Kamalia Municipal Committee

Energy Audit Report

June 2023

History of the Document

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The Consultant is also grateful to entire Kamalia 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 Kamalia MC Background

The historical city of Kamalia is situated at the bank of river Ravi. The history discloses that the town was established prior to the times of Alexander the great. Preliminary it was named as Kot Kamal in the honour of the most prominent personality Kamal Khan who was the head of the Lakhera Kalan of Kharals. It is one of the oldest cities in the Punjab Province having an old mosque of Jahangiri period. It has many historical places like shrine of Hazrat Baba Fazil Dewan, Dargahi Shah, Syed Shabbir Ahmed Shah of Dholar Sharif, Saint of Qdir Bakhsh Sharif. The land of the Tehsil is plane and most of land is under cultivation. The land is very fertile, wheat, sugar cane, rice and cotton etc. are the main crops of the Tehsil. Generally, the inhabitants of Tehsil are agriculturists while the business of poultry in the shape of poultry forms in different part of Tehsil is graded at No. 2 in the whole Punjab. Furthermore, the city of Kamalia is famous at the national level due to its Khaddar and handmade carpets.

The Administration consists of Chief Officer and 4 Municipal Officers to provide basic services to its customers i.e., town planning, water supply, sewerage, streetlights, roads, regulate markets, issue permits and licenses etc. The Kamalia MC has the following management.

Sr. No.	Name of Officer	Designation
1	Mr. Tahir Farooq	Chief Officer
2	Mr. Umer Nawaz Khan*	Municipal Officer (Infrastructure)
3	Mr. Muhammad Zohair	Municipal Officer (Regulation)
4	Mr. Hafiz Masood jillani	Municipal Officer (Finance)
5	Mr. Asad Ali	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Kamalia

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	583,734
Electrical energy used by Wastewater Disposal[2]	kWh/year	356,246
Electrical energy used in Buildings[3]	kWh/year	34,568
Electrical energy used by Streetlights[4]	kWh/year	10,926
Diesel used by Vehicles	liter/year	32,508

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/m3)	0.17
2	Energy Density of Wastewater Disposal	(kWh/m3)	0.05
3	Energy Density of Wastewater Treatment	(kWh/m3)	No wastewater treatment is carried out
4	Energy Cost for Potable Water Production	(PKR/m3)	7.43
5	Energy Cost for Wastewater Disposal	(PKR/m3)	2.04
6	Energy Cost for Wastewater Treatment	(PKR/m3)	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)	176
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	6
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	46,977

[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	41,841
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)	47,309
6	Average daily duration of operation	(Hour)	12.0
7	Average energy costs per kilometer of lit roads	(PKR/km)	7,929
8	Average energy costs per light pole/fixture	(PKR/ fixture)	248
9	Number and percentage of failed public lights		94%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	2.42
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.05
3	Average Energy Cost of Heating	(PKR/m^2)	2
4	Average Energy Cost of Cooling	(PKR/m^2)	38
5	Average Energy Cost of Lighting	(PKR/m^2)	31

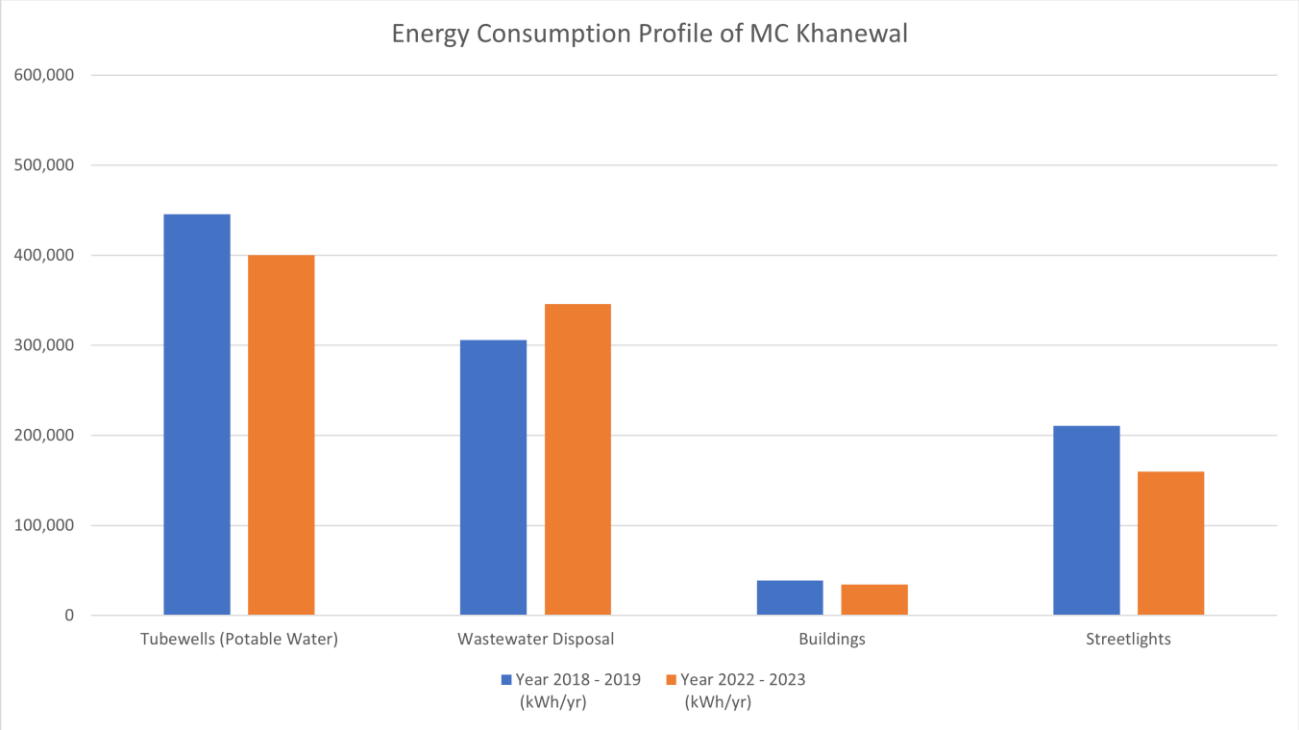
1.5.4 Vehicles

Table 5: KPIs for Vehicles

Sr. No	Description	Unit	KPI
1	Fuel consumption for staff transport vehicles	km/Liter	Cannot be Determined
2	Fuel consumption for solid/liquid waste transport	km/Liter	5.01
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	58

1.6 Impact of Energy Efficiency Investment

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


Energy Consumption Profile of MC Khanewal
600,000
500,000
400,000
300,000
200,000
100,000
0
Tubewells (Potable Water)
Wastewater Disposal
Buildings
Streetlights
Year 2018 - 2019 (kWh/yr)
Year 2022 - 2023 (kWh/yr)

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	13	13	798,248	583,734	214,514	0.16 kWh/m3	0.17 kWh/m3	Replacement of 7 Pumpsets was recommended based on the assessment carried out in 2019. The MC has not undertaken replacement of any proposed pumpsets by the Consultant however, MC has installed 1 pumpset at a new place. It should be noted that the newly installed pumpset was found non-operational during the current audit. Although, the overall energy consumption of the water supply has reduced, the energy consumption per cubic meter of water supply has increased.
2	Wastewater Disposal	6	6	401,943	356,246	45,697	0.06 kWh/m3	0.05 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. However, the Consultant had recommended the MC to undertake repair and maintenance of its existing assets. As seen from the KPI, the overall energy consumption per cubic meter of wastewater disposed has decreased.
3	Buildings	4	6	38,701	34,568	4,133	2.71 kWh/m2	2.42 kWh/m2	General bus stand building and Ramzan Bazar were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these buildings has not been considered in the overall energy consumption and KPI calculations.

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
4	Streetlights	148	128	318,671	10,926	307,745	7,509 kWh/km	176 kWh/km	Based on the previous assessment, there were only 148 MC owned operational lights with an average consumption of 2,153kWh/light/annum, whereas currently there are 128 operational lights with average energy consumption of 85kWh/light/annum. The energy consumption per light fixture of MC has reduced drastically.

1.7 Energy Efficiency Recommendations Matrix

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

1.7.1 Energy Efficiency Recommendations Matrix

Table 6: High Priority Measures

High Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Replacement of Pumpset at (Nadar Anad (Ravi Town) - Unique ID: 81206105)	21,451	5,245	1,469,684	3,445	965,296	18	11
Replacement of Pumpset at (Mai Khanwali chungi - Unique ID: 81206106)	33,531	5,245	1,469,684	5,385	1,508,899	12	17
Replacement of Pumpset at (Bhalla Chowk - Unique ID: 81206114)	6,397	5,245	1,469,684	1,027	287,874	61	3
Replacement of Pumpset at (Mohallah Dulma Thattha - Unique ID: 81206118)	6,929	5,245	1,469,684	1,113	311,822	57	3
Replacement of Pumpset at (Fazal Deewan No. 2 - Unique ID: 81206119)	11,390	5,245	1,469,684	1,829	512,537	34	6
Replacement of Pumpset at (MC office No. 2 (Park) - Unique ID: 81206122)	19,709	3,794	1,063,000	3,165	886,897	14	10
Replacement/Installation of Capacitors	Not Quantifiable	900	252,180	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	337,520	94,572,972	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	30,903	1,831	512,950	4,963	1,390,634	4	15
Total:	**130,310**	**370,270**	**103,749,521**	**20,928**	**5,863,958**		**65**

Table 7: Medium Priority Measures

Medium Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Replacement of existing MC operated non efficient streetlights with LEDs	1,226	729	204,244	197	55,188	44	1
Total:	**1,226**	**729**	**204,244**	**197**	**55,188**	**44**	**1**

Table 8: Low Priority Measures

Low Priority Energy Efficiency Measure	Water Savings m^3/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Installation of Flow meters integrated with a centralized DCS system	40,633	30,000	8,406,000	0	0	0	Not Quantifiable
Total:	**40,633**	**30,000**	**8,406,000**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Kamalia MC has fifteen (15) tubewells for groundwater, all of which are manually operated. Out of these, 12 pumpsets were found to be in working condition.

The MC has three (3) disposal station having fifteen (15) pumps. Out of these, 6 pumpsets were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are five (5) dewatering sets in the MC. All of these dewatering sets 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 four (4) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake assessment of the following pumpsets due to non-functional motor and non-availability of electrical supply
   1. Zeeshan Colony (Unique ID: 81206108)
   2. Beron Kamalia (Unique ID: 81207771)

(iv) Undertake assessment of the following pumpset as there was no suitable space available to install ultrasonic flowmeter
   1. MC office No. 1 (Unique ID: 81206121)

(v) Undertake assessment of the following disposal stations due to non-functional motor
   1. Zeeshan Colony (Unique ID: 81200110-B)
   2. Zeeshan Colony (Unique ID: 81200110-D)
   3. Zeeshan Colony (Unique ID: 81200110-E)
   4. Zeeshan Colony (Unique ID: 81200110-F)
   5. Nawaz Sharif Park (Unique ID: 81206104-C)
   6. Islam Pura Chungi No. 6 (Unique ID: 81206115-A)
   7. Islam Pura Chungi No. 6 (Unique ID: 81206115-D)

(vi) Undertake assessment of the following disposal stations due to non-availability of the water in the well
   1. Zeeshan Colony (Unique ID: 81200110-A)
   2. Zeeshan Colony (Unique ID: 81200110-C)

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

2.1 Inventory for water and wastewater pumping equipment

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

2.1.1 Tubewells

Table 9: Inventory of Tubewells/Water Pumps (Potable Water)

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	Year of Motor Manufacturing	Latitude	Longitude
1	81206113	Jhand Shah	27-13371-2523280	Turbine	Flow Pak	2009	Siemens	2009	30.726083	72.638136
2	81206114	Bhalla Chowk	24-13371-5501403	Turbine	KSB	2015	Siemens	2015	30.726315	72.631146
3	81206116	Islam Pura Chungi No. 6	24-13371-5500604	Turbine	KSB	2015	Siemens	2015	30.726786	72.639384
4	81206117	Muhallah Fazal Deewan (Allah Wali Masjid)	24-13371-5501504	Turbine	KSB	2015	Siemens	2015	30.720597	72.647085
5	81206119	Fazal Deewan No. 2	27-13371-2521620	Turbine	HMA	2015	Siemens	2015	30.72362	72.648493
6	81206120	Fazal Deewan No. 1	24-13371-5501503	Turbine	KSB	2015	Siemens	2015	30.723188	72.648909
7	81206121	MC office No. 1	21-13371-1341302	Turbine	Ittefaq Pumps	2010	Siemens	2010	30.724942	72.648757
8	81206122	MC office No. 2 (Park)	27-13371-2522120	Turbine	KSB	2010	Siemens	2010	30.725533	72.649473
9	81206105	Nadar Anad (Ravi Town)	24-13371-5501703	Turbine	KSB	2015	Siemens	2015	30.729168	72.661932
10	81206106	Mai Khanwali chungi	24-13371-5500204	Turbine	KSB	2015	Siemens	2015	30.735599	72.649949
11	81206118	Mohallah Dulma Thattha	24-13371-5500406	Turbine	KSB	2015	Siemens	2015	30.717783	72.658648
12	81206108	Zeeshan Colony	No-Meter	Turbine	Flowpak	2008	Siemens	2008	30.737243	72.644922
13	81206109	Zeeshan Colony OHR	27-13371-2522280	Turbine	Flow Pak	2009	Siemens	2009	30.737093	72.644465
14	81207771	Beloon Kamalia	No-Meter	Turbine	KSB	2021	Siemens	2021	30.737898	72.630033
15	81206112	Bahlol wala	24-13371-5501303	Turbine	KSB	2015	Siemens	2015	30.73136	72.63966

2.1.2 Disposal Works

Table 10: Inventory Table of Disposal Works

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Pump Capacity (Cusec)	Motor Manufacturer	Motor Capacity (HP)	Latitude	Longitude
1	81206104-A	Nawaz Sharif Park	24-13371-5500405	Centrifugal	KSB	5	Siemens	60	30.712282	72.674769
2	81206104-B	Nawaz Sharif Park	24-13371-5500405	Centrifugal	KSB	5	Siemens	60	30.712282	72.674769
3	81206104-C	Nawaz Sharif Park	24-13371-5500405	Centrifugal	KSB	5	Siemens	N/A	30.712282	72.674769
4	81206104-D	Nawaz Sharif Park	24-13371-5500405	Centrifugal	KSB	5	Siemens	N/A	30.712282	72.674769
5	81200110-A	Zeeshan Colony	27-13371-2522420	Centrifugal	KSB	5	Siemens	60	30.712282	72.674769
6	81200110-B	Zeeshan Colony	27-13371-2522420	Centrifugal	KSB	5	Siemens	60	30.712282	72.674769
7	81200110-C	Zeeshan Colony	27-13371-2522420	Centrifugal	KSB	5	Siemens	N/A	30.712282	72.674769
8	81200110-D	Zeeshan Colony	27-13371-2522420	Centrifugal	KSB	5	Siemens	N/A	30.712282	72.674769
9	81200110-E	Zeeshan Colony	27-13371-2522420	Centrifugal	Beco	2	Beco Newman	25	30.737915	72.642078
10	81200110-F	Zeeshan Colony	27-13371-2522420	Centrifugal	KSB	4	Siemens	40	30.737915	72.642078
11	81206115-A	Islam Pura Chungi No. 6	24-13371-5501500 24-13371-5501502	Centrifugal	KSB	4	Siemens	40	30.737915	72.642078

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Pump Capacity (Cusec)	Motor Manufacturer	Motor Capacity (HP)	Latitude	Longitude
12	81206115-B	Islam Pura Chungi No. 6	24-13371-5501500 24-13371-5501502	Submersible	KSB	1	KSB	10	30.737915	72.642078
13	81206115-C	Islam Pura Chungi No. 6	24-13371-5501500 24-13371-5501502	Submersible	KSB	1	KSB	10	30.737915	72.642078
14	81206115-D	Islam Pura Chungi No. 6	24-13371-5501500 24-13371-5501502	Centrifugal	KSB	5	Siemens	50	30.737915	72.642078
15	81206115-E	Islam Pura Chungi No. 6	24-13371-5501500 24-13371-5501502	Centrifugal	KSB	5	Siemens	73.7	30.72003	72.636999

2.1.3 Dewatering Sets

NTable 11: Inventory of Dewatering Sets

Sr. No.	Unique ID	Location	Quantity	Latitude	Longitude
1	51706247 A	MC Building	2	30.725419	72.648650
2	51706247 B	Near Jamia Masjid Al-Noor, Pirshah	1	30.729653	72.645561
3	51706247 C	Railway road	1	30.728628	72.633164
4	51706247 D	Near City Hospital	1	30.724628	72.634628

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

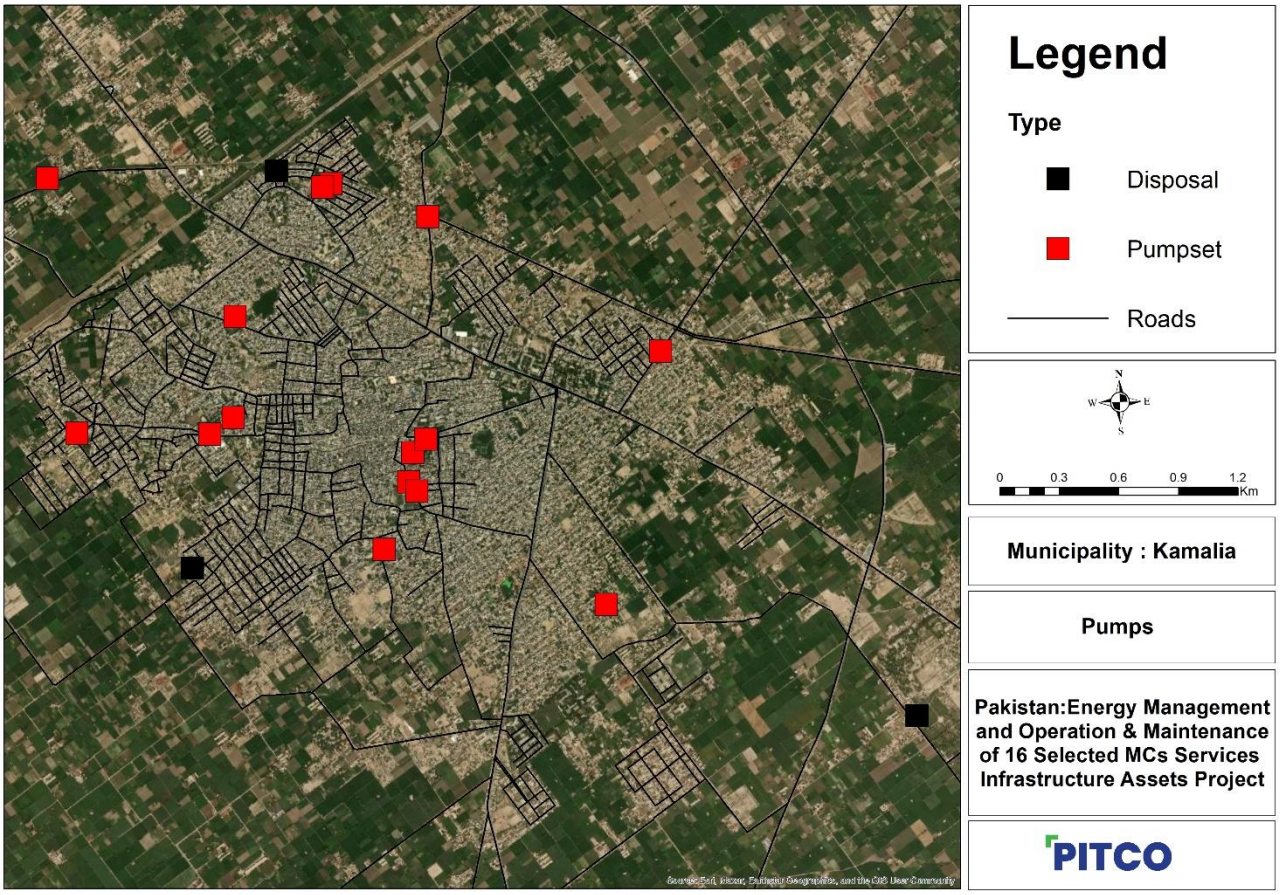


Figure 1: Map for Pumps and Disposal at MC Kamalia

2.3 Baseline Energy Consumption Trend

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

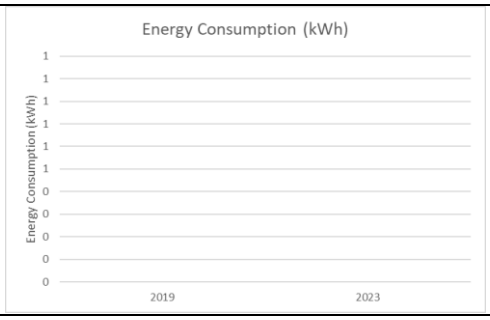
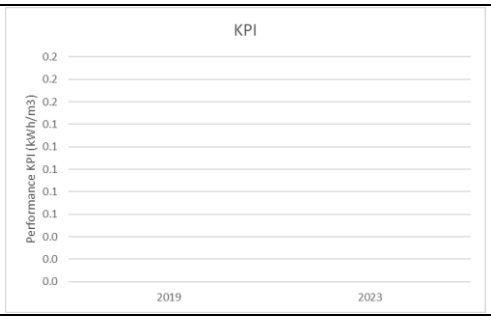
Table 12: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	583,734
Electrical energy used by Wastewater Disposal	kWh/y	356,246
Electrical energy used (Total)	kWh/y	939,980

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)	13	13	798,248	583,734	214,514	0.16 kWh/m3	0.17 kWh/m3	Replacement of 7 Pumpsets was recommended based on the assessment carried out in 2019. The MC has not undertaken replacement of any proposed pumpsets by the Consultant however, MC has installed 1 pumpset at a new place. It should be noted that the newly installed pumpset was found non-operational during the current audit. Although, the overall energy consumption of the water supply has reduced, the energy consumption per cubic meter of water supply has increased.
2	Wastewater Disposal	6	6	401,943	356,246	45,697	0.06 kWh/m3	0.05 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. However, the Consultant had recommended the MC to undertake repair and maintenance of its existing assets. As seen from the KPI, the overall energy consumption per cubic meter of wastewater disposed has decreased.

Replacement of 7 Pumpsets was recommended based on the assessment carried out in 2019. The MC has not undertaken replacement of any proposed pumpsets by the Consultant however, MC has installed 1 pumpset at a new place. A discussion on each newly installed asset is presented below:

Beron Kamalia - Unique ID (81207771)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
N/A	0 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	N/A
	
Comments:	
New pumpset has been installed at this site. No KPI and billing calculations have been presented for the 2023 audit, as this pumpset was found non-operational during the current audit and MC is not currently receiving the bills against this connection. There was no baseline data for the previous audit as this pumpset has been installed at a new site.	

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.

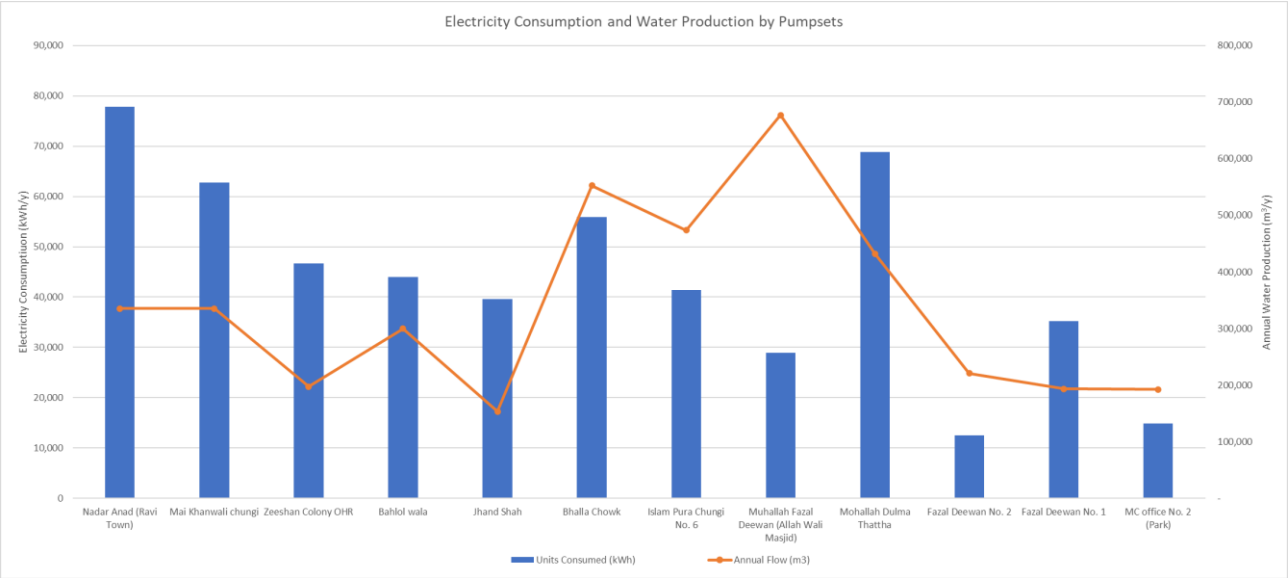
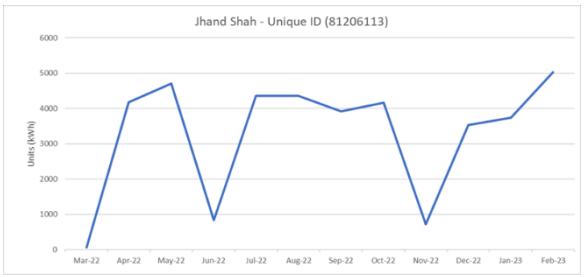


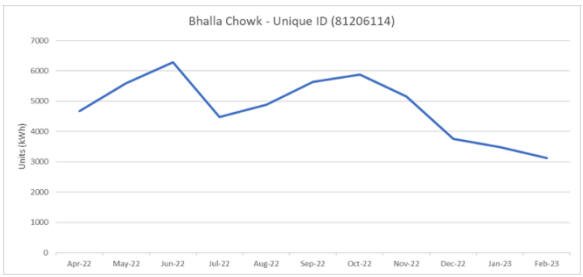
Figure 2: Electricity Consumption and Water Production by Pumpsets

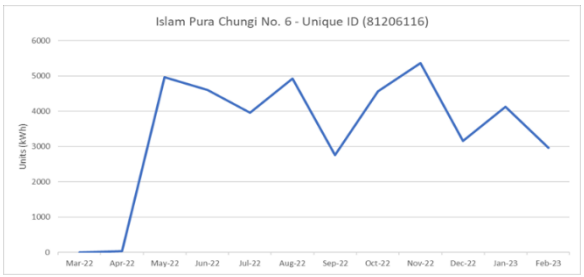
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

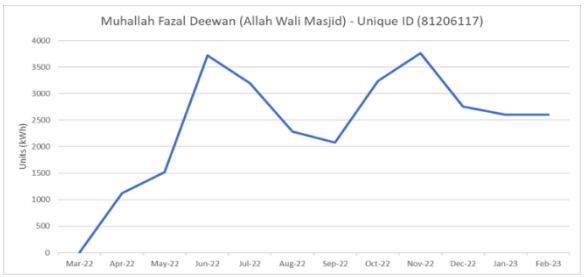
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

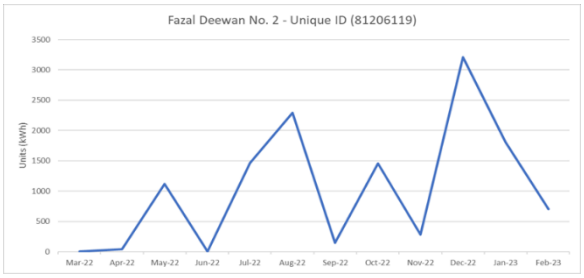
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

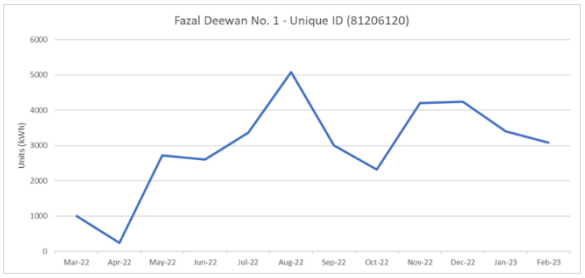


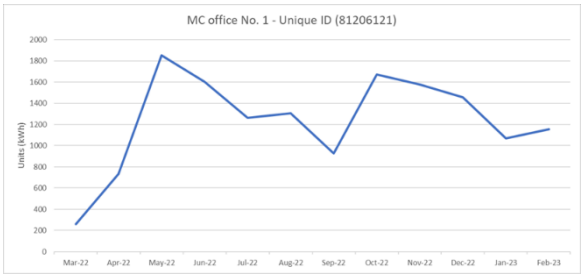


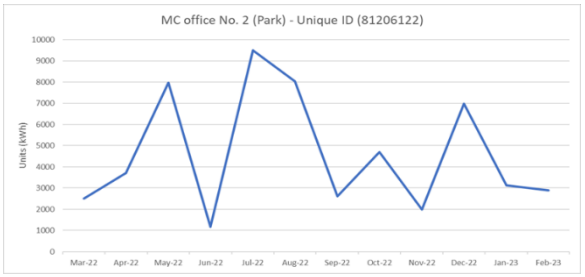


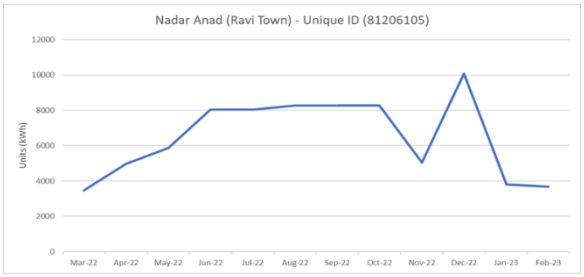


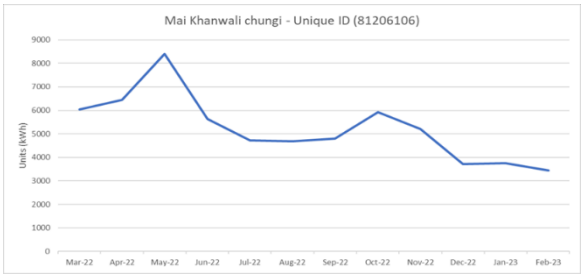


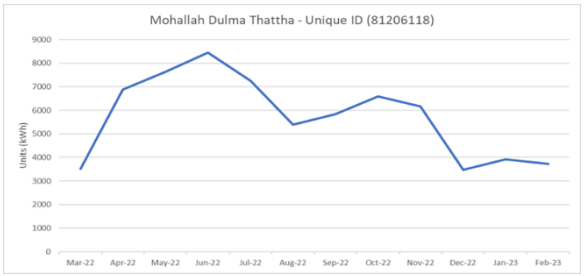


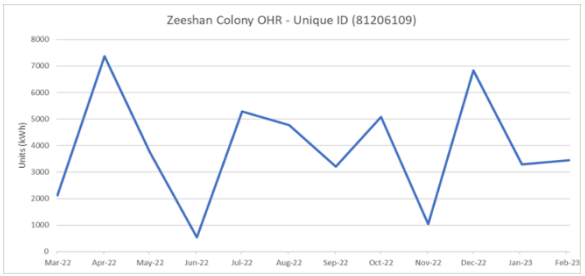












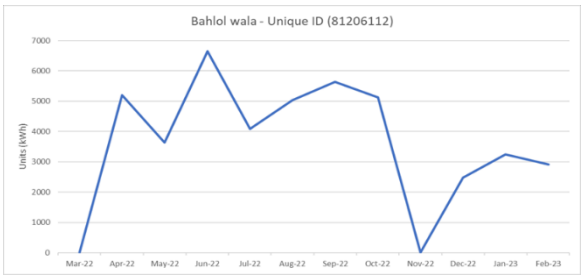
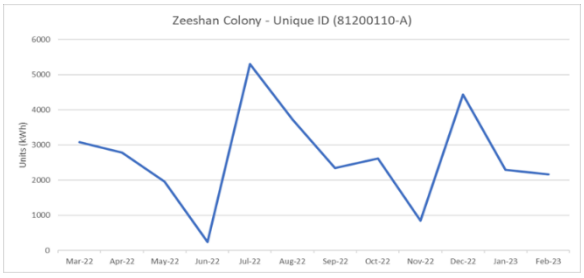
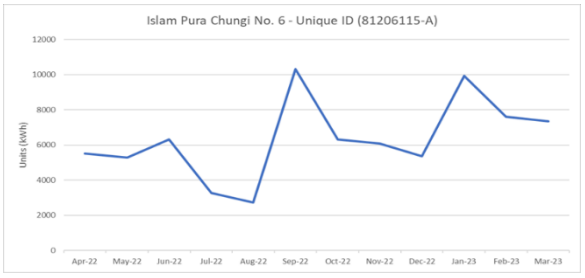


Figure 3: Energy Consumption Trend for Water Pumps





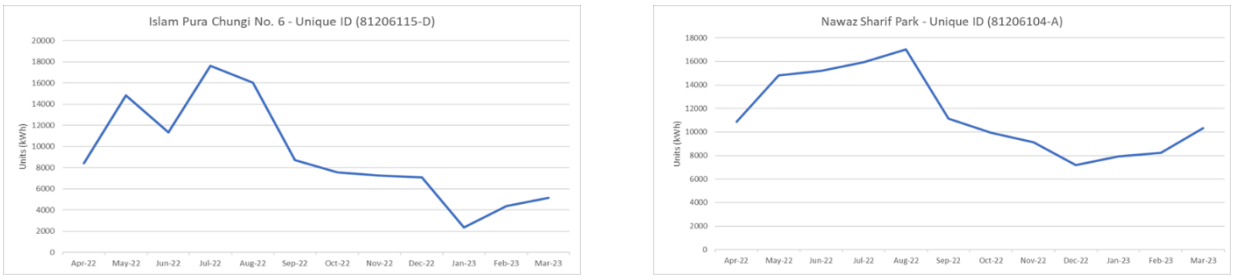


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Kamalia MC has fifteen (15) tubewells for groundwater, all of which are manually operated. Out of these, 12 pumpsets were found to be in working condition.

Performance evaluation of pumpsets could be carried out at only 12 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	81206105	Nadar Anad (Ravi Town)	Yes	Yes
2	81206106	Mai Khanwali chungi	Yes	Yes
3	81206108	Zeeshan Colony	Yes	No
4	81206109	Zeeshan Colony OHR	Yes	Yes
5	81206112	Bahlol wala	Yes	Yes
6	81206113	Jhand Shah	Yes	Yes
7	81206114	Bhalla Chowk	Yes	Yes
8	81206116	Islam Pura Chungi No. 6	Yes	Yes
9	81206117	Muhallah Fazal Deewan (Allah Wali Masjid)	Yes	Yes
10	81206118	Mohallah Dulma Thattha	Yes	Yes
11	81206119	Fazal Deewan No. 2	Yes	Yes
12	81206120	Fazal Deewan No. 1	Yes	Yes
13	81206122	MC office No. 2 (Park)	Yes	Yes
14	81206121	MC office No. 1	Yes	No
15	81207771	Beron Kamalia	Yes	No

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	81206105	Nadar Anad (Ravi Town)	203.9	203.2	28.83	40.87	46%	0.89	Efficiency of the pumpset is unsatisfactory. Previously, it was recommended to replace the pumpset due to lower efficiency of 44%.
2	81206106	Mai Khanwali chungi	203.9	203.3	28.98	48.20	39%	0.88	Efficiency of the pumpset is unsatisfactory. Previously, it was recommended to replace the pumpset due to lower efficiency of 44%.
3	81206109	Zeeshan Colony OHR	101.9	149.6	38.30	34.50	53%	0.81	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 56%.
4	81206112	Bahlol wala	203.9	227.1	39.10	50.50	56%	0.80	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 53%.
5	81206113	Jhand Shah	101.9	155.1	26.05	23.70	55%	0.98	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 53%.
6	81206114	Bhalla Chowk	203.9	334.8	19.97	49.80	43%	0.82	Efficiency of the pumpset is unsatisfactory. Previously, the efficiency of the pumpset was 48%.
7	81206116	Islam Pura Chungi No. 6	203.9	287.1	31.13	49.40	58%	0.84	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 57%.
8	81206117	Muhallah Fazal Deewan (Allah Wali Masjid)	203.9	342.0	25.79	50.60	56%	0.81	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 53%.
9	81206118	Mohallah Dulma Thattha	203.9	327.2	18.45	50.13	39%	0.91	Efficiency of the pumpset is unsatisfactory. Previously, the efficiency of the pumpset was 43%.
10	81206119	Fazal Deewan No. 2	203.9	133.9	22.41	25.27	38%	1.00	Efficiency of the pumpset is unsatisfactory. Previously, the efficiency of the pumpset was 48%.
11	81206120	Fazal Deewan No. 1	203.9	292.8	32.04	50.27	60%	0.85	Efficiency of the pumpset is satisfactory.
12	81206122	MC office No. 2 (Park)	101.9	116.6	25.93	27.30	35%	0.83	Efficiency of the pumpset is unsatisfactory. Previously, the efficiency of the pumpset was 27%.

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	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
81206105	83.04	31	60	-	100	Safe	ok	210	380	0.85	0.89	69%	
81206106	60.13	32	60	-	100	Safe	ok	210	380	0.85	0.88	81%	
81206109	N/A	50	37	-	50	Safe	ok	230	-	-	0.81	93%	
81206112	159.15	38	60	-	100	-	ok	210	380	0.85	0.80	85%	
81206113	N/A	36	37	-	50	Safe	Not ok	-	380	0.85	0.98	64%	
81206114	N/A	39	60	-	100	Safe	ok	210	380	0.85	0.82	83%	
81206116	N/A	42	60	-	100	Safe	Not ok	210	380	0.85	0.84	83%	
81206117	N/A	42	60	-	100	Safe	ok	210	380	0.85	0.81	85%	
81206118	116.14	32	60	-	100	Safe	ok	210	380	0.85	0.91	84%	
81206119	102.10	36	37	-	100	Safe	ok	-	380	0.85	0.99	68%	
81206120	113.85	38	60	-	100	Safe	ok	210	380	0.85	0.85	84%	
81206122	198.29	40	37	-	50	Safe	ok	230	380	0.85	0.83	73%	

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	81206105	Nadar Anad (Ravi Town)	204	59.656	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	203.169	28.8	Flow at Existing Operating Conditions is nearest to duty point	40.87	46%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
2	81206106	Mai Khanwali chungi	204	59.656	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	203.257	29.0	Flow at Existing Operating Conditions is nearest to duty point	48.20	39%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
3	81206113	Jhand Shah	102	37.285	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	155.05	26.0	Flow at Existing Operating Conditions	23.70	55%
2	139.37	29.6	Flow nearest to duty point	22.80	58%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
4	81206116	Islam Pura Chungi No. 6	204	59.656

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	287.1	31.1	Flow at Existing Operating Conditions	49.40	58%
2	241.29	34.6	Flow nearest to duty point	43.80	61%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
5	81206117	Muhallah Fazal Deewan (Allah Wali Masjid)	204	59.656

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	342	25.8	Flow at Existing Operating Conditions	50.60	56%
2	304.33	30.0	Flow nearest to duty point	49.80	59%

1

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
6	81206118	Mohallah Dulma Thattha	204	59.656

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	327.244	18.5	Flow at Existing Operating Conditions	50.13	39%
2	205.649	32.5	Flow nearest to duty point	49.43	43%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
7	81206120	Fazal Deewan No. 1	204	59.656

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	292.844	32.0	Flow at Existing Operating Conditions	50.27	60%
2	205.827	46.1	Flow nearest to duty point	47.60	64%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
8	81206122	MC office No. 2 (Park)	102	37.285

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	116.595	25.9	Flow at Existing Operating Conditions	27.30	35%
2	102.183	33.0	Flow nearest to duty point	28.03	39%

2.4.3 Wastewater Disposal System

The MC has three (3) disposal station having fifteen (15) 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	81206104-A	Nawaz Sharif Park	509.7	288.4	6.71	15.50	40%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 56%.
2	81206104-B	Nawaz Sharif Park	509.7	504.5	6.71	20.90	52%	Efficiency of the pumpset is satisfactory. Previously, pumpset was non-functional.
3	81206104-D	Nawaz Sharif Park	509.7	353.8	6.71	15.10	50%	Efficiency of the pumpset is satisfactory. Previously, pumpset was non-functional.
4	81206115-B	Islam Pura Chungi No. 6	509.7	695.4	8.53	33.90	56%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 51%.
5	81206115-C	Islam Pura Chungi No. 6	509.7	694.9	8.53	33.20	57%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 40%.
6	81206115-E	Islam Pura Chungi No. 6	509.7	532.7	8.53	26.00	56%	Efficiency of the pumpset is satisfactory. Previously, pumpset was non-functional.



Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are five (5) dewatering sets in the MC. All of these dewatering sets 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	81206105	Nadar Anad (Ravi Town)	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
2	81206106	Mai Khanwali chungi	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
3	81206114	Bhalla Chowk	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
4	81206118	Mohallah Dulma Thattha	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
5	81206119	Fazal Deewan No. 2	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
6	81206122	MC office No. 2 (Park)	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
7	81206104-A	Nawaz Sharif Park	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
8	81206104-B	Nawaz Sharif Park	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
9	81206104-D	Nawaz Sharif Park	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
10	81206115-B	Islam Pura Chungi No. 6	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
11	81206115-C	Islam Pura Chungi No. 6	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
12	81206115-E	Islam Pura Chungi No. 6	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
General Observations				
13	General	Smart Metering	No flow meters were installed at any of the tubewells.	Smart flow meters connected to a centralized DCS system needs to be installed to calculate the total water drawn by each pump and to monitor flow and water loss due to leakages. This can also help with water billing if the Government of Punjab intends to do so in future
14	General	Operating Time	Pumps should not be run during Peak electricity consumption hours.	Operational hours of pump should be scheduled keeping in mind the varying peak hours across the year to avoid peak charges. Peak hours for FESCO during the entire year are given in Annexure 1.
15	General	Dewatering Sets	Dewatering sets were in satisfactory condition, but no O&M logs were available with the MC	It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of

Sr No.	Unique ID	Location	Comments	Recommendation
				operation and other maintenance details on a regular basis.
16	General	Water Supply Network	Proper O&M of Air Release Valves	Air release valves installed on the network should be properly maintained.

3 Streetlights

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

3.1 Inventory

Surveyors conducted onsite surveys at Kamalia 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	128	128	-
Non-Operational Street Lights	1,852	1,852	-
Total	**1,980**	**1,980**	**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 total 1,980 streetlights operated by MC, 554 fixtures are installed on PC, 1313 fixtures are installed on steel structure, and 113 fixtures are installed on wires. The streetlight's structural classification is tabulated below.

Table 20: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Wire	Grand Total
MC	554	1,313	113	**1,980**
Private	-	-	-	**0**

Streetlights of Kamalia 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 Kamalia are shown in table below.

Table 21: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Street Line Saddar Office Muhallah Peer Shah Street Line Lari Adda Street Line Pakistan Chowk Street Line Ara Stop No. 3	1168	24-13371-5501600	35.353
2	Street Line Kothi Bahadur Chand Street Line Eid Gah Road Chowk	502	24-13371-5501601	16.336
3	Zeeshan Colony	185	27-13371-2522280	4.954
4	Disposal Works Near Nawaz Sharif Park	15	24-13371-5500405	0.604
5	Nawaz Sharif Park	57	04-13371-0424601	2.153
6	Lady Park	19	27-13371-2523231	1.773
7	Fazil Deewan Park	34	24-13371-5501503	0.839

Out of the 1,980 surveyed lights in the MC, 128 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	12	5		12.0	263	0
LED	18	4		12.0	315	0
LED	25	2		12.0	219	0
LED	120	113		12.0	59,393	0
ILB	100	4		12.0	1,752	0
Total					**61,942**	**0**

Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

[5] Based on Interview with Client.

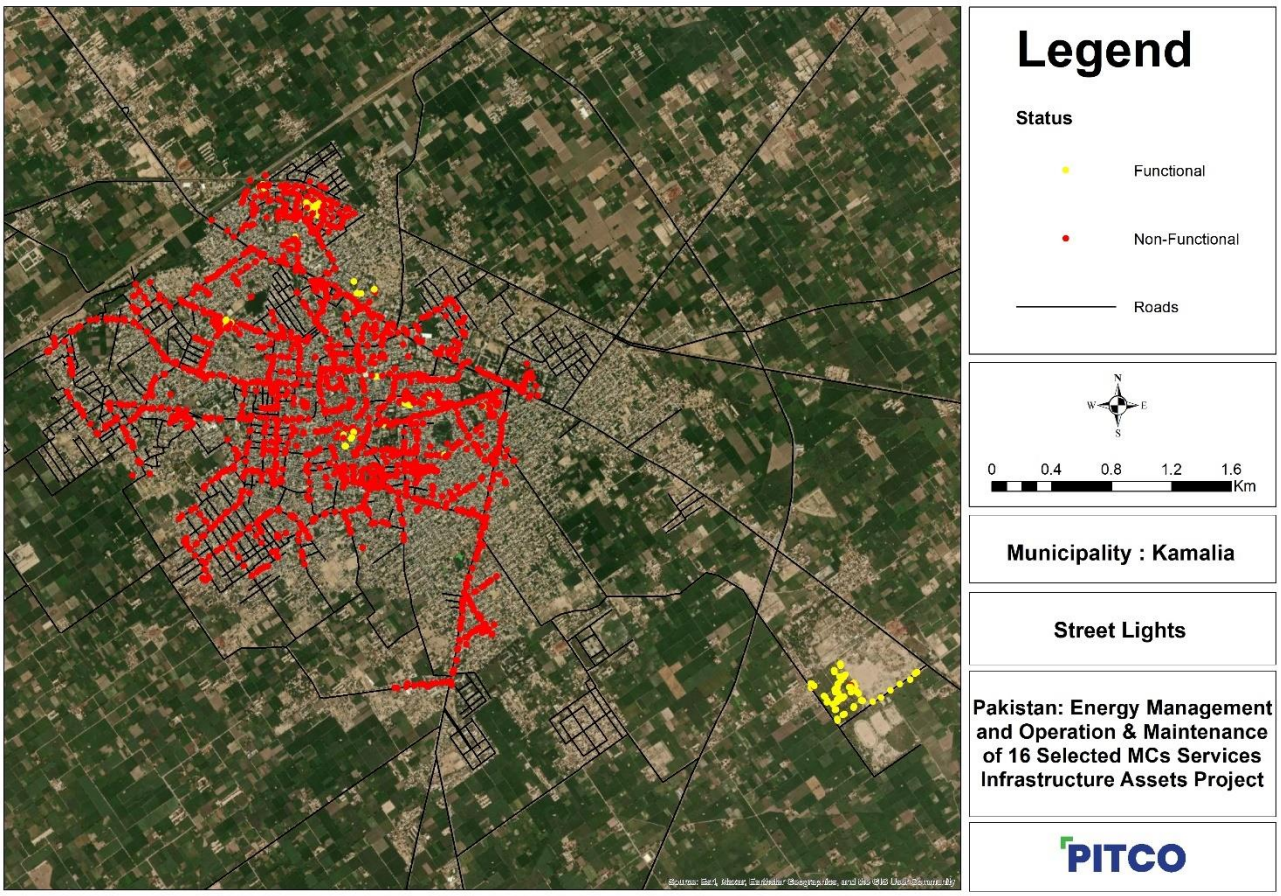


Figure 9: GIS Mapping of street lights in Kamalia MC

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	**10,926**[6]
Total number of operational lights	No.	**128**

[6] Based on electricity bills

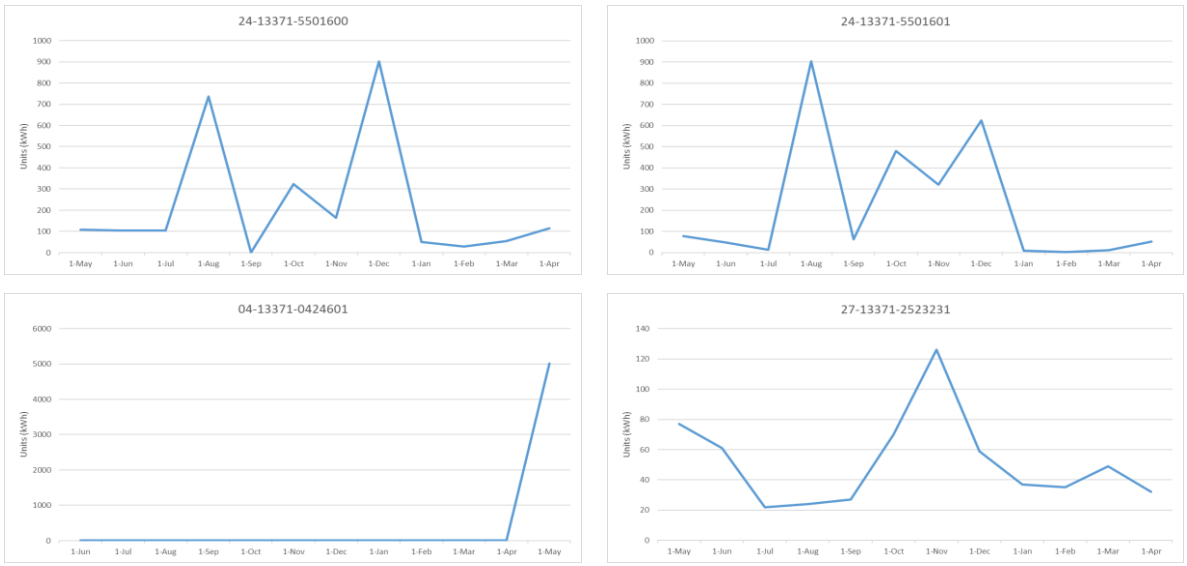


Figure 10: Energy Consumption trend of Streetlights

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	148	128	318,671	10,926	307,745	7,509 kWh/km	176 kWh/km	Based on the previous assessment, there were only 148 MC owned operational lights with an average consumption of 2,153kWh/light/annum, whereas, currently there are 128 operational lights with average energy consumption of 85kWh/light/annum. The energy consumption per light fixture of MC has reduced drastically.

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 Kamalia.

3.5 Observations

- Streetlights in Kamalia MC are operated by MC.
- Most of the operational streetlights are LEDs.
- Approximately 91% of the LED streetlights have a rating of more than 120 Watts.
- Kamalia 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 Kamalia are MC operated • Most of the operational streetlights are LEDs	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	Kamalia 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 Kamalia 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	Jeep Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386648	PK491318	796
2	Unregistered Vehicle 2	Jeep Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386192	Pk490850	796
3	Unregistered Vehicle 3	Jeep Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386401	PK491075	796
4	Unregistered Vehicle 4	Jeep Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386646	491322	796
5	Unregistered Vehicle 5	Jeep Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386313	PK490969	796
6	Unregistered Vehicle 6	Truck Compactor	Isuzu	NPR-130	2022	4WD	Transport of Solid Waste	4HG1-ONF-708	JAANPR71KN-7100993	4570
7	Unregistered Vehicle 7	Truck Compactor	Isuzu	NPR-130	2022	4WD	Transport of Solid Waste	4HG1-ONF-723	JAANPR71KN-7100995	4570
8	Unregistered Vehicle 8	Truck Dumper	Isuzu	FVR-210	2022	4WD	No Task Assigned	4HK1-OMJ-922	JALFVR90MN700059	5193
9	Unregistered Vehicle 9	Truck	Isuzu	NPR-130	2022	4WD	No Task Assigned	ONF-699	JAANPR71KN-7100992	4570
10	Unregistered Vehicle 10	Truck Sucker & Jetting Machine	Isuzu	NPR-130	2022	4WD	No Task Assigned	ONF-717	JAANPR71KN-7100994	4570
11	Unregistered Vehicle 11	Truck	Hino	N/A	2022	4WD	Firefighting	03711-2	FB113K-16473	4009
12	TSG 1399	Truck	Hino	Hino-300	2007	4WD	Sucker Machine	4DJM11100	JHFYF20M506000999	4009
13	Unregistered Vehicle 12	Truck	Hino	Hino-300	2011	4WD	Jetting Machine	WO4DJM12817	JHFYF20MX06002571	4009
14	Unregistered Vehicle 13	Tractor Trolley	Fiat	640	2002	2WD	Transport of Solid Waste	36T13011900	26162	75HP
15	Unregistered Vehicle 14	Tractor Trolley	Fiat	640	2002	4WD	Transport of Solid Waste	4812927	26/430/G	75HP
16	Unregistered Vehicle 15	Tractor Trolley	Millat	MF-240	2002	2WD	Transport of Solid Waste	37111640/1	73657	50HP
17	Unregistered Vehicle 16	Tractor Trolley	Millat	MF-240	2020	2WD	Transport of Solid Waste	N/A	44141/08/20	50HP
18	Unregistered Vehicle 17	Tractor	Millat	MF-375	2002	4WD	Front Loader	130111	K71640/11/13	75HP
19	Unregistered Vehicle 18	Tractor	Millat	MF-260	2002	2WD	Front blade	CN99002V516219	J6048321-11	60HP
20	Unregistered Vehicle 19	Tractor	Millat	MF-240	2016	2WD	Grass Cutter	N/A	43039/01/16	50HP
21	Unregistered Vehicle 20	Pickup	Suzuki	Bolan	2022	2WD	Mobile Workshop	PKT1025246	PK01141768	796
22	TSB-9988	Car	Suzuki	Cultus	2001	2WD	Transport of Staff	812072	SF310PK955369	1000
23	Unregistered Vehicle 21	Rickshaw	United	US200	2021	2WD	No Task Assigned	N/A	US-200-07995	200
24	Unregistered Vehicle 22	Rickshaw	United	US200	2021	2WD	No Task Assigned	N/A	US-200-08161	200
25	Unregistered Vehicle 23	Rickshaw	United	US200	2021	2WD	No Task Assigned	N/A	US-200-08163	200
26	Unregistered Vehicle 24	Rickshaw	United	US200	2021	2WD	No Task Assigned	N/A	US-200-08102	200
27	Unregistered Vehicle 25	Rickshaw	United	US200	2021	2WD	No Task Assigned	N/A	US-200-08101	200

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 1	4:20 PM	5:20 PM	0.54	0.54 Liters/hr	2:30 PM	4:20 PM	26	5.47	0.21 Liters/km
2	Unregistered Vehicle 6	4:32 PM	5:32 PM	2.51	2.51 Liters/hr	2:36 PM	4:32 PM	44	10	0.23 Liters/km
3	Unregistered Vehicle 12	1:05 PM	2:05 PM	1.84	1.84 Liters/hr	11:50 AM	1:05 PM		12.25	9.8 Liters/hr
4	Unregistered Vehicle 14	12:55 PM	1:55 PM	1.57	1.57 Liters/hr	11:05 AM	12:55 PM		4.2	2.29 Liters/hr
5	Unregistered Vehicle 15	11:35 AM	12:35 PM	0.71	0.71 Liters/hr	10:00 AM	11:35 AM		3.68	2.32 Liters/hr
6	Unregistered Vehicle 17	12:10 PM	1:10 PM	0.99	0.99 Liters/hr	11:10 AM	12:10 PM		3.69	3.69 Liters/hr
7	Unregistered Vehicle 18	12:35 PM	1:35 PM	1.04	1.04 Liters/hr	11:30 AM	12:35 PM		3.69	3.41 Liters/hr

Table 27: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	TSG 1399	5.00
2	Unregistered Vehicle 12	6.0
3	Unregistered Vehicle 13	5.5
4	Unregistered Vehicle 14	5.5
5	Unregistered Vehicle 15	4.5
6	Unregistered Vehicle 16	4.5
7	Unregistered Vehicle 17	6.5
8	Unregistered Vehicle 18	5.0

The logbooks of remaining vehicles are not available in MC.

The MC made 7 of its vehicles available to the Consultant for carrying out on-field testing. The average fuel consumption of the vehicles in idle condition was found to be 1.31 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 4.302 liters/hour and 0.22 liter/km (for two vehicles in which the odometer was working).

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	32,508
Annual Cost of Fuel (Diesel)	PKR/y	9,524,844
Annual Consumption of Fuel (Petrol)	Liter/y	0
Annual Cost of Fuel (Petrol)	PKR/y	0

4.3 Maintenance Log of Vehicles

No record was available for the maintenance and repairing (if any) of the vehicles that are in use of the MC. Purchase record of newly bought vehicle is available with MC. Pictures of some of the vehicles owned by Kamalia 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 Kamalia 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 6 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.

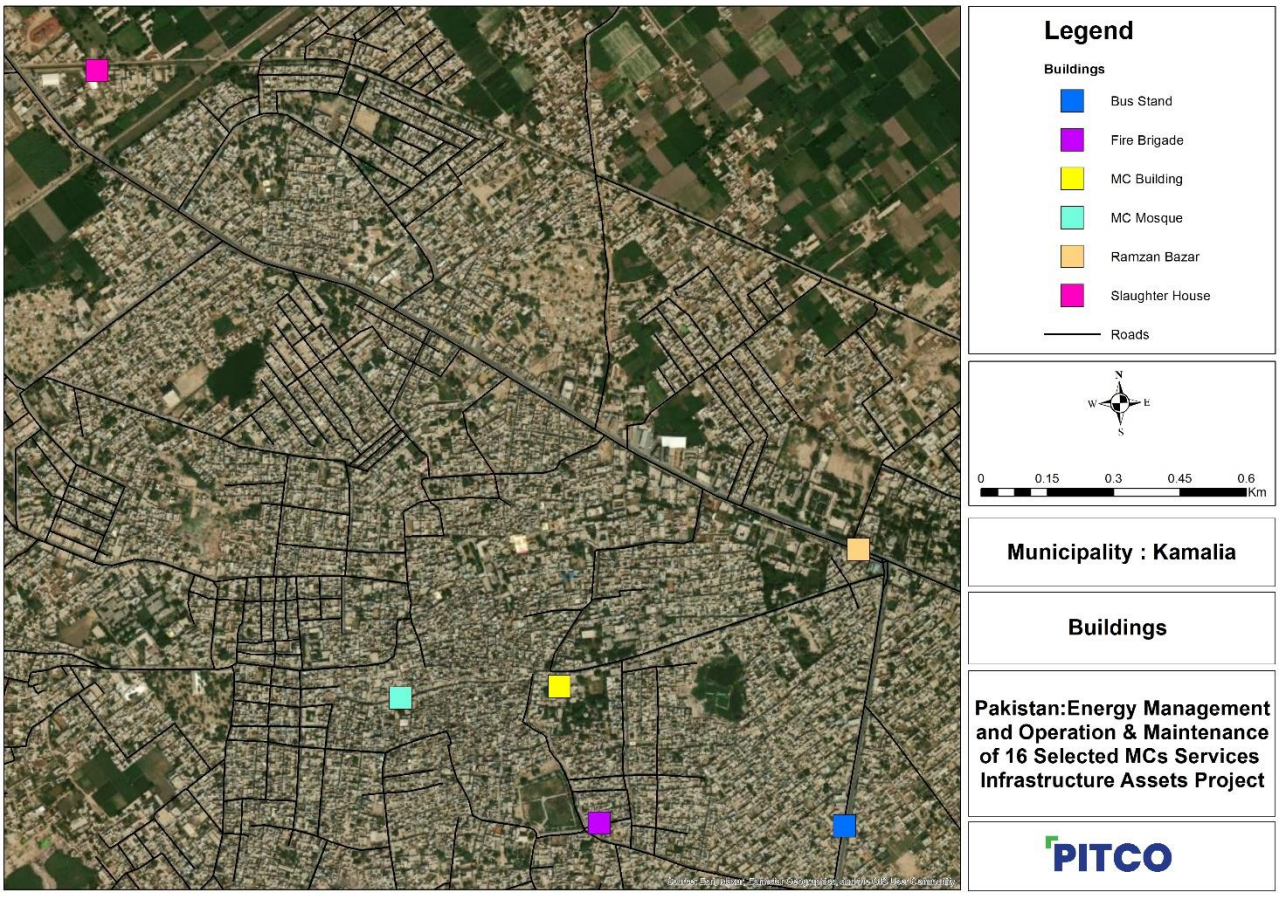


Figure 12: Map for Buildings

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	Bus Stand	N:30.722333 E:72.655254	81206123-2	MC	N/A	Satisfactory	2,001	No Proper Insulation	1
2	Slaughter House	N:30.738176 E:72.638216	81206111	MC	38	Satisfactory	502	No Proper Insulation	1
3	Fire Brigade	N:30.7225533 E:72.649473	51406245	MC	N/A	Satisfactory	152	No Proper Insulation	1
4	Ramzan Bazar	N:30.727942 E:72.655787	81206123-1	MC	N/A	Satisfactory	251	No Proper Insulation	1
5	MC Mosque	N:30.725221 E:72.6448864	51406244	MC	22	Satisfactory	506	No Proper Insulation	1
6	MC Building	N:30.725354 E:72.648636	81206123	MC	32	Satisfactory	13,100	No Proper Insulation	1

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

Table 30: Number of Heating Units in MC Buildings

Sr. No.	Name of Room	Type of Heating Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Energy consumption (kWh/year)
MC Building								
1	**Administration office**	Geyser	1	2000	4	4	104	832
	Total							**832**

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

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Bus Stand								
1	**Room 1**	Ceiling Fan	2	80	2	8	208	67
2	**Room 2**	Ceiling Fan	1	80	2	8	208	33
3	**Washroom**	Ceiling Fan	1	80	2	8	208	33
1	**Office**	Ceiling Fan	1	80	14	8	208	233
Ramzan Bazar								
1	**Counter 1**	Ceiling Fan	1	80	10	8	208	166
2	**Counter 3**	Ceiling Fan	1	80	10	8	208	166
3	**Counter 6**	Ceiling Fan	1	80	10	8	208	166
4	**Counter 7**	Ceiling Fan	1	80	10	8	208	166
5	**Counter 10**	Pedestal Fan	1	125	10	8	208	260
MC Mosque								
1	**Main Hall**	Ceiling Fan	9	80	4	8	208	599
2	**Main Hall**	Air Cooler	2	125	3	6	156	117
3	**Main Hall**	Bracket Fan	1	50	4	8	208	42
4	**Outside**	Ceiling Fan	5	80	5	8	208	416
1	**Administrative office**	Ceiling Fan	4	80	4	8	208	266
2	**Administrative office**	Inverter	1	1452	3	5	130	566
3	**Administrative office**	Window AC	1	5000	3	5	130	1,950
4	**Administrative Retiring Room**	Bracket Fan	2	50	3	8	208	62
5	**Administrative Retiring Room**	Window AC	1	5,000	2	5	130	1,300
6	**Administrative Retiring Room**	Exhaust Fan	1	30	3	8	208	19
7	**Operator Room**	Ceiling Fan	1	80	7	8	208	116
8	**MOR Office**	Ceiling Fan	1	80	6	8	208	100
9	**MOR Office**	Exhaust Fan	2	30	6	8	208	75
10	**Co-office**	Ceiling Fan	2	80	6	8	208	200
11	**Co-office**	Air Cooler	2	125	2	7	182	91
12	**Co-office**	Exhaust Fan	3	30	6	8	208	112
13	**CO P.A**	Ceiling Fan	1	80	6	8	208	100
14	**CO P.A**	Exhaust Fan	1	30	3	8	208	19
15	**Gallery 1**	Ceiling Fan	2	80	8	8	208	266
16	**Sanitation Branch**	Ceiling Fan	1	80	7	8	208	116
17	**Divorce Branch**	Ceiling Fan	1	80	7	8	208	116
18	**Divorce Branch**	Air Cooler	1	125	6	7	182	137
19	**Water Work Branch**	Ceiling Fan	1	80	7	8	208	116
20	**Water Work Branch**	Air Cooler	1	125	6	7	182	137
21	**Patwari Office**	Ceiling Fan	1	80	7	8	208	116

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
22	**IPI Centre**	Ceiling Fan	2	80	7	8	208	233
23	**Accounts Branch**	Ceiling Fan	2	80	7	8	208	233
24	**Accounts Branch**	Air Cooler	1	125	6	7	182	137
25	**Accounts Branch**	Exhaust Fan	2	30	6	8	208	75
26	**MOF Office**	Ceiling Fan	1	80	6	8	208	100
27	**MOF Office**	Air Cooler	1	125	5	8	208	130
28	**MOF Office**	Exhaust Fan	1	30	6	8	208	37
29	**MOP Office**	Ceiling Fan	1	80	6	8	208	100
30	**MOP Office**	Split AC	1	1650	5	5	130	1,073
31	**Death & Birth Branch**	Ceiling Fan	1	80	7	8	208	116
32	**Death & Birth Branch**	Air Cooler	1	125	6	8	208	156
33	**Death & Birth Branch**	Exhaust Fan	1	30	7	8	208	44
34	**Engineer Wing**	Ceiling Fan	1	80	7	8	208	116
35	**Engineer Wing**	Exhaust Fan	1	30	4	8	208	25
36	**Finance Computer Room**	Ceiling Fan	1	80	8	8	208	133
37	**Assistant Director**	Ceiling Fan	1	80	7	8	208	116
38	**MOI Office**	Ceiling Fan	1	80	7	8	208	116
39	**MOI Office**	Window AC	1	5000	4	5	130	2,600
40	**MOI Office**	Exhaust Fan	1	30	6	8	208	37
41	**Meeting Hall**	Bracket Fan	11	50	2	8	208	229
42	**Meeting Hall**	Pedestal Fan	1	125	1	8	208	26
43	**Election Room**	Pedestal Fan	1	125	6	8	208	156
44	**Gallery 4**	Ceiling Fan	1	80	8	8	208	133
45	**Record Room**	Ceiling Fan	2	80	7	8	208	233
46	**Record Room**	Exhaust Fan	2	30	6	8	208	75
47	**Store**	Ceiling Fan	2	80	2	8	208	67
48	**Store**	Pedestal Fan	1	125	2	8	208	52
49	**Store 2**	Ceiling Fan	2	80	2	8	208	67
50	**Union Office**	Ceiling Fan	2	80	6	8	208	200
51	**Tax Clerk**	Ceiling Fan	2	80	7	8	208	233
52	**Tax Clerk**	Exhaust Fan	1	30	5	8	208	31
	Total							**15,526**

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[9]	Operating days per year	Annual Energy consumption (kWh/year)
Slaughter House							
1	**Hall No. 1**	ILB	5	100	8	312	1,248
2	**Hall No. 1**	LED	2	12	8	312	60
3	**Hall No. 2**	LED	11	12	8	312	329
4	**Washroom**	LED	1	12	4	312	15
5	**Doctor Room**	LED	1	12	8	312	30
Fire Brigade							
1	**Office**	LED	1	18	12	312	67
2	**Outside**	LED	1	18	10	312	56
Ramzan Bazar							
1	**Counter 2**	LED	1	12	10	312	37
2	**Counter 3**	LED	1	12	10	312	37
3	**Counter 6**	LED	1	12	10	312	37
4	**Counter 6**	LED	4	12	10	312	150
5	**Counter 7**	ILB	1	100	10	312	312
6	**Counter 7**	LED	2	12	10	312	75
7	**Counter 10**	ILB	1	100	10	312	312
MC Mosque							
1	**Main Hall**	LED	3	18	5	312	84
2	**Main Hall**	LED	6	12	5	312	112
3	**Outside**	LED	2	12	8	312	60
4	**Outside**	LED	2	120	12	312	899
1	**Administrative office**	LED	5	20	4	312	125
2	**Administrative Retiring Room**	LED	2	18	4	312	45
3	**Administrative Retiring Room**	Tube Light	1	40	4	312	50
4	**Administrative Retiring Room**	LED	2	12	4	312	30
5	**Administrative Retiring Room**	LED	4	18	4	312	90
6	**Operator Room**	ILB	1	100	2	312	62
7	**Operator Room**	Tube Light	2	40	0	312	0
8	**Operator Room**	CFL	3	23	7	312	151
9	**MOR Office**	LED	1	12	6	312	22
10	**MOR Office**	LED	2	18	6	312	67
11	**Co-office**	LED	7	20	6	312	262
12	**Co-office**	LED	2	12	6	312	45
13	**Co P.A**	LED	2	18	8	312	90
14	**Co P.A**	LED	2	20	8	312	100
15	**Gallery 1**	LED	6	18	8	312	270
16	**Sanitation Branch**	ILB	1	100	3	312	94
17	**Sanitation Branch**	LED	3	18	8	312	135

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

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Energy consumption (kWh/year)
18	Divorce Branch	Tube Light	2	40	6	312	150
19	Divorce Branch	CFL	2	23	8	312	115
20	Water Work Branch	LED	1	12	8	312	30
21	Patwari office	CFL	3	23	6	312	129
22	Patwari office	LED	1	18	6	312	34
23	Gallery 2	CFL	2	23	8	312	115
24	Gallery 2	LED	1	18	8	312	45
25	Water House	Tube Light	2	40	0	312	0
26	Water House	CFL	3	23	4	312	86
27	Water House	LED	1	12	4	312	15
28	Water House	LED	1	18	4	312	22
29	IPI Center	CFL	2	23	0	312	0
30	IPI Center	LED	2	18	8	312	90
31	IPI Center	LED	1	12	8	312	30
32	Accounts Branch	LED	2	30	8	312	150
33	Accounts Branch	LED	2	18	8	312	90
34	Accounts Branch	LED	1	12	8	312	30
35	MOF office	Tube Light	1	40	6	312	75
36	MOF office	LED	3	20	7	312	131
37	MOF office	LED	1	18	7	312	39
38	MOP office	LED	4	20	7	312	175
39	MOP office	LED	1	12	4	312	15
40	Death & Divorce Branch	Tube Light	2	40	0	312	0
41	Death & Divorce Branch	CFL	3	23	8	312	172
42	Death & Divorce Branch	LED	1	12	8	312	30
43	Engineering Wing	Tube Light	2	40	0	312	0
44	Engineering Wing	CFL	1	23	8	312	57
45	Engineering Wing	LED	2	18	8	312	90
46	Engineering Wing	LED	1	12	6	312	22
47	Finance Computer Room	LED	5	18	8	312	225
48	Gallery 3	CFL	2	23	8	312	115
49	Assistant Director Audit Accounts	ILB	1	100	2	312	62
50	Assistant Director Audit Accounts	LED	7	18	7	312	275
51	MOI Office	LED	3	18	8	312	135
52	MOI Office	LED	3	12	8	312	90
53	Meeting hall	Tube Light	16	40	2	312	399
54	Meeting hall	CFL	10	23	2	312	144
55	Electrician Room	Tube Light	2	40	0	312	0
56	Electrician Room	LED	1	30	8	312	75
57	Electrician Room	LED	1	18	8	312	45
58	Gallery 4	CFL	1	23	8	312	57
59	Gallery 4	LED	1	18	8	312	45
60	Record Room MOI	LED	5	12	0	312	0

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Energy consumption (kWh/year)
61	**Record Room MOI**	LED	2	18	8	312	90
62	**Record Room MOI**	LED	1	30	8	312	75
63	**Record Room MOI**	LED	2	7	8	312	35
64	**Record Room MOI**	Zero Bulb	1	12	8	312	30
65	**Store**	ILB	1	100	2	312	62
66	**Store 2**	Tube Light	2	40	2	312	50
67	**Union office**	Tube Light	2	40	6	312	150
68	**Outside**	LED	6	120	12	312	2,696
69	**Tax Clerk**	Tube Light	3	40	0	312	0
70	**Tax Clerk**	CFL	1	23	6	312	43
71	**Tax Clerk**	LED	3	18	8	312	135
	Total						**12,528**

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[10]
1	Annual Electricity Consumption	kWh	34,568
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[10] 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	4	6	38,701	34,568	4,133	2.71 kWh/m2	2.42 kWh/m2	General bus stand building and Ramzan Bazar were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these buildings has not been considered in the overall energy consumption and KPI calculations.

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

Table 34: Cooling Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Office	Exhaust Fan	3	0	16
MC Office	Ceiling Fan	36	0	37
MC Office	Air Cooler	8	0	7
MC Office	Split AC	1	0	1
MC Office	Window AC	4	4	3
MC Office	Inverter	-	-	1
MC Office	Pedestal Fan	-	-	3
MC Office	Bracket Fan	14	0	13
Fire Brigade	Ceiling Fan	1	0	1
Mosque	Ceiling Fan	13	0	14
Mosque	Air Cooler	-	-	2
Mosque	Bracket Fan	-	-	1

Table 35: Lighting Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Office	Tube Light	73	73	37
MC Office	LED	97	0	117
MC Office	Incandescent Light Bulb	2	2	4
MC Office	CFL	10	10	33
Fire Brigade	Incandescent Light Bulb	1	1	0
Fire Brigade	LED	-	-	2
Mosque	LED	16	0	13
Slaughter House	Incandescent Light Bulb	17	17	5

Table 36: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh	Comments
MC Office	28,484	27,508	General bus stand building and Ramzan Bazar were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these buildings has not been considered in the overall energy consumption and KPI calculations.
Fire Brigade	703	412	
Mosque	6,164	753	
Slaughter House	3,350	5,895	
Overall	**38,701**	**34,568**	

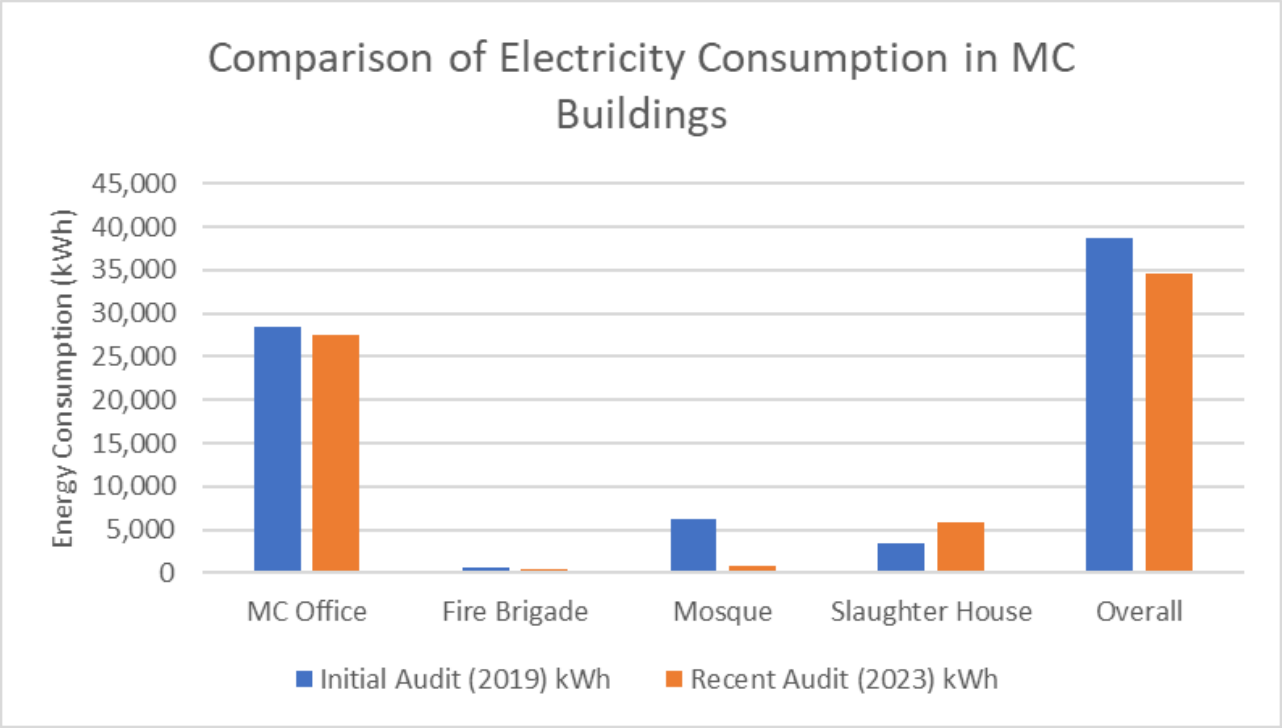


Figure 13:Comparison of Electricity Consumption in MC Buildings

5.4 Maintenance Logs of Buildings

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

6 Solar Assessment for MC Kamalia

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

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

All the MC operated buildings including MC Main Office Building, Bus Stand, Slaughter House, Fire Brigade, Ramzan Bazar and MC Mosque have single phase 220V electrical connection. However, the single-phase connections are not eligible for net metering, therefore, the Consultant has only carried out detailed assessment of single-phase connection that exceeds above 5 kW based on their historical electricity bill. Metering details of each building is presented below.

Table 37: Metering details at MC Kamalia

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Main MC Office Building	81206123	12133711342000 (1ϕ)	3	A-3a (66)
			12133711341200 (1ϕ)	1	A-3a (66
			12133711342200 (1ϕ)	3	A-1a (01)
			21133711341201 (1ϕ)	4	B1 (07)
2	Bus Stand	81206123-2	08133710790302 (1ϕ)	3	A-2a (04)
3	Slaughter House	81206111	08133710785800 (1ϕ)	1	A-3a (66)
4	Fire Brigade	51406245	12133711345000 (1ϕ)	3	A-2a (04)
5	Ramzan Bazar	81206123-1	19133711958700 (1ϕ)	1	A-3a (66)
6	MC Mosque	51406244	12133711341500 (1ϕ)	3	A-1a (01)

6.1 Main MC Office Building

The project site i.e. Main MC Office Building is located near Kamalia, Toba Tek Singh District, Punjab, Pakistan while the geographical co-ordinates of location are 30.725354°N (latitude) and 72.648636°E (longitude).

Figure 14: Front View Of Main MC Office Building

Figure 15: Aerial View of Main MC Office building

6.1.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Main MC Office Building is 27,508 kWh. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 38:Solar System Requirement

Sr. No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	12133711342000	6,776	565	1,157[11]	5
2	12133711341200	10,969	914	1,150[12]	8
3	12133711342200	8,350	696	1,773[13]	6
4	21133711341201	1,413	118	463[14]	1
Total					**20**

Note: Based on the assessment of the historical billings it is identified that the total system requirement of four single-phase electrical connections at this site is **20 kW**. However, it is highly recommended to replace this single-phase connection to three-phase connection before the installation of solar system as estimated by the Consultant.

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Office Building is 141,007 ft^2 whereas, the total area of rooftop available for the solar installation is 12,381 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.

[11] This energy consumption peak is from the month of April, 2022.
[12] This energy consumption peak is from the month of August, 2022.
[13] This energy consumption peak is from the month of July, 2022.
[14] This energy consumption peak is from the month of August, 2022.

Figure 16: Top view of the building section-A

Figure 17: Top view of the building section-B

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

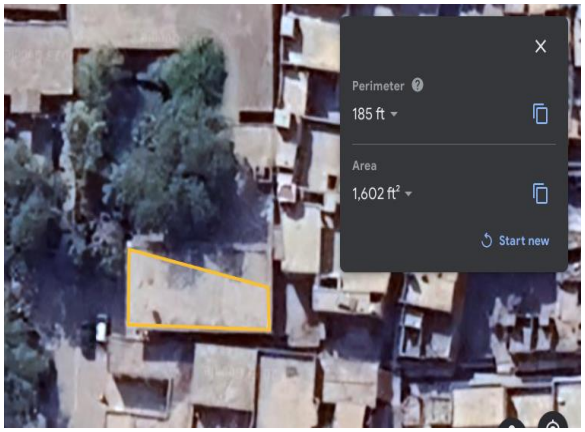


Figure 18: Location for Installation-A

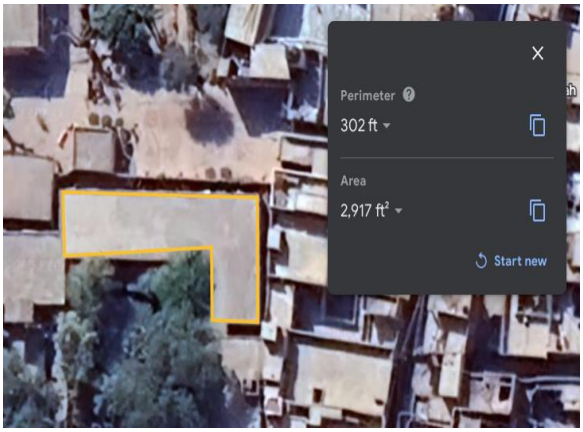


Figure 19: Location for Installation-B

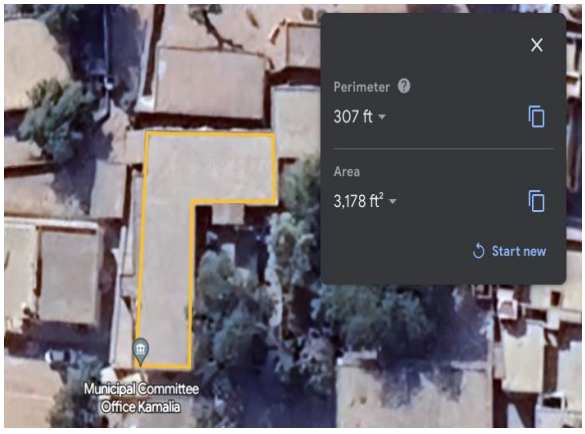


Figure 20: Location for Installation-C

Table 39: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Total
Area availability (ft²)	1,602	2,917	3,178	7,697
Solar system capacity (kW)	16	29	32	77

6.2 Bus Stand

The project site i.e. Bus Stand is located near Kamalia, Toba Tek Singh District, Punjab, Pakistan while the geographical co-ordinates of location are 30.7080277°N (latitude) and 72.6526666°E (longitude).

Figure 21: Front view of the Bus Stand

Figure 22: Aerial view of the Bus Stand

6.2.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption of Bus Stand is 3,102 kWh with the peak electricity consumption of 309 kWh in January 2023. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 40: Solar System Requirement

Sr. No.	Metre Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	08133710790302	3,102	259	309	2

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

6.3 Slaughter House

The project site i.e. Slaughter House is located near Kamalia, Toba Tek Singh District, Punjab, Pakistan while the geographical co-ordinates of location are 30.73789°N (latitude) and 72.62993°E (longitude).

Figure 23: Front view of Slaughterhouse

Figure 24: Aerial view of Slaughterhouse

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 Slaughterhouse is 5,895 kWh with the peak electricity consumption of 802 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 41: Solar System Requirement

Sr. No.	Metre Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	08133710785800	5,895	491	802	4

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

6.4 MC Mosque

The project site i.e. MC Mosque is located near Kamalia, Toba Tek Singh District, Punjab, Pakistan while the geographical co-ordinates of location are 30.72528°N (latitude) and 72.64904°E (longitude).

Figure 25: Aerial View of MC Mosque

6.4.1 Solar System Requirement

Based on the analysis of energy bills from June 2022 to May2023, it is identified that the annual energy consumption of MC Mosque is 753 kWh with the peak electricity consumption of 123 kWh in August 2023. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 42: Solar System Requirement

Sr. No.	Metre Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	12133711341500	753	63	123	1

Note: Based on the analysis of the historical billings it is identified that the system requirement for this site is **1 kW** with a single-phase connection furthermore as building is connected to the national grid through a single-phase electricity connection, it is not recommended to install the solar system at this site.

6.5 Ramzan Bazar

The project site i.e. Ramzan Bazar is located near Katchery Road, Kamalia, Toba Tek Singh District, Punjab, Pakistan while the geographical co-ordinates of location are 30.72763889°N (latitude) and 72.65627778°E (longitude).

Figure 26: Front view of Ramzan Bazar

Figure 27: Aerial view of Ramzan Bazar

6.5.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Ramzan Bazar is 4,384 kWh with the peak electricity consumption of 978 kWh in April 2023. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 43: Solar System Requirement

Sr. No.	Metre Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	19133711958700	4,384	365	978	3

Note: Based on the analysis of the historical billings it is identified that the system requirement for this site is **3 kW** with a single-phase connection furthermore as building is connected to the national grid through a single-phase electricity connection, it is not recommended to install the solar system at this site.

6.6 Fire Brigade

The project site i.e. Fire Brigade is located Kamalia, Toba Tek Singh District, Punjab, Pakistan while the geographical co-ordinates of location are 30.72494444°N (latitude) and 72.64919444°E (longitude).

Figure 28: Aerial view of Fire Brigade

6.6.1 Solar System Requirement

Based on the analysis of energy bills from June 2022 to May 2023, it is identified that the annual energy consumption of Fire Brigade is 412 kWh with the peak electricity consumption of 66 kWh in May 2023. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 44: Solar System Requirement

Sr. No.	Metre Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	12133711345000	412	34	66	1

Note: Based on the analysis of the historical billings it is identified that the system requirement for this site is **1 kW** with a single-phase connection furthermore as building is connected to the national grid through a single-phase electricity connection, it is not recommended to install the solar system at this site.

6.7 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.

6.7.1 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.

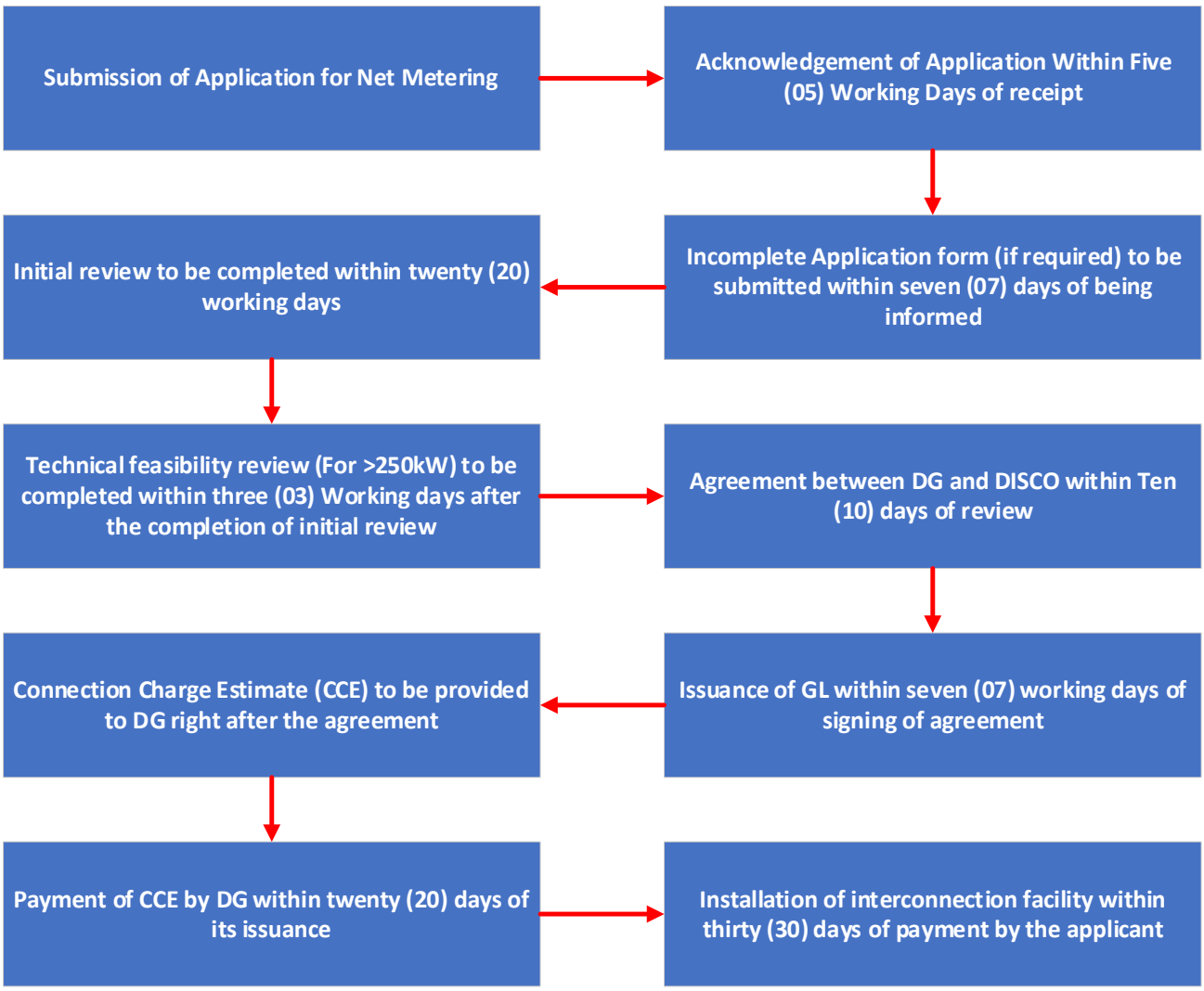


Figure 29: Pakistan Net Metering Application Process

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

7 Recommended Energy Efficiency Measures

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

7.1 Energy Efficiency Measures for Water Pumps & Wastewater Disposal System

7.1.1 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Nadar Anad (Ravi Town) - Unique ID: 81206105)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 46%.

Recommended Action

Replacement of Pump with new PECO 12MC 3-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 45: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	204
Design Head of Existing Pump	ft	210
Design Motor Power of Existing Pump	kW	60
Measured Flow	m^3/h	203
Measured Head	m	28.8
Measured Motor Power	kW	40.87
Pump Efficiency	%	46%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	204
Proposed Head	m	46
Power Consumption of Proposed Pump	kW	28.0
Motor Size of Proposed Pump	hp	50.0
Operational Hours of Proposed Pump	h	5.0
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	67,430
Energy Required by Proposed Pump	kWh/y	45,979
Saving Potential	kWh/y	21,451
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,445
Investment	US $	5,245
Simple Payback Period	months	18

7.1.2 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Mai Khanwali chungi - Unique ID: 81206106)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 39%.

Recommended Action

Replacement of Pump with new PECO 12MC 3-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 46: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	204
Design Head of Existing Pump	ft	210
Design Motor Power of Existing Pump	kW	60
Measured Flow	m^3/h	203
Measured Head	m	29.0
Measured Motor Power	kW	48.20
Pump Efficiency	%	39%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	204
Proposed Head	m	46
Power Consumption of Proposed Pump	kW	28.0
Motor Size of Proposed Pump	hp	50.0
Operational Hours of Proposed Pump	h	5.0
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	79,530
Energy Required by Proposed Pump	kWh/y	45,999
Saving Potential	kWh/y	33,531
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	5,385
Investment	US $	5,245
Simple Payback Period	months	12

7.1.3 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Bhalla Chowk - Unique ID: 81206114)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 43%.

Recommended Action

Replacement of Pump with new PECO 12MC 3-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 47: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	204
Design Head of Existing Pump	ft	210
Design Motor Power of Existing Pump	kW	60
Measured Flow	m^3/h	335
Measured Head	m	20.0
Measured Motor Power	kW	49.80
Pump Efficiency	%	43%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	204
Proposed Head	m	46
Power Consumption of Proposed Pump	kW	28.0
Motor Size of Proposed Pump	hp	50.0
Operational Hours of Proposed Pump	h	8.2
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	82,170
Energy Required by Proposed Pump	kWh/y	75,773
Saving Potential	kWh/y	6,397
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,027
Investment	US $	5,245
Simple Payback Period	months	61

7.1.4 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Mohallah Dulma Thattha - Unique ID: 81206118)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 39%.

Recommended Action

Replacement of Pump with new PECO 12MC 3-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 48: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	204
Design Head of Existing Pump	ft	210
Design Motor Power of Existing Pump	kW	60
Measured Flow	m^3/h	327
Measured Head	m	18.5
Measured Motor Power	kW	50.13
Pump Efficiency	%	39%
Existing Operational Hours	h	4.0
Proposed Pump Flow	m^3/h	204
Proposed Head	m	46
Power Consumption of Proposed Pump	kW	28.0
Motor Size of Proposed Pump	hp	50.0
Operational Hours of Proposed Pump	h	6.4
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	66,176
Energy Required by Proposed Pump	kWh/y	59,247
Saving Potential	kWh/y	6,929
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,113
Investment	US $	5,245
Simple Payback Period	months	57

7.1.5 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Fazal Deewan No. 2 - Unique ID: 81206119)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 38%.

Recommended Action

Replacement of Pump with new PECO 12WC 3-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 49: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	204
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	37
Measured Flow	m^3/h	134
Measured Head	m	22.4
Measured Motor Power	kW	25.27
Pump Efficiency	%	38%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	204
Proposed Head	m	46
Power Consumption of Proposed Pump	kW	28.0
Motor Size of Proposed Pump	hp	50.0
Operational Hours of Proposed Pump	h	3.3
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	41,690
Energy Required by Proposed Pump	kWh/y	30,300
Saving Potential	kWh/y	11,390
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,829
Investment	US $	5,245
Simple Payback Period	months	34

7.1.6 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (MC office No. 2 (Park) - Unique ID: 81206122)

Study & Investigation

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

Recommended Action

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

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

Saving Assessment

Table 50: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	230
Design Motor Power of Existing Pump	kW	37
Measured Flow	m^3/h	117
Measured Head	m	25.9
Measured Motor Power	kW	27.30
Pump Efficiency	%	35%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	37
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	5.7
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	45,045
Energy Required by Proposed Pump	kWh/y	25,336
Saving Potential	kWh/y	19,709
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,165
Investment	US $	3,794
Simple Payback Period	months	14

7.1.7 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 51: 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	Nawaz Sharif Park	81206104-A	5.0	3.0	50	150
2	Nawaz Sharif Park	81206104-B	5.0	3.0	50	150
3	Nawaz Sharif Park	81206104-D	2.5	3.0	50	150
4	Islam Pura Chungi No. 6	81206115-B	5.0	3.0	50	150
5	Islam Pura Chungi No. 6	81206115-C	5.0	3.0	50	150
6	Islam Pura Chungi No. 6	81206115-E	2.5	3.0	50	150
Total						**900**

7.1.8 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 30 smart water meters on all operational potable water and disposal pumps.
- DCS system will help in water data review, development of KPI, analysis of generation and consumption trends during different seasons and times of year.
- In the long term, the measure will help the GoPb tremendously if it intends to meter the water usage of its commercial and domestic consumers, and determine a water tariff (based on actual consumption).
- Overall reduction in water & corresponding energy consumption

Saving Assessment

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

Table 52: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	4,063,265
Annual Water consumption (post-implementation)	m^3/y	4,022,632
Annual Water saving per year	m^3/y	40,633
Estimate of Investment (including the cost of the server)	US$	30,000

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 1,980 streetlights are being operated by the municipality. Out of these, 1,852 were found to be non-operational. It was also observed that all of streetlights are manually operated.

Recommended Action

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

Figure 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 53: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	1852
Number of non-functional streetlights (>20 feet)	#	0
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	1,852

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	94,564,972
Proposed number of photocell switches	#	8
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	8,000
Upfront investment cost	PKR	94,572,972
Upfront investment cost	US$	337,520
Annual Operating Electricity unit	kWh/yr	243,353
Annual Operating Cost	PKR/yr	10,950,876
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	1,032,573
Monthly diesel cost for operating fork lifter for two days	PKR/month	20,000
Monthly cost of renting Fork Lifter for two days	PKR/month	80,000
Miscellaneous Cost	PKR/month	20,000
Monthly maintenance cost	PKR/month	120,000

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

Project

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

Study & Investigation

During the assessment it was observed that there are 1,980 streetlights operated by municipality out of which 128 are operational. 113 of the operational streetlights were LEDs so they are not recommended for replacement.

Recommended Action

It is recommended to replace above mentioned streetlights with LEDs. It is recommended to install 50-watt LED for streetlights installed at a height of 20 feet of more & 30-watt LED for the streetlight installed at a height of less than 20 feet.

Saving Assessment

LED lamps will have less maintenance issues as compared to conventional tube lights and energy savers (CFLs), because LED has higher operational life.
Automatic photocell switches will optimize the daily operational hours of streetlights resulting in electricity savings and cost of operation (no more dedicated person will be required for operation of streetlights).

Table 54: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	4
Number of functional streetlights (>20 feet)	#	0
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	4

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Upfront investment cost	PKR	204,244
Upfront investment cost	US$	729
Annual Operating Electricity unit	kWh/yr	526
Annual Electricity Consumption of Existing Lights	kWh/yr	1,752
Financial Savings	US$/yr	197
Payback	months	44

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 55: 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
Slaughter House											
1	ILB	5	100	500	1,248	LED Bulb 13 Watts	13	65	162	350	1,750
Ramzan Bazar											
2	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
3	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
Main MC Building											
4	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
5	ILB	1	100	100	250	LED Bulb 13 Watts	15	15	37	350	350
6	CFL	3	23	69	172	LED Bulb 13 Watts	13	39	97	350	1,050
7	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
8	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
9	CFL	2	23	46	115	LED Bulb 13 Watts	13	26	65	350	700
10	CFL	3	23	69	172	LED Bulb 13 Watts	13	39	97	350	1,050
11	CFL	2	23	46	115	LED Bulb 13 Watts	13	26	65	350	700
12	CFL	3	23	69	172	LED Bulb 13 Watts	13	39	97	350	1,050
13	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
14	CFL	3	23	69	172	LED Bulb 13 Watts	13	39	97	350	1,050
15	CFL	1	23	23	57	LED Bulb 13 Watts	13	13	32	350	350
16	CFL	2	23	46	115	LED Bulb 13 Watts	13	26	65	350	700

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
17	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
18	Tube Light	16	40	640	1,597	LED Rod 20 Watts	20	320	799	2,900	46,400
19	CFL	10	23	230	574	LED Bulb 13 Watts	13	130	324	350	3,500
20	CFL	1	23	23	57	LED Bulb 13 Watts	13	13	32	350	350
21	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
22	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
23	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
24	Window AC	1	5000	5000	12,480	Inverter 1.5 tons	1,452	1,452	3,624	143,000	143,000
25	Window AC	1	5000	5000	12,480	Inverter 1.5 tons	1,453	1,453	3,627	143,000	143,000
26	Window AC	1	5000	5000	12,480	Inverter 1.5 tons	1,454	1,454	3,629	143,000	143,000
	Total										**512,950**

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 56: Saving & cost benefit analysis

Parameters	Unit	Value
Average Operational Days for Building Lighting Equipment	days/year	312
Average Operational Hours for Building Lighting Equipment	Hours/day	8
Average Operational Days for Building Cooling Equipment	days/year	130
Average Operational Hours for Building Cooling Equipment	Hours/day	3
Energy consumption of inefficient Equipment	kWh/yr	44,304
Energy consumption of Proposed Equipment	kWh/yr	13,414
Energy Savings	kWh/yr	30,890
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	4,961
Upfront Investment (including change in fixtures)	USD	1,831
Payback Period	Months	4

8 Investment Estimate (including Material Specification/Quantities)

8.1 Potable Water Pump

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

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

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

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

Pump assembly of	5	stages with flow type impellers				
Column assembly of	6	inches I.D with flanged joins		each 10 ft length	0	Sets
				and one top set	1	feet length
Discharge head Inch	6			column shaft dia	0	mm
Electric Motor vertical hollow shaft 25 HP/4 Pole						included
DWT with Discharge Head						included
Mechanical installation within Pump House Only						included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	908,547
Sales Tax @ 17%	Rs:	154,453
Total Cost of Pumpset	Rs:	1,063,000

8.1.2 Investment Estimate (including Material Specification/Quantities) for PECO 12 MC /3 Stages, 50hp Motor

Pump Size	12 MC /3 Stages		
Capacity	203.9 m3/hr	Max. O.D bowl	11.5 Inches
Speed	1450 rpm	I.D tubewell	-
Pump Input	50 HP	Length of suction pipe	
Prime Mover (SEM/DE)	50 HP		
		Length of bowl assembly	
		Length of column pipe	0
		Length of top pipe	1 Ft
		Total length of column	1 Ft

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

Pump assembly of	2	stages with flow type impellers			
Column assembly of	8	inshces I.D with flanged joins	each 10 ft length	0	Sets
			and one top set	1	feet length
			column shaft dia	38	mm
Discharge Head Inch	8				with prelubrication tank
Electric Motor vertical hollow shaft 50 HP/4 Pole					included
DWT 12 MC					included
Discharge head 8 " with top shaft					included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	1,256,140
Sales Tax @ 17%	Rs:	213,544
Total Cost of Pumpset	Rs:	1,469,684

8.2 Investment Estimate (including Material Specification/Quantities) Streetlights

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

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	1852	51,061	94,564,972
2	Accessories	Photocell switch				8	1,000	8,000
Lumpsum Price (PKR)								**94,572,972**
Lumpsum Price (USD)								**337,520**

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head	30	4200 Lm	140 Lm/Watt	4	51,061	204,244

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
		30W						
Lumpsum Price (PKR)								**204,244**
Lumpsum Price (USD)								**729**

8.3 Investment Estimate (including Material Specification/Quantities) Buildings

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

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

Sr. No	Proposed Equipment	Wattage of Proposed Equipment	Equipment Count	Overall Wattage of Proposed Equipment	Individual Cost of Proposed Equipment (PKR)	Cost of Proposed Equipment
1	LED Bulb 13 Watts	13	41	533	350	14,350
2	LED Rod 20 Watts	20	24	480	2,900	69,600
3	Inverter 1.5 tons	1452	3	4,356	143,000	429,000
Lumpsum Price (PKR)						**512,950**
Lumpsum Price (USD)						**1,831**

9 Summary of Energy Efficiency Measures

MC Kamalia's annual energy consumption is 1,313,448 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$ 21,125** with an estimated investment of **US$ 400,998**
- Reduce electricity consumption by approx. **131,537 kWh**
- Reduce GHG Emissions by **66 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of FESCO

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