	LED Panel 36 Watts	36	8	288	6200	49600
4	LED Bulb 13 Watts	13	6	78	350	2100
Lumpsum Price (PKR)						**162,730**
Lumpsum Price (USD)						**581**

9 Summary of Energy Efficiency Measures

MC Kamoke's annual energy consumption is 1,311,709 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$ 459** with an estimated investment of **US$ 71,135**
- Reduce electricity consumption by approx. **2,855 kWh**
- Reduce GHG Emissions by **1 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of LESCO

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

Annexure 2: List of Energy Audit Equipment

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

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