Hafizabad Municipal Committee

Energy Audit Report

June 2023

History of the Document

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The Consultant is also grateful to entire Hafizabad 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 Hafizabad MC Background

The city of Hafizabad is located at 32.07138° N, 73.68777° E. Hafizabad has a population of 245,784 and is the 31st largest city of Pakistan.

The Hafizabad district is bounded on the north by Mandi Bahauddin district, on the west by Chiniot and Sargodha districts, on the south by Faisalabad district and on the east by Gujranwala district.

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

Sr. No.	Name of Officer	Designation
1	Mr. Imtiaz Ali Baig	Administrator
2	Mr. Qazi Abid Qayyum	Chief Officer
3	Muhammad Amin*	Municipal Officer (Infrastructure)
4	Ms. Farwa Rasheed	Municipal Officer (Regulation)
5	Ms. Aqsa Rasheed	Municipal Officer (Finance)
6	Mr. Muhammad Bilal	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Hafizabad

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	443,490
Electrical energy used by Wastewater Disposal[2]	kWh/year	516,747
Electrical energy used in Buildings[3]	kWh/year	40,646
Electrical energy used by Streetlights[4]	kWh/year	127,203
Diesel used by Vehicles	liter/year	110,964
Petrol used by Vehicles	liter/year	0

1.5 Key Performance Indicators

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

1.5.1 Potable Water & Wastewater Pumps

Table 2: KPIs for Potable Water & Wastewater pumps

Sr. No.	Description	Unit	KPI
1	Energy Density of Potable Water Production	(kWh/m^3)	0.14
2	Energy Density of Wastewater Disposal	(kWh/m^3)	0.05
3	Energy Density of Wastewater Treatment	(kWh/m^3) – if applicable	No wastewater treatment is carried out
4	Energy Cost on Potable Water Production	(PKR/m^3)	6.35
5	Energy Cost on Wastewater Disposal	(PKR/m^3)	2.36
6	Energy Cost on Wastewater Treatment	(PKR/m^3) – if applicable	No wastewater treatment is carried out

1.5.2 Streetlights

Table 3: KPIs for Streetlights

Sr. No.	Description	Unit	KPI
1	Average electricity consumed per kilometer of lit roads	(kWh/km)	14,087
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	669
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	41,863
		PKR/Lighting Equipment	42,771
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)	111,250

[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
6	Average daily duration of operation	(Hour)	9.5
7	Average energy costs per kilometer of lit roads	(PKR/km)	633,902
8	Average energy costs per light pole/fixture	(PKR/ fixture)	30,127
9	Number and percentage of failed public lights		6%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	4.13
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.09
3	Average Energy Cost of Heating	(PKR/m^2)	4
4	Average Energy Cost of Cooling	(PKR/m^2)	73
5	Average Energy Cost of Lighting	(PKR/m^2)	51

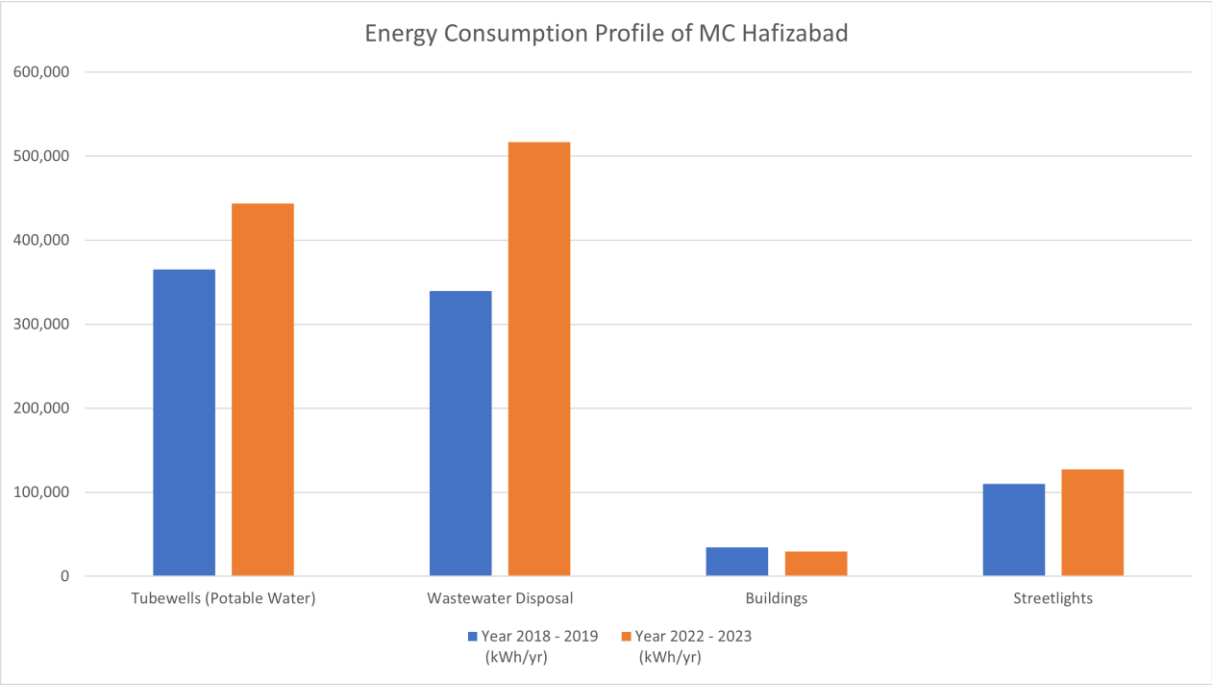
1.5.4 Vehicles

Table 5: KPIs for Vehicles

Sr. No	Description	Unit	KPI
1	Fuel consumption for staff transport vehicles	km/Liter	Cannot be Determined
2	Fuel consumption for solid/liquid waste transport	km/Liter	3.94
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	74

1.6 Impact of Energy Efficiency Investment

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



		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	7	8	365,325	443,490	-78,165	0.17 kWh/m3	0.14 kWh/m3	Replacement of 2 Pumpset was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 4 pumps which has resulted in significant improvement in the KPI for water supply. As seen from the KPI, the water supply pumpsets are performing efficiently and the corresponding water supply to the MC has increased significantly. Moreover, number of operational pumpsets and operational hours of the functional pumpsets have increased due to which the annual energy consumption has increased.
2	Wastewater Disposal	5	8	339,602	516,747	-177,145	0.06 kWh/m3	0.05 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal has improved as well. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.
3	Buildings	3	4	34,323	29,525	4,798	4.29 kWh/m2	3.73 kWh/m2	Bus Stand building was not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of this building has not been

		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
									considered in the overall energy consumption and KPI calculations. Furthermore, MOI branch has shared electricity meter with Pumpset so, for the purpose of this comparison, its energy consumption is also not considered in the overall energy consumption and KPI calculations.
4	Streetlights	130	301	109,859	127,203	-17,344	32,732 kWh/km	14,087 kWh/km	Based on the previous assessment, there were only 130 MC owned operational lights with an average consumption of 845kWh/light/annum, whereas currently there are 301 operational lights with average energy consumption of 422kWh/light/annum. The MC has significantly improved its energy consumption per light fixture.

1.7 Energy Efficiency Recommendations Matrix

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

1.7.1 Energy Efficiency Recommendations Matrix

Table 6: High Priority Measures

High Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Replacement of Pumpset at (MC office Pump No. 3 - Unique ID: 81506175)	16,500	4,151	1,163,000	2,650	742,519	19	8
Replacement of Pumpset at (Mian Da Kot - Unique ID: 81506182)	48,009	4,151	1,163,000	7,710	2,160,385	6	24
Replacement of Pumpset at (Family Park - Unique ID: 81506190)	32,326	4,151	1,163,000	5,191	1,454,658	10	16
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	3,494	978,971	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	1,525	269	75,350	245	68,628	13	1
Total:	**98,360**	**17,115**	**4,795,501**	**15,797**	**4,426,189**		**49**

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	6,728	1,730	484,857	1,081	302,757	19	4
Total:	**6,728**	**1,730**	**484,857**	**1,081**	**302,757**	**19**	**4**

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	33,119	28,000	7,845,600	0	0	0	Not Quantifiable
Total:	**33,119**	**28,000**	**7,845,600**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Hafizabad MC has fourteen (14) tubewells for groundwater, all of which are manually operated. Out of these, 8 pumpsets were found to be in working condition.

The MC has four (4) disposal station having fourteen (14) pumps out of which 9 were found to be functional. The pumps are used to dispose the wastewater to the nearby drain. There are ten (10) dewatering sets in the MC. Out of these, 5 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 three (3) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake assessment of the following pumpsets due to non-functional motor, MCU and transformer
   1. MC office Pump No. 2 (Unique ID: 81506177)
   2. General Bus Stand (Unique ID: 81506200)
   3. Rasheed Pura (Unique ID: 82506280)
   4. Family Park (Unique ID: 81506190-1)

(iv) Undertake assessment of the following pumpsets as these pumpsets have been abandoned by the MC
   1. Mohallah Taj-pura (Unique ID: 81506189)
   2. Mughal Pura (Unique ID: 81506192)

(v) Undertake assessment of the following disposal stations due to non-functional pumpset, motor and MCU
   1. Kolo Road (Unique ID: 81506185-A)
   2. Madrian wala (Unique ID: 81506188-A)
   3. Ghari Awan Disposal (Unique ID: 81506196-A)
   4. Ghari Awan Disposal (Unique ID: 81506196-B)
   5. Ghari Awan Disposal (Unique ID: 81506196-D)
   6. Ghari Awan Disposal (Unique ID: 81506196-F)

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

2.1 Inventory for water and wastewater pumping equipment

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

2.1.1 Tubewells

Table 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	81506175	MC office Pump No. 3	27-12245-2042300	Turbine	Beco	1967	Beco	1967	32.071395	73.687937
2	81506176	Jinnah Hall	27-12245-2042100	Turbine	KSB	2020	Siemens	2020	32.071679	73.687626
3	81506177	MC office Pump No. 2	27-12245-2042300	Turbine	HMA	2005	Siemens	2005	32.071513	73.687809
4	81506180	Bijli Mohallah	27-12245-0404700	Turbine	KSB	2020	Siemens	2020	32.078655	73.692
5	81506182	Mian Da Kot	27-12245-1281304	Turbine	HMA	2007	Siemens	2007	32.07443	73.681412
6	81506181	Ali Town	27-12245-0827903	Turbine	HMA Pumps	2007	Siemens	2007	32.0863302	73.682398
7	81506189	Mohallah Taj-pura	27-12247-0833608	Turbine	GrundFos	N/A	Siemens	N/A	32.058883	73.673683
8	81506195	Muslim High School	24-12247-0390103	Turbine	HMA	2003	Siemens	2003	32.067594	73.683831
9	81506190	Family Park	27-12247-1049300	Turbine	Peco	2001	Peco	2001	32.06275	73.677647
10	81506190-1	Family Park	27-12247-1049300	Turbine	KSB	2020	Siemens	2020	32.061095	73.677642
11	81506192	Mughal Pura	No-Meter	Turbine	N/A	N/A	N/A	N/A	32.069878	73.673552
12	81506193	Hussain Pura	24-12247-0052900	Turbine	KSB	2020	Siemens	2020	32.069454	73.681588
13	81506200	General Bus Stand	27-12246-0380103	Turbine	Ittefaq Pump	2010	Siemens	2010	32.070849	73.694028
14	82506280	Rasheed Pura	No-Meter	Turbine	N/A	N/A	N/A	N/A	32.065381	73.664561

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	81506185-A	Kolo Road	30-12245-0072052	Centrifugal	KSB	4	Siemens	50	32.076567	73.67735
2	81506185-B	Kolo Road	30-12245-0072052	Centrifugal	Flow Pak	5	Siemens	50	32.076567	73.67735
3	81506185-C	Kolo Road	30-12245-0072052	Centrifugal	Flow Pak	5	Siemens	50	32.076567	73.67735
4	81506188-A	Madrian wala	28-12247-1049100	Centrifugal	KSB	5	Siemens	50	32.056837	73.664619
5	81506188-B	Madrian wala	28-12247-1049100	Centrifugal	KSB	4	Siemens	50	32.056837	73.664619
6	81506188-C	Madrian wala	28-12247-1049100	Centrifugal	KSB	4	Siemens	50	32.056837	73.664619
7	81506188-D	Madrian wala	28-12247-1049100	Centrifugal	KSB	5	Siemens	50	32.056837	73.664619
8	81506196-A	Kassoki Road	28-12246-1063103	Centrifugal	KSB	4	Siemens	50	32.044917	73.701996
9	81506196-B	Kassoki Road	28-12246-1063103	Centrifugal	Flow Pak	8	Siemens	100	32.044917	73.701996
10	81506196-C	Kassoki Road	28-12246-1063103	Centrifugal	KSB	4	Siemens	50	32.044917	73.701996
11	81506196-D	Kassoki Road	28-12246-1063103	Centrifugal	Flow Pak	8	Siemens	100	32.044917	73.701996
12	81506196-E	Kassoki Road	28-12246-1063103	Centrifugal	KSB	4	Siemens	50	32.044917	73.701996

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Pump Capacity (Cusec)	Motor Manufacturer	Motor Capacity (Hp)	Latitude	Longitude
13	81506196-F	Kassoki Road	28-12246-1063103	Centrifugal	KSB	4	Siemens	50	32.044917	73.701996
14	81506198	Housing Colony	27-12245-0017701	Centrifugal	N/A	3	Siemens	40	32.077636	73.719069

2.1.3 Filtration Units

Table 11: Inventory of Filtration Units

Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East
1	81506178	MC office	Water supplied from adjoining Pumpset					32.07154	73.687716
2	81506183	Mian Da Kot	Water supplied from adjoining Pumpset					32.074447	73.681319
3	81506184	Muhallah Hussain Pump	Centrifugal	1	Deep Well Pump	N/A	Asli Punjab	32.070318	73.676751
4	81506186	Kolo Road Sangai Mandi	Centrifugal	1	Deep Well Pump	N/A	Eagle	32.07896	73.670741
5	81506191	Family Park	Water supplied from adjoining Pumpset					32.0627	73.677798
6	81506194	Hussain Pura Qatal Gara Chowk	Centrifugal	1	Golden Pumps	N/A	Golden Motors	32.069574	73.681886
7	81506197	Al-Munib Marriage	Centrifugal	1	Punjab Pump	N/A	Asli Punjab	32.062583	73.68954
8	81506199	Sona Service Station	Centrifugal	1	Golden Pumps	N/A	Golden Motors	32.07305	73.698721
9	81506203	Govt Degree College Alipur Road	Centrifugal	1	Deep Well Pump	N/A	Golden Motors	32.075978	73.687962
10	81506204	Cham-e-Rasul Masjid	Centrifugal	1	Golden Pumps	N/A	Golden Motors	32.07932	73.690359
11	81506201	General Bus Stand	Centrifugal	1	Golden Pumps	N/A	Golden Motors	32.069885	73.694275

2.1.4 Dewatering Sets Details

Details of the MC Dewatering Sets are given below.

Table 12: Dewatering Sets' Details

Sr. No.	Unique ID	Location	Quantity	Latitude	Longitude
1	81506179 A	Ali Pur Chatha Road	1	32.094088	73.699096
2	81506179 B	Sheikhupura Road	1	32.059228	73.692017
3	81506179 C	Saghar Road	1	32.077222	73.699173
4	81506179 D	Near Bilal Rice Mills	1	32.065535	73.66038
5	81506179 E	Jalalpur Road	1	32.07126	73.687027
6	81506179 F	Kolo Tarar Road	5	32.077253	73.675049

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

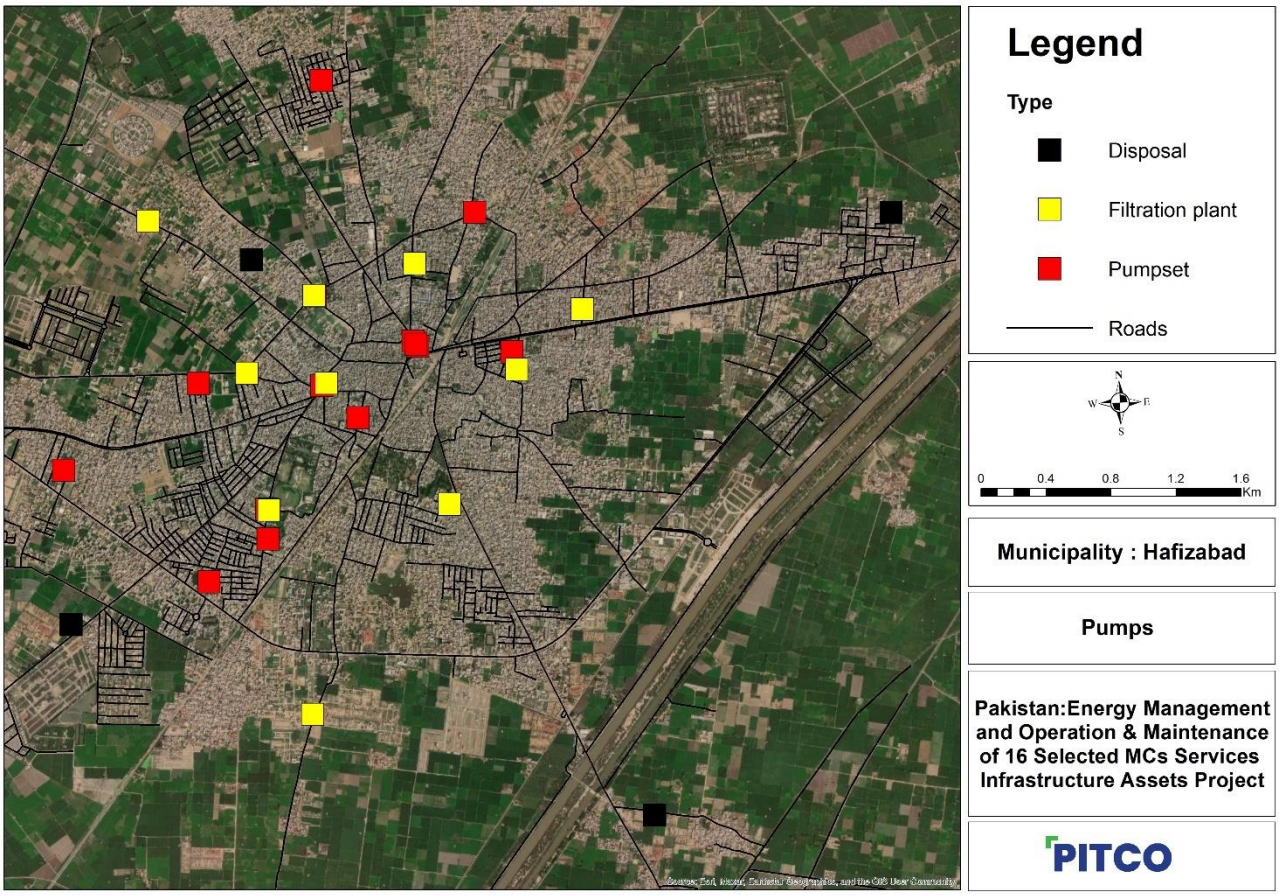


Figure 1: Map for Pumps and Disposal at MC Hafizabad

2.3 Baseline Energy Consumption Trend

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

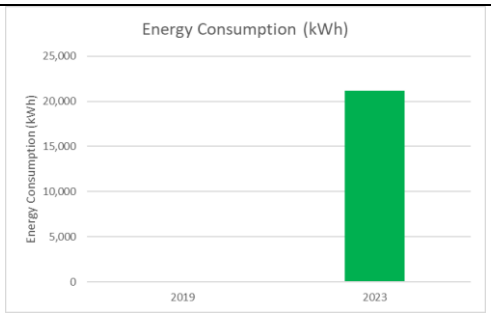
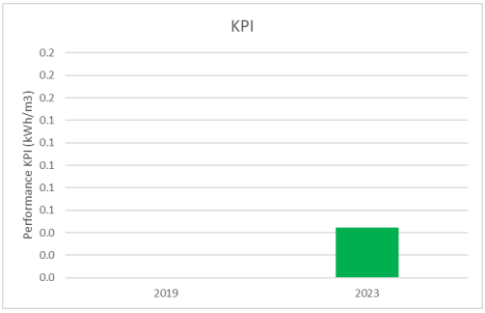
Table 13: Baseline Energy Consumption Trend

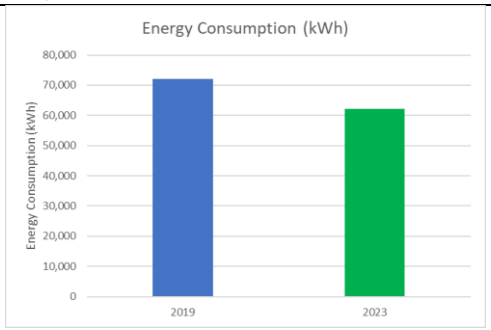
Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	443,490
Electrical energy used by Wastewater Disposal	kWh/y	516,747
Electrical energy used (Total)	kWh/y	960,237

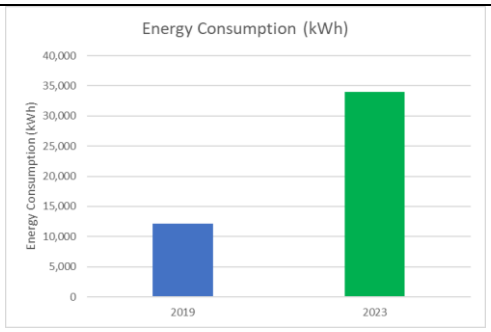
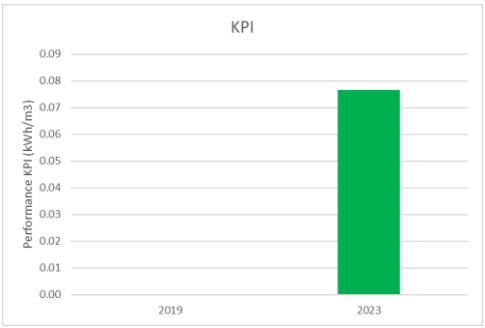
A comparison of current electricity consumption by the MC's water supply and disposal assets compared to results of the energy audit activity carried out in 2019, is presented in the following table:

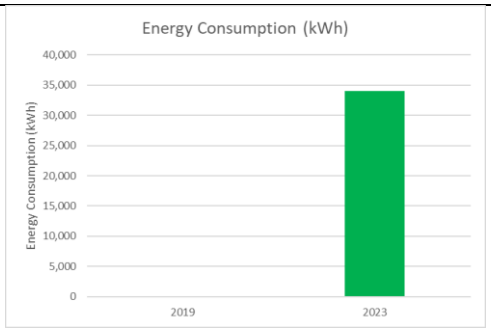
		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	7	8	365,325	443,490	-78,165	0.17 kWh/m3	0.14 kWh/m3	Replacement of 2 Pumpset was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 4 pumps which has resulted in significant improvement in the KPI for water supply. As seen from the KPI, the water supply pumpsets are performing efficiently and the corresponding water supply to the MC has increased significantly. Moreover, number of operational pumpsets and operational hours of the functional pumpsets have increased due to which the annual energy consumption has increased.
2	Wastewater Disposal	5	8	339,602	516,747	-177,145	0.06 kWh/m3	0.05 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal has improved as well. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.

Replacement of 2 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken installation of 4 new pumpsets. A discussion on each newly installed asset is presented below:

Jinnah Hall - Unique ID (81506176)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	21,166 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.04 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No calculations of the KPI have been calculated for the previous audit, as this site was abandoned by the MC and there were no billing details available for this pumpset.	

Bijli Mohallah - Unique ID (81506180)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
72,136 kWh	62,189 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.20 kWh/m3	0.14 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of pumpset was recommended due to the low efficiency. Annual energy consumption of this pumpset in 2019 was 72,136 kWh whereas, annual energy consumption of this pumpset of current year is 62,189 kWh with an annual energy savings of 9,947 kWh. As seen from the KPI, the new pumpset is performing efficiently and the corresponding water supply to the MC from this pumpset has increased significantly.	

Hussain Pura - Unique ID (81506193)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
12,195 kWh	34,008 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.08 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Annual energy consumption of this pumpset in 2019 was 12,195 kWh whereas, annual energy consumption of this pumpset of current year is 34,008 kWh with an increase of 21,813 kWh in an annual energy consumption. As seen from the KPI, the new pumpset is performing efficiently. No KPIs have been calculated for 2019 audit, no flow was detected due to lack of sufficient space on the delivery pipe for the installation of transducers of the flow meter.	

Family Park - Unique ID (81506190-1)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
N/A	34,064 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	N/A
	
Comments:	
A new pumpset has been installed at this site. This site was found to be non-operational during the current audit due to non-availability of the electrical supply. There is no baseline data available for this site as this pumpset has been installed on 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.

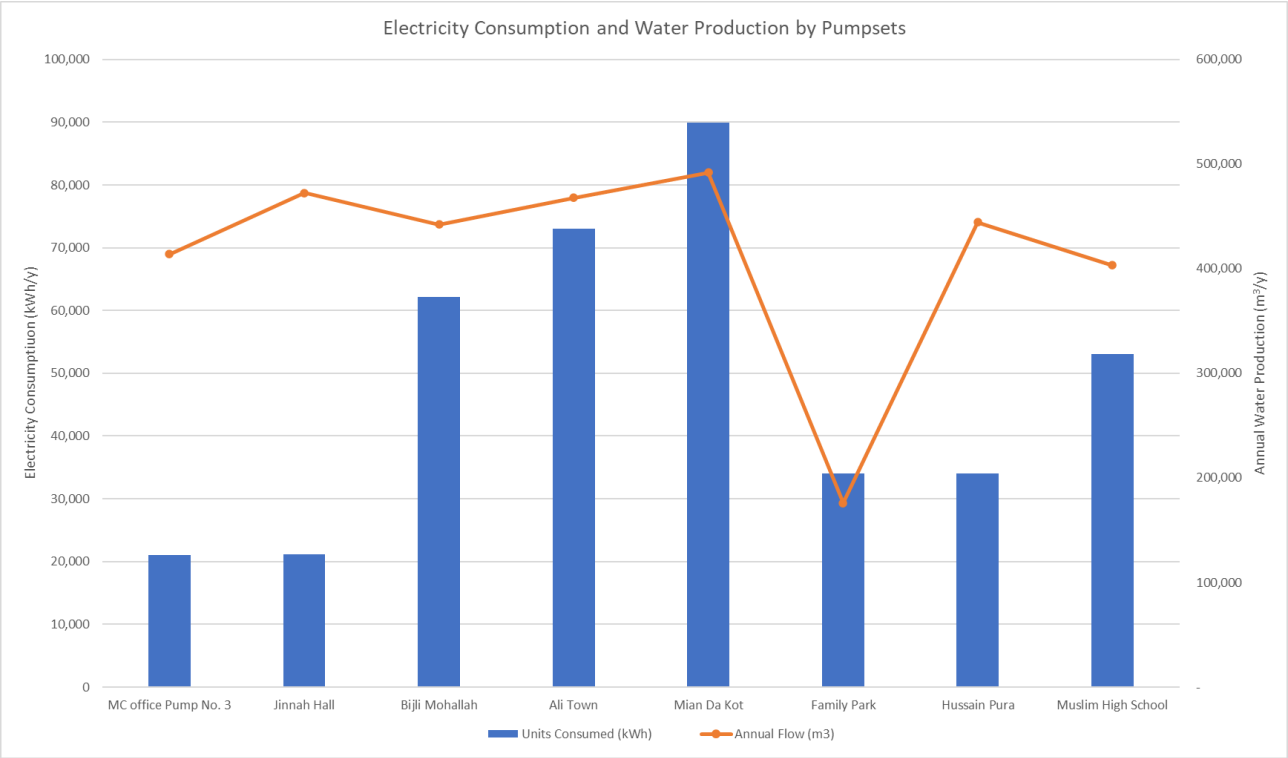
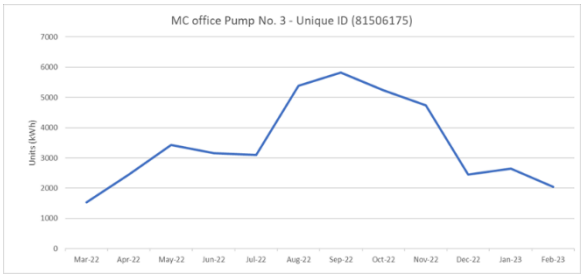


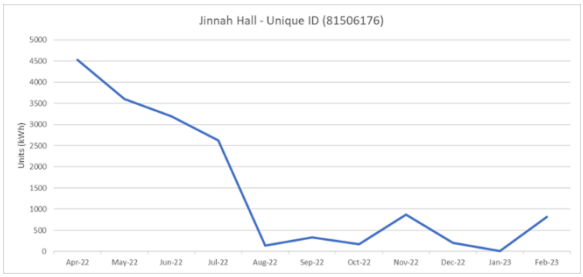
Figure 2: Electricity Consumption and Water Production by Pumpsets

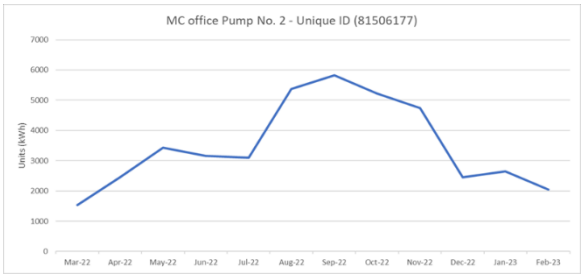
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

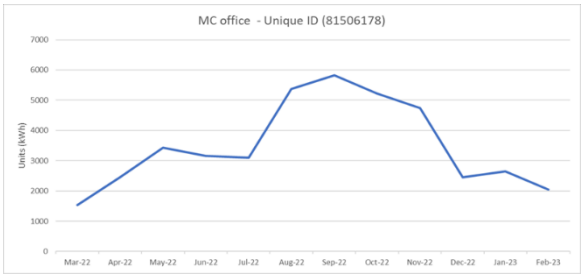
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

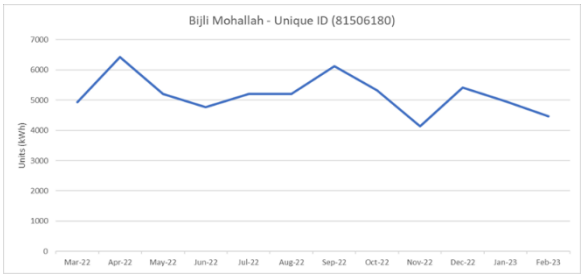
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

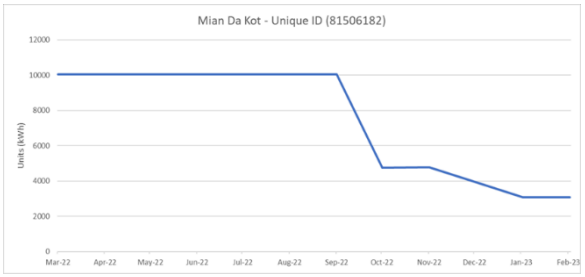


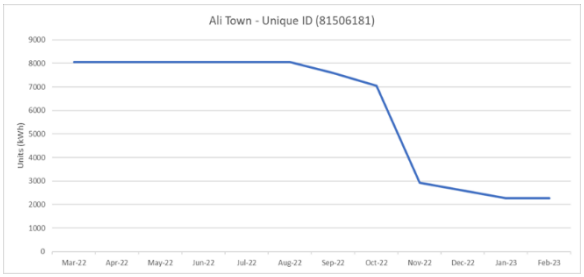


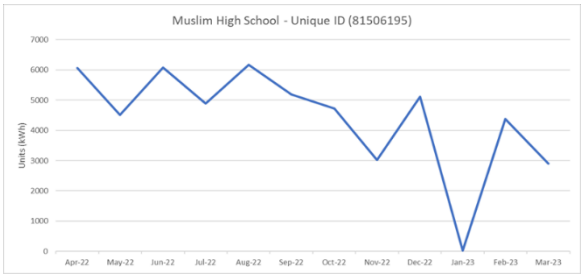


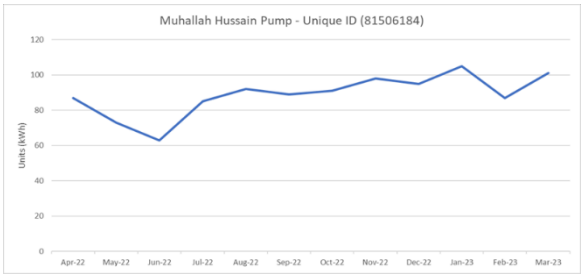


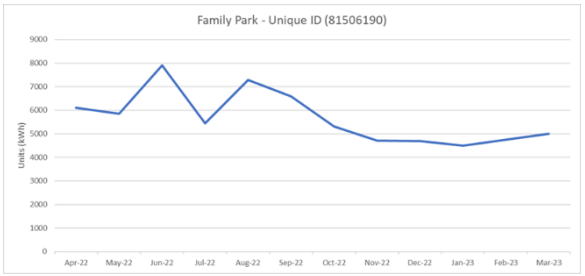


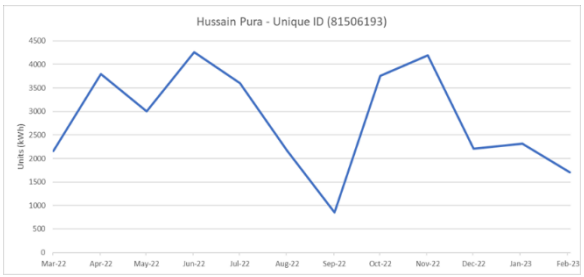












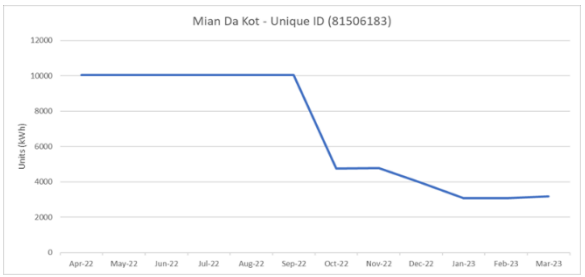


Figure 3: Energy Consumption Trend for Water Pumps

Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Hafizabad MC has fourteen (14) tubewells for groundwater, all of which are manually operated. Performance evaluation of pumpsets could be carried out at only 8 locations due to the reasons specified under section 2. Performance analysis was carried out for the operational tubewells, by simultaneous measurement of flow and electrical consumption. The list of audit equipment used by the Consultant is attached as Annexure 2. Since the Sluice valves at several pumping stations were either jammed or broken, it was not possible to determine system resistance and/or assess the pumpset performance at its duty point. Nevertheless, the purpose of the energy audit is to evaluate the energy consumption of MC's water supply network based on their actual/existing working condition. Therefore, any measurements made by altering the actual field operating mode/conditions will not be a true representation of the energy consumption of assets.

Pumps with efficiencies of 55% or higher are deemed satisfactory in terms of performance while those below 55% are recommended for replacement. This approach is based on the methodology adopted by the Consultant for the audits conducted under USAID funded TWEIP project wherein detailed discussions were held with the leading pump manufacturers of Pakistan (KSB, HMA, PECO, Flowpak, etc.) to determine a cut-off efficiency values for replacement; as new pumpsets have an average in-field efficiency value of around 70%, a cut-off value of 55% was agreed upon to ensure at least 25% improvement in energy efficiency for the end users (Capital Development Authority (CDA), Karachi Water and Sewerage Board (KWSB), and Farmers). This methodology was successfully implemented during the detailed energy audit of 135 pumpsets at CDA and 294 at KWSB.



Figure 5: Sample pictures from field audit of pumpsets

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

Table 14: Matrix of Pumpset Assessment and Billing Data Availability

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
1	81506175	MC office Pump No. 3	Yes	Yes
2	81506176	Jinnah Hall	Yes	Yes
3	81506177	MC office Pump No. 2	Yes	No
4	81506180	Bijli Mohallah	Yes	Yes
5	81506181	Ali Town	Yes	Yes
6	81506182	Mian Da Kot	Yes	Yes
7	81506189	Mohallah Taj-pura	Yes	No
8	81506190	Family Park	Yes	Yes
9	81506192	Mughal Pura	Yes	No
10	81506193	Hussain Pura	Yes	Yes
11	81506195	Muslim High School	Yes	Yes
12	81506200	General Bus Stand	Yes	No
13	82506280	Rasheed Pura	Yes	No
14	81506190-1	Family Park	Yes	No

Table 15: Pumpset Primary Performance Parameters

Sr No.	Unique ID	Location	Rated Pump Flow m^3/hr	Measured Flow m^3/hr	Dynamic Head m	Power Consumption kW	Pump Efficiency %	Measured Power Factor	Comments
1	81506175	MC office Pump No. 3	152.9	156.8	20.75	24.60	42%	0.90	Efficiency of the pumpset is unsatisfactory. Gate/sluice valve is jammed. Previously, the efficiency of the pumpset was 61%.
2	81506176	Jinnah Hall	101.9	179.0	24.26	23.97	58%	0.76	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, this pumpset was abandoned by the MC.
3	81506180	Bijli Mohallah	101.9	167.5	25.18	23.83	57%	0.81	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, it was recommended to replace the pumpset.
4	81506181	Ali Town	152.9	141.7	36.19	30.30	54%	0.85	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, this site was non-functional.
5	81506182	Mian Da Kot	152.9	149.1	17.56	32.00	26%	0.86	Efficiency of the pumpset is unsatisfactory. Previously, the efficiency of the pumpset was 52%.
6	81506190	Family Park	152.9	53.3	17.09	16.03	18%	0.70	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve is jammed. Previously, it was recommended to replace the pumpset.
7	81506193	Hussain Pura	101.9	168.4	20.60	20.21	55%	0.70	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, no flow was detected due to lack of sufficient space on the delivery pipe for the installation of transducers of the flow meter
8	81506195	Muslim High School	101.9	152.8	24.26	22.17	54%	0.89	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 60%.

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

Table 16: Pumpset Secondary Performance Parameters

Unique ID	Motor Vibration Hz	Temperature of Motor	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
81506175	4.48	30	30	-	100	Safe	Not ok	150	400	-	0.90	82%	
81506176	6.37	34	30	92	100	Safe	ok	200	400	0.84	0.76	80%	Low PF
81506180	4.68	45	30	92	100	Safe	ok	200	400	0.84	0.81	80%	
81506181	53.05	28	30	-	50	Safe	-	150	400	0.88	0.85	102%	Overloaded Motor
81506182	53.05	34	30	-	50	Safe	ok	150	400	0.88	0.86	107%	Overloaded Motor
81506190	76.26	35	37	-	50	Safe	ok	-	400	-	0.70	43%	Low PF
81506193	79.58	32	30	91	50	Safe	ok	200	400	0.85	0.70	68%	Low PF
81506195	4.90	31	22	-	100	Safe	Not ok	150	400	0.86	0.89	99%	

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

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

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
1	81506176	Jinnah Hall	102	29.828	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	178.984	24.3	Flow at Existing Operating Conditions	23.97	58%
2	106.153	45.4	Flow nearest to duty point	24.50	63%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
2	81506180	Bijli Mohallah	102	29.828	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	167.548	25.2	Flow at Existing Operating Conditions	23.83	57%
2	103.645	44.2	Flow nearest to duty point	23.77	62%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
3	81506182	Mian Da Kot	153	29.828	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	149.08	17.6	Flow at Existing Operating Conditions is nearest to duty point	32.00	26%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
4	81506193	Hussain Pura	102	29.828	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	168.35	20.6	Flow at Existing Operating Conditions	20.21	55%
2	119.08	36.1	Flow nearest to duty point	22.40	61%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
5	81506195	Muslim High School	102	22.371	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	152.786	24.3	Flow at Existing Operating Conditions	22.17	54%
2	100.2	39.0	Flow nearest to duty point	21.20	59%

2.4.3 Wastewater Disposal System

The MC has four (4) disposal station having fourteen (14) 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 18: Disposal Performance Parameters

Sr No	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	PITCO Comments
1	81506198	Housing Colony	305.8	321.8	7.62	17.10	46%	Efficiency of the pumpset is satisfactory. Previously, it was recommended to repair the pumpset.
2	81506185-B	Kolo Road	509.7	525.1	7.62	30.60	42%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 41%.
3	81506185-C	Kolo Road	509.7	444.3	7.62	26.75	41%	Efficiency of the pumpset is satisfactory. Previously, this pumpset was non-functional.
4	81506188-B	Madrian wala	407.8	773.8	6.25	29.40	53%	Efficiency of the pumpset is satisfactory. Previously, this pumpset was non-functional.
5	81506188-D	Madrian wala	509.7	629.6	6.25	32.00	39%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, this pumpset was non-functional.
6	81506196-C	Ghari Awan Disposal	407.8	425.2	6.10	17.80	47%	Efficiency of the pumpset is satisfactory. Previously, this pumpset was non-functional.
7	81506196-E	Ghari Awan Disposal	407.8	419.9	6.10	20.08	41%	Efficiency of the pumpset is satisfactory. Previously, this pumpset was non-functional.

Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are ten (10) dewatering sets in the MC. Out of these, 5 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 19: Water Pumps and Wastewater Disposal System: Recommendations for improvement

Sr No.	Unique ID	Location	Comments	Recommendation
Pumps				
1	81506175	MC office Pump No. 3	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
2	81506176	Jinnah Hall	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
3	81506181	Ali Town	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
4	81506182	Mian Da Kot	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
5	81506190	Family Park	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
6	81506193	Hussain Pura	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
7	81506195	Muslim High School	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
8	81506188-D	Madrian wala	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
9	81506196-C	Ghari Awan Disposal	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
10	81506196-E	Ghari Awan Disposal	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
General Observations				
11	General	Smart Metering	No flow meters were installed at any of the tubewells.	Smart flow meters connected to a centralized DCS system needs to be installed to calculate the total water drawn by each pump and to monitor flow and water loss due to leakages. This can also help with water billing if the Government of Punjab intends to do so in future
12	General	Operating Time	Pumps should not be run during Peak electricity consumption hours.	Operational hours of pump should be scheduled keeping in mind the varying peak hours across the year to avoid peak charges. Peak hours for GEPCO during the entire year are given in Annexure 1.

Sr No.	Unique ID	Location	Comments	Recommendation
13	General	Dewatering Sets	Dewatering sets were in satisfactory condition, but no O&M logs were available with the MC	It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.
14	General	Water Supply Network	Proper O&M of Air Release Valves	Air release valves installed on the network should be properly maintained.

3 Streetlights

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

3.1 Inventory

Surveyors conducted onsite surveys at Hafizabad 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 20: Inventory Detail of Streetlights

	Streetlights	MC Operated	Privately Operated
Operational Street Lights	301	301	
Non Operational Street Lights	19	19	
Total	**320**	**320**	**0**

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

Out of the total streetlights operated by MC, there are 7 light fixtures installed on PC, 47 fixtures are installed on steel structure, and 137 fixtures are installed on tubular structure. The streetlights' structural classification is tabulated below.

Table 21: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Grand Total
MC	7	47	137	**191**
Private				0

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

Table 22: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Gujranwala Road	134	19122452001112	2.496
2	Dehinagran Wali Road	35	24122470175701	2.142
3	Family Park	9	24122460795400	0.233
4	Graveyard	30	16122450648102	1.328
5	Ali Pur Road	9	08122460713903	0.292
6	J-Pur Road	103	27122471049300	2.539

Out of the 320 surveyed lights in the MC, 301 lights were found to be operational. Details are given in the following table:

Table 23: Details of Operational Streetlights

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours[5]	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	18	6		12.0	473	
LED	30	4		12.0	526	
LED	50	6		12.0	1,314	
LED	100	7		12.0	3,066	
LED	120	237		12.0	124,567	
LED	150	32		12.0	21,024	
Sodium Light	100	4		12.0	1,752	
Sodium Light	400	5		12.0	8,760	
Total					**161,482**	

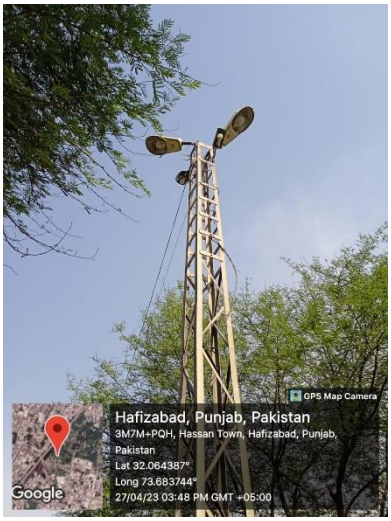


Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

[5] Based on Interview with Client.

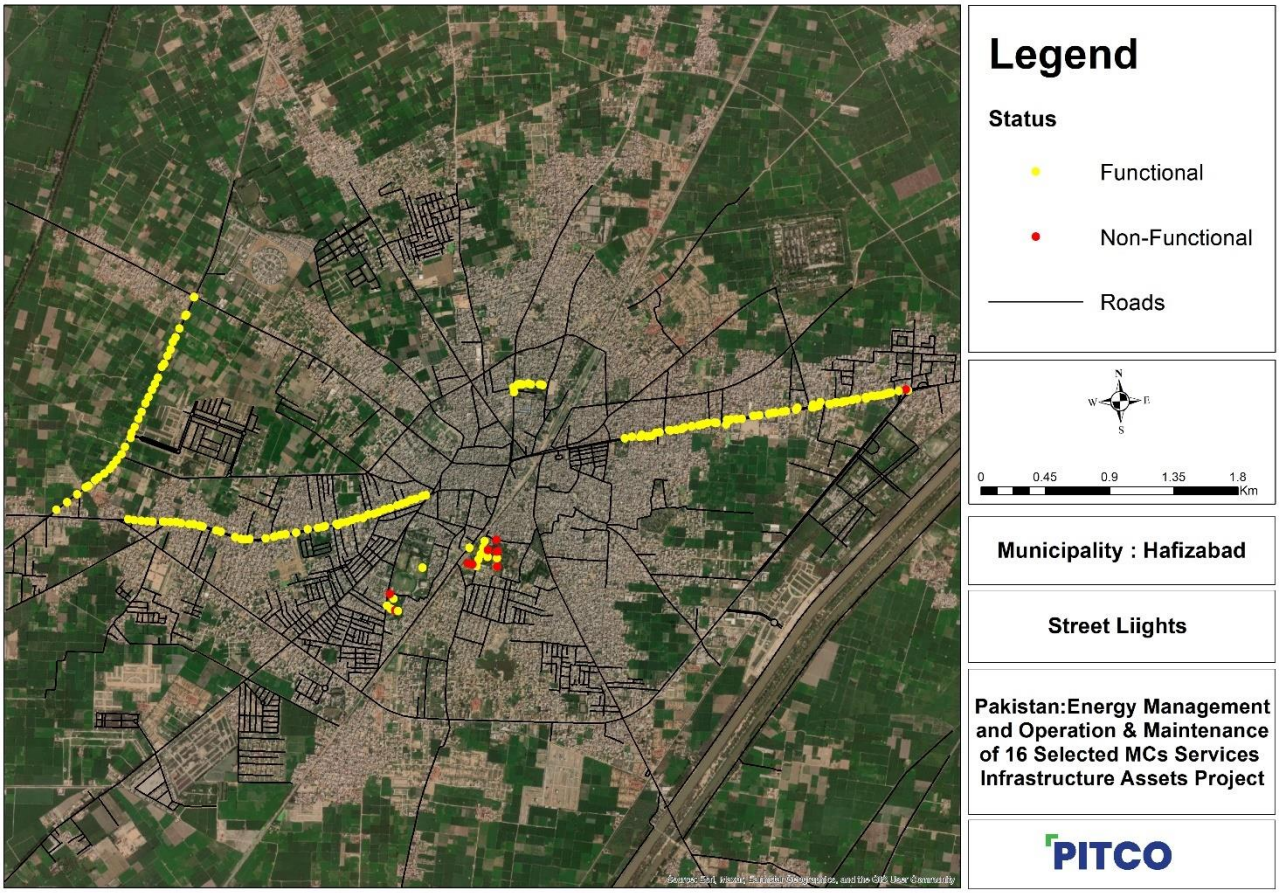


Figure 9: GIS Mapping of street lights in Hafizabad MC

3.3 Baseline Energy Consumption Trend

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

Table 24: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy consumed	kWh/y	**127,203**
Total number of operational lights	No.	**301**

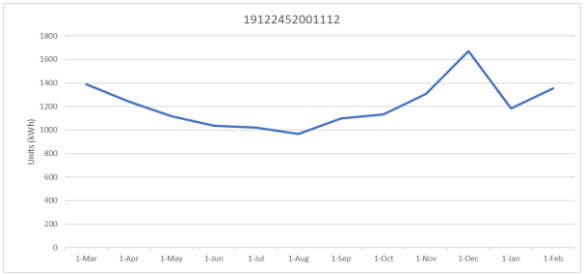


Figure 10: Energy Consumption trend of Streetlights

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	130	301	109,859	127,203	-17,344	32,732 kWh/km	14,087 kWh/km	Based on the previous assessment, there were only 130 MC owned operational lights with an average consumption of 845kWh/light/annum, whereas, currently there are 301 operational lights with average energy consumption of 422kWh/light/annum. The MC has significantly improved its energy consumption per light fixture.

3.4 Maintenance & Replacement of Streetlights

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

3.5 Observations

- All Streetlights in Hafizabad MC are operated by MC.
- Most of the operational streetlights are LEDs.
- Approximately 92% of the LED streetlights have a rating of 120 Watts or more.
- Hafizabad 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 25: Streetlights - recommendations for improvement

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

Table 26: Vehicle Inventory Detail

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
1	Unregistered Vehicle 1	Mini Tipper	Suzuki	Ravi	2022	2WD	No task assigned	386056	490714	796
2	Unregistered Vehicle 2	Mini Tipper	Suzuki	Ravi	2022	2WD	No task assigned	386072	490734	796
3	Unregistered Vehicle 3	Mini Tipper	Suzuki	Ravi	2022	2WD	No task assigned	386054	490696	796
4	Unregistered Vehicle 4	Mini Tipper	Suzuki	Ravi	2022	2WD	No task assigned	386068	490732	796
5	Unregistered Vehicle 5	Mini Tipper	Suzuki	Ravi	2022	2WD	No task assigned	386048	490706	796
6	Unregistered Vehicle 6	Mini Tipper	Suzuki	Ravi	2022	2WD	No task assigned	386069	490707	796
7	Unregistered Vehicle 7	Truck	Hino	NR-500	2022	4WD	No task assigned	F08JKLB-10333	J08EVUM10639	4465
8	Unregistered Vehicle 8	Truck	Hino	NR-500	2022	4WD	No task assigned	FG8JKLB-10330	J08EVUM10636	4465
9	Unregistered Vehicle 9	Truck	Hino	NR-300	2022	4WD	No task assigned	N04CWGM50236	JHHYGKOF104600199	4009
10	Unregistered Vehicle 10	Truck	Hino	NR-300	2022	4WD	No task assigned	N04CWGM50227	JHHYGKOF204600194	4009
11	Unregistered Vehicle 11	Truck	Hino	NR-300	2022	4WD	No task assigned	N04CWGM50225	JHHYGKOF904600192	4009
12	Unregistered Vehicle 12	Truck	Hino	NR-300	2022	4WD	No task assigned	N04CWGM50241	JHHYGKOF404600200	4009
13	Unregistered Vehicle 13	Truck	Hino	NR-300	2022	4WD	No task assigned	N04CWGM50217	JHHYGKOF704600188	4009
14	Unregistered Vehicle 14	Truck	Hino	NR-300	2022	4WD	No task assigned	N04CWGM50250	JHHYGKOF304600205	4009
15	Unregistered Vehicle 15	Truck	Hino	NR-300	2022	4WD	No task assigned	N04CWGM50226	JHHYGKOF004600193	4009
16	Unregistered Vehicle 16	Truck	Hino	NR-300	2022	4WD	No task assigned	N04CWGM50219	JHHYGKOF5046000190	4009
17	Unregistered Vehicle 17	Truck	Hino	NR-300	2022	4WD	No task assigned	N04CWGM50220	JHHYGKOF504600191	4009
18	Unregistered Vehicle 18	Mini Tipper	Suzuki	Ravi	2022	2WD	No task assigned	PKT 386077	490740	796
19	Unregistered Vehicle 19	Mini Tipper	Suzuki	Ravi	2022	2WD	No task assigned	386045	490695	796
20	Unregistered Vehicle 20	Tractor	Millat	MF-385	2020	4WD	Backhoe	LM9B572V504550F	84895	85HP
21	Unregistered Vehicle 21	Tractor	Millat	MF-385	2020	4WD	Transport of Solid Waste	N/A	84811	85HP
22	Unregistered Vehicle 22	Tractor	Fiat	NH-640	1974	4WD	Front blade	4.1041E+11	00681409F8	85HP
23	Unregistered Vehicle 23	Tractor Front loader	Millat	MF-385	2007	4WD	Transport of Solid Waste	LM9B570V508885M	360	85HP
24	Unregistered Vehicle 24	Tractor Front loader	Millat	MF-385	2016	4WD	Transport of Solid Waste	LM9B572V0306A	1415384002	85HP
25	Unregistered Vehicle 25	Tractor	Fiat	NH-640	1974	4WD	Water Bowser	N/A	8045	85HP
26	Unregistered Vehicle 26	Tractor	Fiat	NH480	1974	2WD	Water Bowser	4601040	N/A	55HP
27	Unregistered Vehicle 27	Tractor	Millat	MF-240	2003	2WD	Transport of Solid Waste	CE97065V578985	MTL/A1123/78	50HP
28	Unregistered Vehicle 28	Tractor Trolley	Millat	MF-240	2003	2WD	Transport of Solid Waste	CE22488U626137G	MTL/065/13	50HP
29	Unregistered Vehicle 29	Tractor Trolley	Millat	MF-240	2007	2WD	Transport of Solid Waste	CE99001-5860505	40455/25/9	50HP
30	Unregistered Vehicle 30	Tractor Trolley	Millat	MF-240	2020	2WD	Transport of Solid Waste	CE99001-VF373449F	43922-05	50HP
31	Unregistered Vehicle 31	Tractor Trolley	Millat	MF-240	2020	2WD	Transport of Solid Waste	N/A	43922/03/20	50HP
32	Unregistered Vehicle 32	Tractor Trolley	Millat	MF-240	2007	2WD	Transport of Solid Waste	N/A	MTL/A1104/96	50HP
33	Unregistered Vehicle 33	Tractor	Millat	MF-240	2007	2WD	No Task Assigned	N/A	N/A	50HP
34	Unregistered Vehicle 34	Compactor	Isuzu	Reward NP	2020	4WD	Transport of Solid Waste	00J421	JAAMPR71KL-7100685	4009

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
35	Unregistered Vehicle 35	Mini Tractor	Millat	300/A	2007	2WD	Transport of Solid Waste	55001	C5-002127A	35HP
36	Unregistered Vehicle 36	Truck Sucker Jetting	Nissan	PKB211	2007	4WD	Suction & Jetting Machine	A3000111B00000	2710032Z71	3400
37	Unregistered Vehicle 37	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	786072	PK 490740	796
38	Unregistered Vehicle 38	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	386045	490695	796
39	Unregistered Vehicle 39	Mini Tipper	Faw	GA1024V	2014	2WD	No Task Assigned	5600749-2	AHMPD115EE000100	970
40	Unregistered Vehicle 40	Mini Tipper	Faw	GA1024V	2014	2WD	No Task Assigned	5700845-12	AHRMPD115EE000099	970
41	Unregistered Vehicle 41	Mini Pickup	Suzuki	Ravi	2007	2WD	Transport of staff	221107	Pk 325774	796
42	HZK-4200	Car	Suzuki	Cultus	2002	2WD	Transport of staff	N/A	SF410PK404880	1000
43	HZA-4100	Double Cabin Truck	Toyota	Hilux	2002	4WD	Transport of staff	2L	LN145-7009260	2446
44	HZA-3939	Car	Suzuki	Cultus	2002	2WD	Transport of staff	812034	G10-306947	1000
45	Unregistered Vehicle 42	Rickshaw	Tez Raftar	TR 200	2020	2WD	No task assigned	PS3200MCL000251	N/A	200
46	Unregistered Vehicle 43	Rickshaw	Tez Raftar	TR 200	2020	2WD	No task assigned	PS3200MCLl000250	N/A	200
47	Unregistered Vehicle 44	Rickshaw	Tez Raftar	TR 200	2020	2WD	Transport of Solid Waste	PS3200MCL000246	N/A	200
48	Unregistered Vehicle 45	Rickshaw	Tez Raftar	TR 200	2020	2WD	Transport of Solid Waste	PS3200MCL000247	N/A	200
49	Unregistered Vehicle 46	Rickshaw	Tez Raftar	TR 200	2020	2WD	Transport of Solid Waste	PS3200MCL000241	N/A	200
50	Unregistered Vehicle 47	Rickshaw	Tez Raftar	TR 200	2020	2WD	Transport of Solid Waste	PS3200MCL000249	N/A	200
51	Unregistered Vehicle 48	Rickshaw	Tez Raftar	TR 200	2020	2WD	Transport of Solid Waste	PS3200MCL000248	N/A	200
52	Unregistered Vehicle 49	Rickshaw	Tez Raftar	TR 200	2020	2WD	Transport of Solid Waste	PS3200MCL000244	N/A	200
53	Unregistered Vehicle 50	Rickshaw	Tez Raftar	TR 200	2020	2WD	Transport of Solid Waste	PS3200MCL000252	N/A	200
54	Unregistered Vehicle 51	Rickshaw	Tez Raftar	TR 200	2020	2WD	Transport of Solid Waste	PS3200MCL000245	N/A	200
55	Unregistered Vehicle 52	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006545	LXKKCK108KM000018	150
56	Unregistered Vehicle 53	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006563	LXKKCK10XKM000230	150
57	Unregistered Vehicle 54	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006544	LXKKCK103KM000265	150
58	Unregistered Vehicle 55	Rickshaw	Tez Raftar	TR 150	2020	2WD	No task assigned	PS3150MCL006554	LXKKCK105KM000025	150
59	Unregistered Vehicle 56	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL005310	LXKKCK105KM000292	150
60	Unregistered Vehicle 57	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL005307	LXKKCK101KM000300	150
61	Unregistered Vehicle 58	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006561	LXKKCK104JM001701	150
62	Unregistered Vehicle 59	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006562	LXKKCK103KM000282	150
63	Unregistered Vehicle 60	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL005303	LXKKCK101KM000037	150
64	Unregistered Vehicle 61	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006557	LXKKCK106KM000020	150
65	Unregistered Vehicle 62	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL005305	LXKKCK103KM000007	150
66	Unregistered Vehicle 63	Rickshaw	Tez Raftar	TR 150	2020	2WD	No task assigned	PS3150MCL006546	LXKKCK108KM000293	150
67	Unregistered Vehicle 64	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL005875	LXKKCK103KM000041	150
68	Unregistered Vehicle 65	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL004844	N/A	150
69	Unregistered Vehicle 66	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006558	LXKKCK100KM000286	150
70	Unregistered Vehicle 67	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006549	LXKKCK107KM000009	150
71	Unregistered Vehicle 68	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006550	LXKKCK10XKM000022	150
72	Unregistered Vehicle 69	Rickshaw	Tez Raftar	TR 150	2020	2WD	No task assigned	PS3150MCL006547	LXKKCK103KM000010	150
73	Unregistered Vehicle 70	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006548	LXKKCK107KM000284	150
74	Unregistered Vehicle 71	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL005311	LXKKCK109KM000298	150
75	Unregistered Vehicle 72	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006555	LXKKCK109KM000013	150
76	Unregistered Vehicle 73	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006559	LXKKCK107KM000270	150

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)
77	Unregistered Vehicle 74	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006560	LXKKCK108KM000276	150
78	Unregistered Vehicle 75	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006553	LXKKCK108KM000267	150
79	Unregistered Vehicle 76	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL005306	LXKKCK100KM000028	150
80	Unregistered Vehicle 77	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006551	LXKKCK106KM000034	150
81	Unregistered Vehicle 78	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006556	LXKKCK106KM000290	150
82	Unregistered Vehicle 79	Rickshaw	Tez Raftar	TR 150	2020	2WD	Transport of Solid Waste	PS3150MCL006552	LXKKCK106KM000030	150
83	HZ-3899	Bike	Yamaha	2 Stroke	1994	2WD	Transport of Staff	N/A	3AMB-118050K	110
84	HZ-5699	Bike	Yamaha	2 Stroke	2007	2WD	Transport of Staff	N/A	SHM-013465K	110
85	Unregistered Vehicle 80	Rickshaw	Yamaha	2 Stroke	2007	2WD	Transport of Solid Waste	N/A	N/A	110
86	Unregistered Vehicle 81	Rickshaw	Suzuki	Raider 110	2016	2WD	No task assigned	N/A	N/A	110
87	Unregistered Vehicle 82	Rickshaw	Road Prince	RP100	2016	2WD	No task assigned	NS10014081	N/A	100
88	Unregistered Vehicle 83	Rickshaw	Suzuki	GS 150	2016	2WD	No task assigned	N/A	N/A	150
89	Unregistered Vehicle 84	Rickshaw	Road Prince	RP100	2016	2WD	No task assigned	KP10044869	SP110PK10044869	100
90	Unregistered Vehicle 85	Rickshaw	Suzuki	GS 150	2016	2WD	Transport of Solid Waste	N/A	N/A	150

4.2 Baseline Fuel Consumption Trend

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

Table 27: 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 20	9:05 AM	10:05 AM	1.84	1.84 Liters/hr	7:55 AM	9:05 AM		5.19	4.45 Liters/hr
2	Unregistered Vehicle 21	9:20 AM	10:20 AM	3.43	3.43 Liters/hr	8:03 AM	9:20 AM		4.82	3.76 Liters/hr
3	Unregistered Vehicle 22	9:15 AM	10:15 AM	1.82	1.82 Liters/hr	7:45 AM	9:15 AM		5.07	3.38 Liters/hr
4	Unregistered Vehicle 25	9:10 AM	10:10 AM	2.05	2.05 Liters/hr	8:00 AM	9:10 AM		2.88	2.47 Liters/hr
5	Unregistered Vehicle 30	9:08 AM	10:08 AM	1.48	1.48 Liters/hr	7:53 AM	9:08 AM		4.02	3.22 Liters/hr
6	Unregistered Vehicle 34	8:25 AM	9:25 AM	1.9	1.9 Liters/hr	7:15 AM	8:25 AM		6.43	5.51 Liters/hr
7	Unregistered Vehicle 35	8:37 AM	9:37 AM	1.18	1.18 Liters/hr	7:18 AM	8:37 AM		2.21	1.68 Liters/hr
8	Unregistered Vehicle 36	9:00 AM	10:00 AM	2.13	2.13 Liters/hr	7:50 AM	9:00 AM		10.37	8.89 Liters/hr
9	Unregistered Vehicle 38	9:20 AM	10:20 AM	0.28	0.28 Liters/hr	8:10 AM	9:20 AM		2.98	2.55 Liters/hr
10	Unregistered Vehicle 45	8:40 AM	9:40 AM	0.63	0.63 Liters/hr	7:40 AM	8:40 AM		1.59	1.59 Liters/hr
11	Unregistered Vehicle 58	8:50 AM	9:50 AM	0.32	0.32 Liters/hr	7:42 AM	8:50 AM		1.48	1.31 Liters/hr
12	HZ-3899	9:55 AM	10:55 AM	0.18	0.18 Liters/hr	8:55 AM	9:55 AM		1.21	1.21 Liters/hr

Table 28: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	Unregistered Vehicle 20	10.48
2	Unregistered Vehicle 21	4.65

Sr. No.	Unique Registration Number	Fuel Usage on logbook
3	Unregistered Vehicle 23	3.92
4	Unregistered Vehicle 24	3.00
5	Unregistered Vehicle 25	3.35
6	Unregistered Vehicle 27	2.77
7	Unregistered Vehicle 28	5.13
8	Unregistered Vehicle 29	2.89
9	Unregistered Vehicle 30	2.97
10	Unregistered Vehicle 31	2.87
11	Unregistered Vehicle 32	3.00
12	Unregistered Vehicle 33	3.12
13	Unregistered Vehicle 34	5.05
14	Unregistered Vehicle 52	4.54
15	Unregistered Vehicle 66	9.71
16	Unregistered Vehicle 77	9.42

The logbooks of remaining vehicles are not available in MC.

The MC made 12 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 1.44 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 3.34 liters/hour.

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

Table 29: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	110,964
Annual Cost of Fuel (Diesel)	PKR/y	32,512,452
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 Hafizabad 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 Hafizabad 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 4 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.

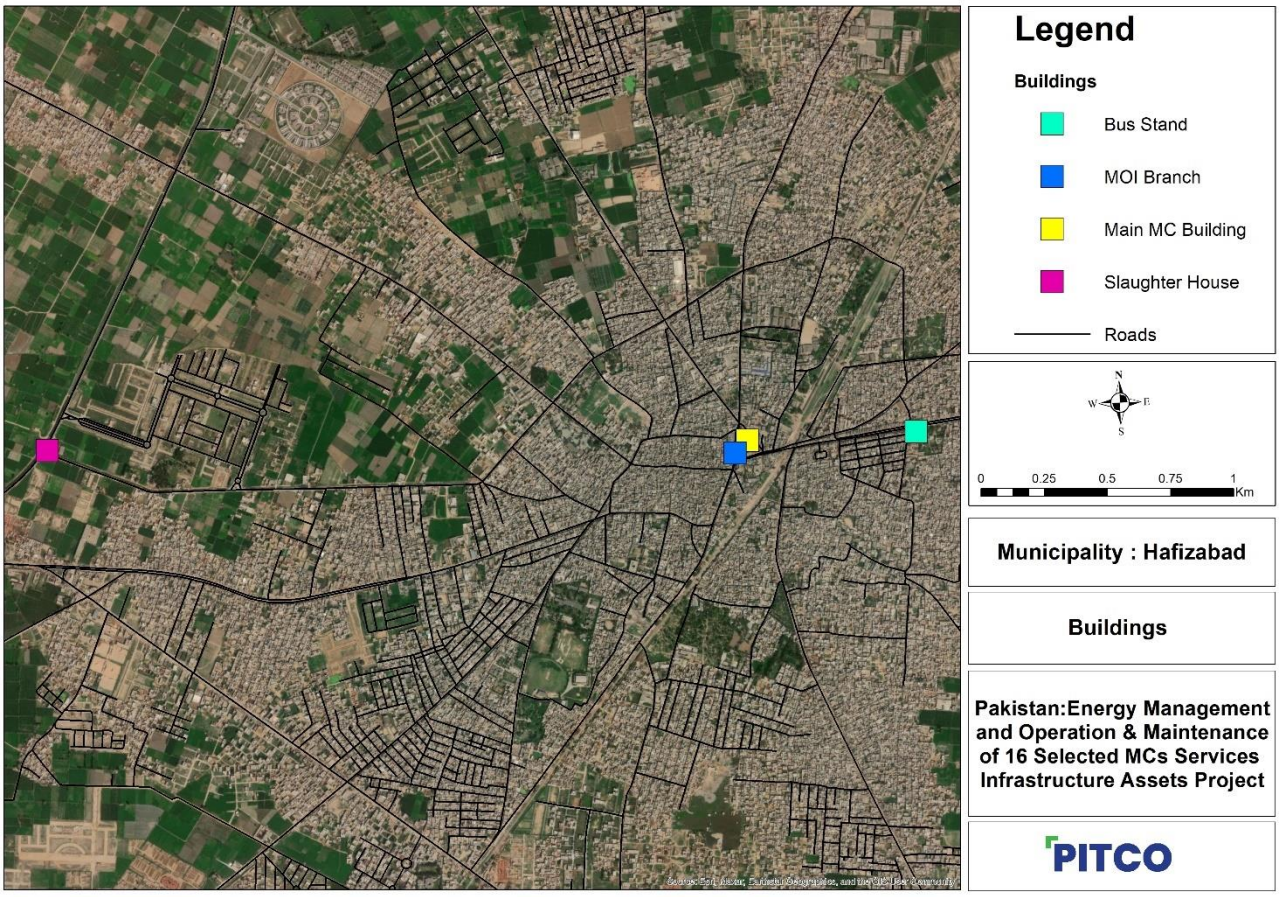


Figure 12: Map for Buildings

5.2 Building Details

Details of the MC buildings are given below.

Table 30: Buildings' Details

Sr. No.	Address	GPS	Unique ID	Ownership	Age of Building	Condition of Building	Total Area (m2)	Insulation of Building	Number of Floors
1	Main MC Building	N:32.07149 E:73.68778	81506202	MC	52	Satisfactory	6,152	No Proper Insulation	1
2	MOI Branch	N:32.07106 E:73.68725	81506179	MC	7	Satisfactory	1,751	No Proper Insulation	1
3	Bus Stand	N:32.071540 E:73.694856	81506202-1	MC	N/A	Satisfactory	500	No Proper Insulation	1
4	Slaughter House	N:32.072207 E:73.658497	81506187	MC	17	Satisfactory	1771	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 31: Number of Heating Units in MC Buildings

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[6]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Main MC Building								
1	**Deputy Director Accounting**	Electric Heater	1	1000	3	3	78	234
2	**Cashier Room**	Electric Heater	2	1000	0	0	0	0
MOI Branch								
1	**Head Clerk Room**	Electric Heater	1	1000	3	4	104	312
2	**MOI office**	Electric Heater	1	1000	2	4	104	208
3	**Washroom**	Electric Heater	1	1000	0	0	0	0
	Total							**754**

Table 32: Number of Cooling Units in Office Buildings of the MC

Sr. No	Name of Room	Type of Cooling Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating months per year	Operating days per year	Annual Energy consumption (kWh/year)
Main MC Building								
1	**Registration Branch**	Ceiling Fan	4	80	8	8	208	532

[6] 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	Count of Equipment	Capacity in Watts	Daily operating hours	Operating months per year	Operating days per year	Annual Energy consumption (kWh/year)
2	**MOR Office**	Bracket Fan	4	50	6	8	208	250
3	**MOR Office**	Split AC	1	1800	4	4	104	749
4	**MOR Office**	Exhaust Fan	1	30	5	8	208	31
5	**Deputy Director Accounts**	Ceiling Fan	1	80	7	8	208	116
6	**Deputy Director Accounts**	Split AC	1	1800	4	4	104	749
7	**IT Officer**	Ceiling Fan	1	80	7	8	208	116
8	**IT Officer**	Split AC	1	1650	4	4	104	686
9	**Account Branch**	Ceiling Fan	4	80	7	8	208	466
10	**Account Branch**	Air Cooler	1	125	6	7	182	137
11	**Cashier Room**	Ceiling Fan	1	80	7	8	208	116
12	**Superintendent Office**	Ceiling Fan	2	80	7	8	208	233
13	**Administrative Office**	Bracket Fan	6	50	7	8	208	437
14	**Administrative Office**	Inverter AC	1	1700	2	4	104	354
15	**Administrative Office**	Exhaust Fan	2	30	6	8	208	75
16	**One Window Operation**	Bracket Fan	2	50	8	8	208	166
17	**One Window Operation**	Split AC	1	1800	4	4	104	749
18	**Meeting Hall**	Ceiling Fan	12	80	1	8	208	200
19	**Kitchen**	Bracket Fan	1	50	6	8	208	62
20	**CO-Office**	Bracket Fan	4	50	7	8	208	291
21	**CO-Office**	Inverter AC	1	1700	2	4	104	354
22	**CO-Office**	Exhaust Fan	2	30	7	8	208	87
23	**Gallery 1**	Bracket Fan	2	50	2	8	208	42
24	**MOF Office**	Ceiling Fan	1	80	6	8	208	100
25	**MOF Office**	Split AC	1	1800	4	4	104	749
26	**MOF Office**	Exhaust Fan	1	30	5	8	208	31
27	**Union Office**	Exhaust Fan	2	30	7	8	208	87
28	**Gallery**	Ceiling Fan	2	80	6	8	208	200
MOI Branch								
1	**Computer Room**	Ceiling Fan	1	80	8	8	208	133
2	**Computer Room**	Split AC	1	1650	4	5	130	858
3	**Kitchen**	Bracket Fan	1	50	7	8	208	73
4	**Kitchen**	Exhaust Fan	1	30	5	8	208	31
5	**Head Clerk Room**	Ceiling Fan	1	80	7	8	208	116
6	**Store**	Ceiling Fan	1	80	2	8	208	33
7	**MOI Office**	Ceiling Fan	1	80	6	8	208	100
8	**MOI Office**	Split AC	1	1800	4	5	130	936
9	**Gallery**	Exhaust Fan	1	30	7	8	208	44
10	**Room 1**	Ceiling Fan	1	80	6	8	208	100
Bus Stand								
1	**Office**	Ceiling Fan	1	80	14	8	208	233
2	**Ladies Washroom**	Exhaust Fan	1	30	12	8	208	75
3	**Outside**	Ceiling Fan	2	80	14	8	208	466

Sr. No	Name of Room	Type of Cooling Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating months per year	Operating days per year	Annual Energy consumption (kWh/year)
Slaughter House								
1	**Main Hall**	Ceiling Fan	19	80	8	8	208	2,529
2	**Main Hall**	Exhaust Fan	2	30	8	9	234	112
3	**Doctor Room**	Ceiling Fan	1	80	8	8	208	133
	Total							14,138

Table 33: Number of Lighting Unit in Office Buildings of the MC

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating days per year	Annual Energy consumption (kWh/year)
Main MC Building							
1	**Registration Branch**	LED	6	18	8	312	270
2	**Registration Branch**	LED	2	12	8	312	60
3	**Registration Branch**	LED	3	7	8	312	52
4	**MOR Office**	LED	2	7	4	312	17
5	**MOR Office**	LED	2	20	4	312	50
6	**MOR Office**	LED	3	30	6	312	168
7	**MOR Office**	LED	1	18	6	312	34
8	**Deputy Director Accountant**	LED	1	40	8	312	100
9	**Deputy Director Accountant**	LED	1	12	8	312	30
10	**Deputy Director Accountant**	LED	1	9	8	312	22
11	**IT Officer**	LED	1	30	7	312	66
12	**IT Officer**	LED	2	12	6	312	45
13	**IT Officer**	LED	1	18	6	312	34
14	**Account Branch**	CFL	1	24	7	312	52
15	**Account Branch**	LED	4	12	8	312	120
16	**Account Branch**	LED	3	18	8	312	135
17	**Cashier Room**	LED	2	12	8	312	60
18	**Superintendent Office**	LED	5	18	7	312	197
19	**Ladies Washroom**	LED	1	12	8	312	30
20	**Administrative Office**	LED	1	50	6	312	94
21	**Administrative Office**	LED	21	18	6	312	708
22	**One window operation**	LED	5	18	8	312	225
23	**One window operation**	LED	1	12	8	312	30
24	**Meeting Hall**	LED	5	20	1	312	31
25	**Meeting Hall**	LED	5	7	1	312	11
26	**Meeting Hall**	LED	105	10	1	312	328
27	**Kitchen**	LED	2	7	6	312	26
28	**Kitchen**	LED	4	4	6	312	30
29	**Co-Office**	LED	18	7	6	312	236
30	**Co-Office**	LED	6	4	6	312	45
31	**Co-Office**	LED	1	40	6	312	75

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating days per year	Annual Energy consumption (kWh/year)
32	**Gallery 1**	LED	20	7	2	312	87
33	**MOP Office**	LED	1	50	6	312	94
34	**MOP Office**	LED	1	30	6	312	56
35	**MOP Office**	LED	1	12	6	312	22
36	**MOF Office**	LED	2	12	6	312	45
37	**MOF Office**	LED	1	30	6	312	56
38	**Union Office**	LED	1	18	8	312	45
39	**Union Office**	LED	2	30	8	312	150
40	**Union Office**	LED	1	12	8	312	30
41	**Gallery 2**	LED	7	12	8	312	210
42	**Gallery 2**	LED	2	18	8	312	90
43	**Outside**	LED	22	18	12	312	1,483
44	**Outside**	Tube Light	1	40	0	312	0
45	**Outside**	LED	5	50	12	312	936
46	**Outside**	LED	8	7	6	312	105
47	**Ground**	Electric Rod	3	400	2	312	749
MOI Branch							
1	**Computer room**	LED	2	12	8	312	60
2	**Computer room**	LED	1	30	8	312	75
3	**Kitchen**	LED	1	24	6	312	45
4	**Head clerk room**	LED	2	24	8	312	120
5	**Store**	LED	1	12	2	312	7
6	**MOI office**	LED	3	30	6	312	168
7	**MOI office**	LED	6	4	6	312	45
8	**Washroom**	Tube Light	1	40	0	312	0
9	**Washroom**	LED	1	12	2	312	7
10	**Gallery**	LED	2	24	8	312	120
11	**Washroom**	LED	2	12	2	312	15
12	**Outside**	Tube Light	1	40	0	312	0
13	**Outside**	LED	2	1	8	312	5
14	**Room 1**	LED	1	12	6	312	22
15	**Room 1**	LED	1	18	6	312	34
16	**Kitchen**	LED	1	18	2	312	11
Bus Stand							
1	**Office**	LED	1	12	12	312	45
2	**Gents Washroom**	LED	2	12	12	312	90
3	**Ladies Washroom**	LED	2	12	12	312	90
4	**Outside**	ICL	1	100	0	312	0
5	**Outside**	LED	4	12	12	312	180
Slaughter House							
1	**Outside of the hall**	LED	4	50	12	312	749
2	**Main Hall**	ICL	2	100	0	312	0
3	**Main Hall**	LED	8	18	8	312	359

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating days per year	Annual Energy consumption (kWh/year)
4	**Doctor Room**	LED	1	12	8	312	30
	Total						**9,813**

5.3 Baseline Energy Consumption Trend

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

Table 34: Energy consumption in Office Buildings

Sl No.	Description	Unit	Value[7]
1	Annual Electricity Consumption	kWh	40,646
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[7] Based on Utility Bills

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Buildings	3	4	34,323	29,525	4,798	4.29 kWh/m2	3.73 kWh/m2	Bus Stand building was not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Furthermore, MOI branch has shared electricity meter with Pumpset so, for the purpose of this comparison, its energy consumotion is also not 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 35: Cooling Equipment Comparison

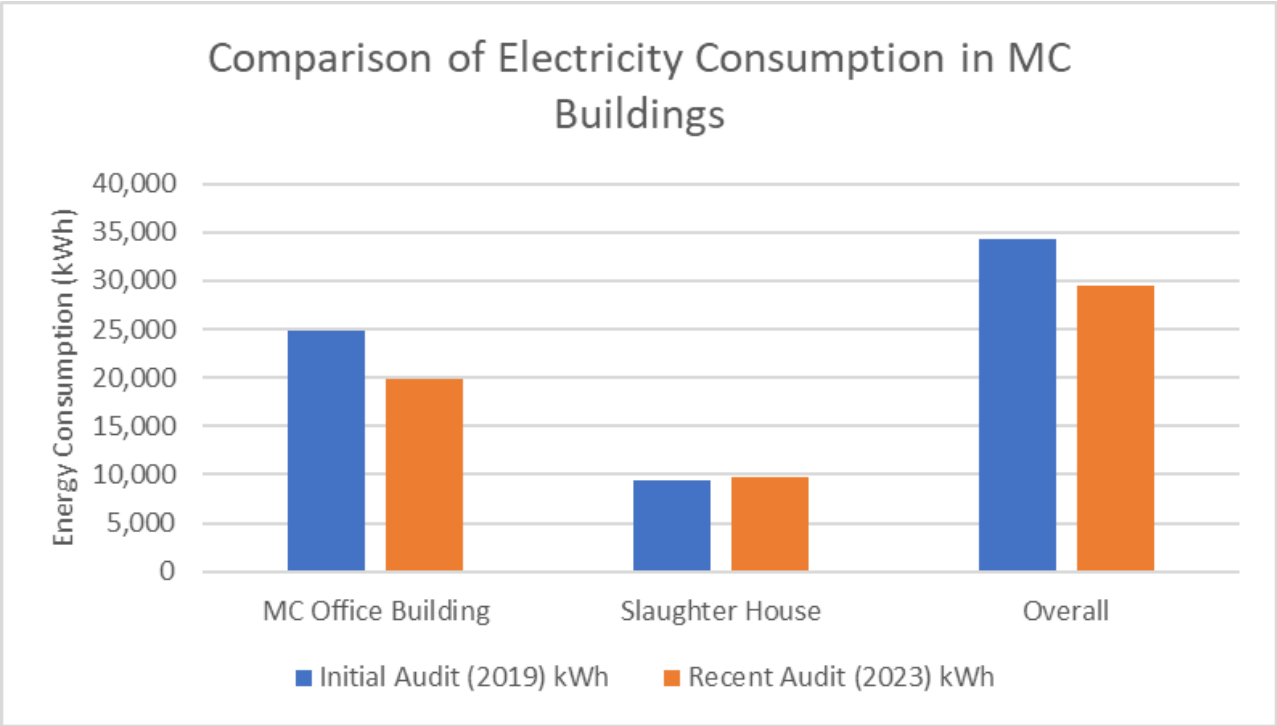
Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
Slaughter House	Ceiling Fans	25	0	20
Slaughter House	Exhaust Fan	-	-	2
MC Office Building	Ceiling Fans	27	0	28
MC Office Building	Split AC	6	0	5
MC Office Building	Bracket Fan	22	0	19
MC Office Building	Inverter	3	0	2
MC Office Building	Pedestal Fan	1	0	0
MC Office Building	Air Cooler	3	0	1
MC Office Building	Exhaust Fan	-	-	8

Table 36: Lighting Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
Slaughter House	Tube Light	12	12	0
Slaughter House	Incandescent Lights bulb	2	2	2
Slaughter House	CFL	4	4	0
Slaughter House	LED	2	0	13
MC Office Building	Tube Light	11	11	1
MC Office Building	LED	309	0	289
MC Office Building	Incandescent Lights bulb	1	1	0
MC Office Building	CFL	-	-	1

Table 37: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh	Comments
MC Office Building	24,897	19,825	Bus Stand building was not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Furthermore, MOI branch building has shared electricity meter with Pump set so, for the purpose of this comparison, its energy consumption is also not considered in the overall energy consumption and KPI calculations.
Slaughter House	9,426	9,700	
Overall	**34,323**	**29,525**	



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 Hafizabad

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

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

MC Main Office Buildings, MOI Branch and Slaughterhouse have Three Phase 400V electrical connection whereas Bus stand has single phase 220V electrical connection. As single-phase connections are not eligible for net metering, therefore, the Consultant has only carried out detailed assessment of system size requirement for the three phase connection buildings only. However, if the system requirement of any site with single-phase connection exceeds above 5 kW based on the historical electricity bill, the Consultant has provided the detailed assessment of available solar system capacity. Metering details of each building is presented below.

Table 38: Metering details at MC Hafizabad

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Main MC Building	31706525	17122452301400 3ϕ	7	A-3a (66)
2	MOI Branch	31706524	27122452042100 3ϕ	29	A-3a (66)
3	Bus Stand	31706520	15122460202200 1ϕ	1	A-3a (66)
4	Slaughter House	81707300	16122470919000 3ϕ	6	A-3a (66)

6.1 Main MC Office Building

The project site i.e. Main MC Office Building is located near Press Club, Ketchary Rd, Hafizabad, Punjab, Pakistan while the geographical co-ordinates of location are 32.07111°N (latitude) and 73.68694°E (longitude).

Figure 13: Front View Of Main MC Office Building

Figure 14: Aerial View of MC Office Main building

6.1.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption of Main MC Office Building is 19,825 kWh with the peak electricity consumption of 3,356 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 39: Solar System Requirement

Sr. No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	17122452301400	19,825	1,652	3,356	15

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Office Building is 66,220 ft^2 whereas, the total area of rooftop available for the solar installation is 7,514 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

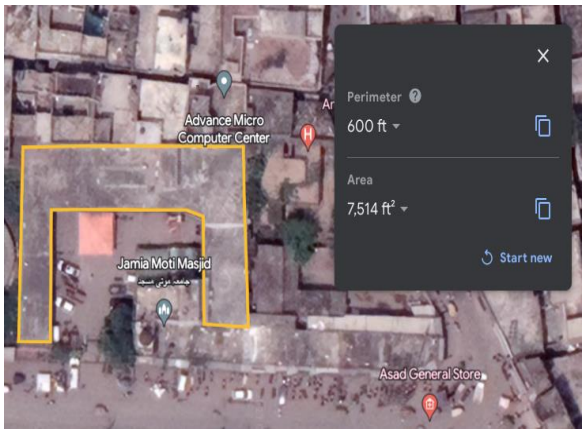


Figure 15: Top View of Main MC Office building

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

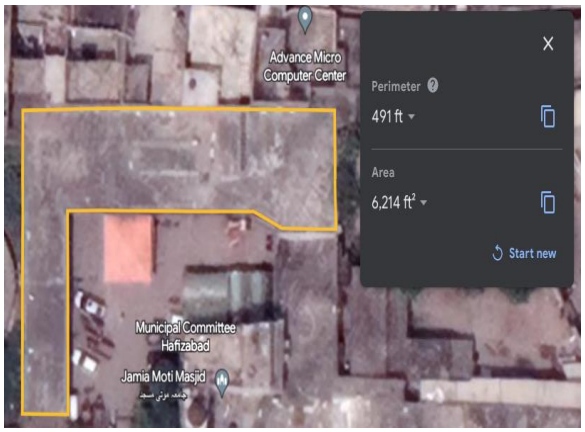


Figure 16: Location for Solar Installation-A

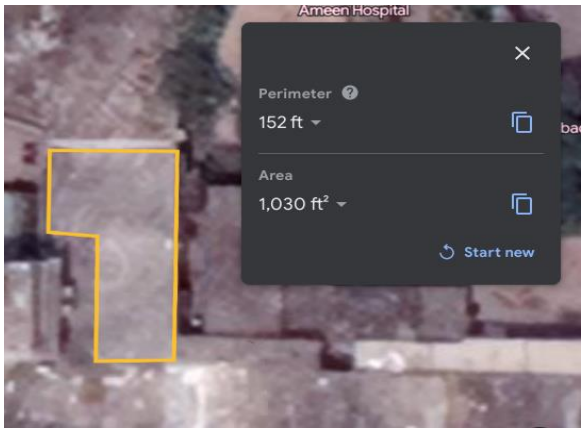


Figure 17: Location for Solar Installation-B

Table 40: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Total
Area availability (ft^2)	6,241	1,030	7,271
Solar system capacity (kW)	62	10	72

6.2 MOI Branch

The project site i.e. MOI branch is located near Jinnah Public Hall, Ketchary Rd, Hafizabad, Punjab, Pakistan while the geographical co-ordinates of location are 32.071337°N (latitude) and 73.68784°E (longitude).

Figure 18: Figure 6: Aerial view of MOI Branch

6.2.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to February 2023, it is identified that the annual energy consumption of MOI Branch is 17,460 kWh[8] with the peak electricity consumption of 4,529 kWh in April 2022. The annual energy consumption for MOI Branch cannot be accurately determined as this meter is shared with water supply pump set. Therefore, the Consultant has only carried out the assessment of installation capacity of solar system.

6.2.2 Roof Assessment

As per the Consultant's assessment, the total area of the MOI Branch is 33,756 ft^2 whereas, the total area of rooftop available for the solar installation is 3,728 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

Figure 19: Top View of the building

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

[8] Jinnah Hall water supply pump set is the main consumer of this annual electricity consumption.

Figure 20: Location for Solar Installation

Table 41: System Size Calculation with Respect to Area

Parameters	Location
Area availability (ft²)	2,366
Solar system capacity (kW)	23

6.3 Bus Stand

The project site i.e. Bus Stand is located near General Bus Stand, Gujranwala Rd, Hafizabad, Punjab, Pakistan while the geographical co-ordinates of location are 32.071077°N (latitude) and 73.69481°E (longitude).

Figure 21: Aerial View of Bus Stand

6.3.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption of Bus Stand 5,301 kWh with the peak electricity consumption of 997 kWh in December 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 42: 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	15122460202200	5,301	442	997	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 Slaughterhouse

The project site i.e. Slaughterhouse office is located near Hafizabad, Punjab, Pakistan while the geographical co-ordinates of location are 32.07234°N (latitude) and 73.65886°E (longitude).

Figure 22: Front View of the Slaughterhouse

Figure 23: Aerial view of the Slaughterhouse

6.4.1 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 Slaughterhouse is 9,700 kWh with the peak electricity consumption of 1,749 kWh in June 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 43: 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	16122470919000	9,700	808	1,749	7

6.4.2 Roof Assessment

As per the Consultant's assessment, the total area of the Slaughterhouse is 19,063 ft^2 whereas, the total area of rooftop available for the solar installation is 6,175 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

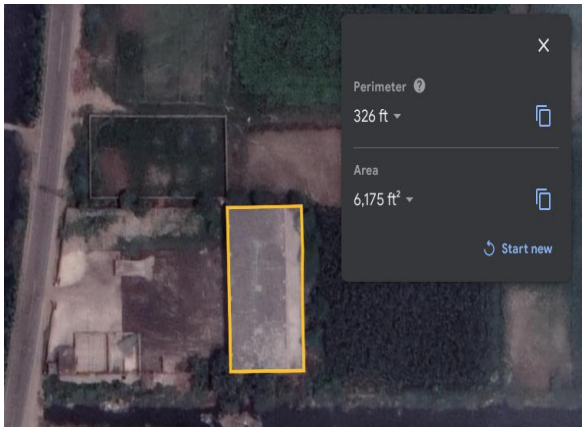


Figure 24: Top View of the building

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

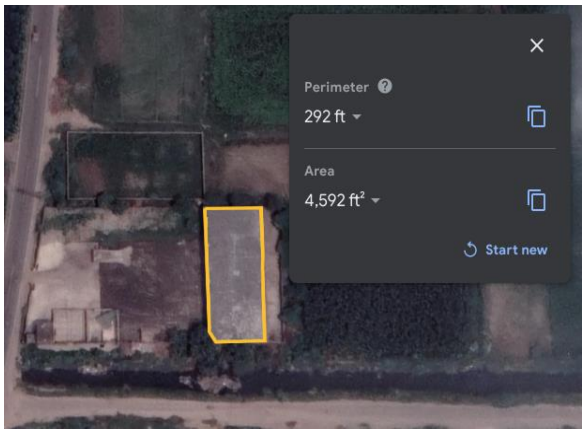


Figure 25: Location for Solar Installation

Table 44: System Size Calculation with Respect to Area

Parameters	Location
Area availability (ft²)	4,592
Solar system capacity (kW)	46

6.5 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.

6.5.1 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.

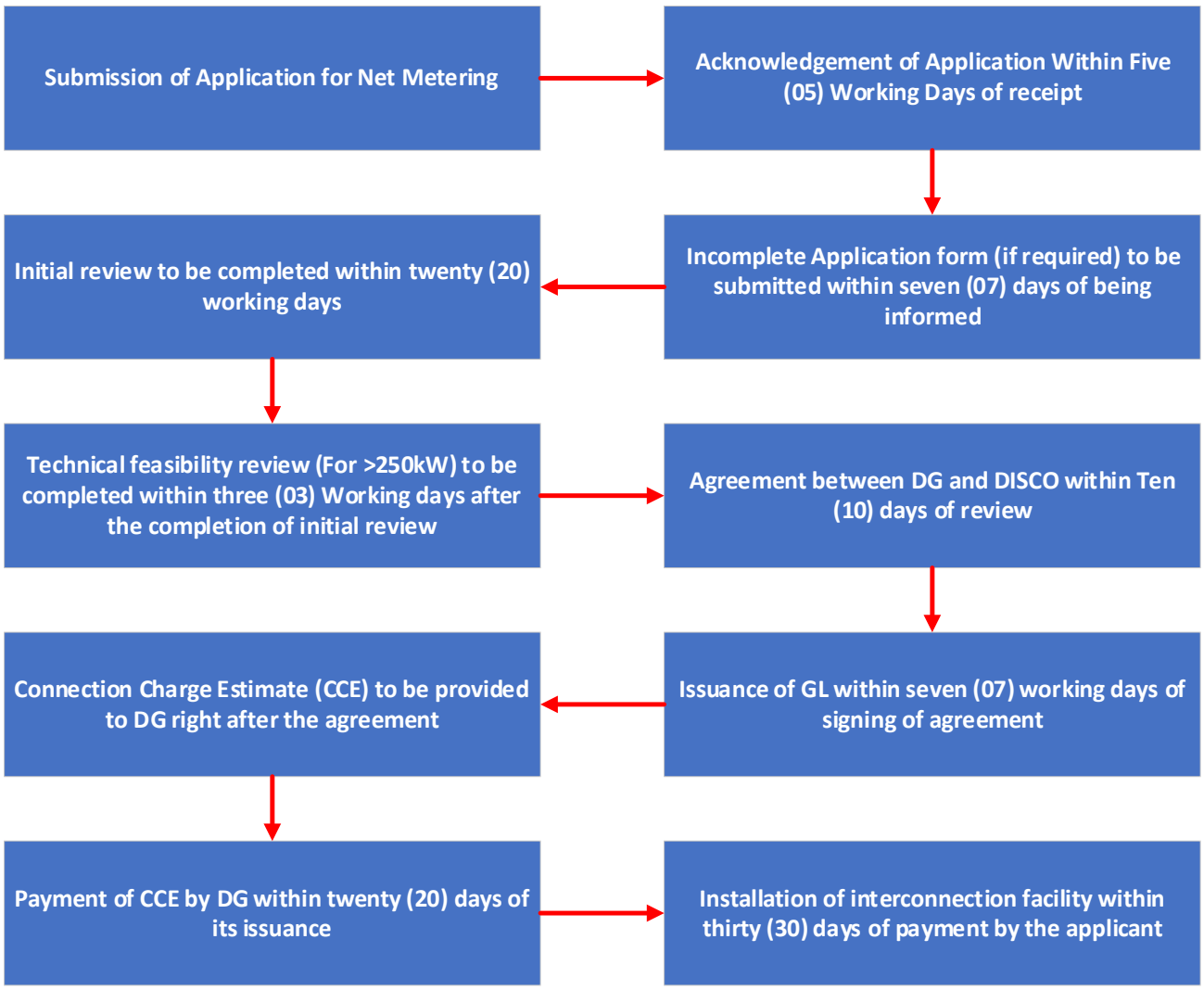


Figure 26: Pakistan Net Metering Application Process

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 (MC office Pump No. 3 - Unique ID: 81506175)

Study & Investigation

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

Recommended Action

Replacement of Pump with new PECO 10WC 3-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 45: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	153
Design Head of Existing Pump	ft	150
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	157
Measured Head	m	20.7
Measured Motor Power	kW	24.60
Pump Efficiency	%	42%
Existing Operational Hours	h	8.0
Proposed Pump Flow	m^3/h	153
Proposed Head	m	25
Power Consumption of Proposed Pump	kW	17.9
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	8.2
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	64,944
Energy Required by Proposed Pump	kWh/y	48,444
Saving Potential	kWh/y	16,500
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,650
Investment	US $	4,151
Simple Payback Period	months	19

7.1.2 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Mian Da Kot - Unique ID: 81506182)

Study & Investigation

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

Recommended Action

Replacement of Pump with new PECO 10WC 3-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 46: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	153
Design Head of Existing Pump	ft	150
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	149
Measured Head	m	17.6
Measured Motor Power	kW	32.00
Pump Efficiency	%	26%
Existing Operational Hours	h	10.0
Proposed Pump Flow	m^3/h	153
Proposed Head	m	25
Power Consumption of Proposed Pump	kW	17.9
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	9.8
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	105,600
Energy Required by Proposed Pump	kWh/y	57,591
Saving Potential	kWh/y	48,009
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	7,710
Investment	US $	4,151
Simple Payback Period	months	6

7.1.3 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Family Park - Unique ID: 81506190)

Study & Investigation

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

Recommended Action

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

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

Saving Assessment

Table 47: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	153
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	37
Measured Flow	m^3/h	53
Measured Head	m	17.1
Measured Motor Power	kW	16.03
Pump Efficiency	%	18%
Existing Operational Hours	h	10.0
Proposed Pump Flow	m^3/h	153
Proposed Head	m	25
Power Consumption of Proposed Pump	kW	17.9
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	3.5
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	52,910
Energy Required by Proposed Pump	kWh/y	20,584
Saving Potential	kWh/y	32,326
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	5,191
Investment	US $	4,151
Simple Payback Period	months	10

7.1.4 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 48: 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	Jinnah Hall	81506176	2.5	3.0	50	150
2	Family Park	81506190	2.5	3.0	50	150
3	Hussain Pura	81506193	2.5	3.0	50	150
4	Madrian wala	81506188-D	2.5	3.0	50	150
5	Ghari Awan Disposal	81506196-C	5.0	3.0	50	150
6	Ghari Awan Disposal	81506196-E	2.5	3.0	50	150
Total						**900**

7.1.5 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 28 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 49: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	3,311,875
Annual Water consumption (post-implementation)	m^3/y	3,278,756
Annual Water saving per year	m^3/y	33,119
Estimate of Investment (including the cost of the server)	US$	28,000

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 320 streetlights are being operated by the municipality. Out of these, 19 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 27: 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 50: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	19
Number of non-functional streetlights (>20 feet)	#	1
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	18

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	24
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	972,971
Proposed number of photocell switches	#	6
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	6,000
Upfront investment cost	PKR	978,971
Upfront investment cost	US$	3,494
Annual Operating Electricity unit	kWh/yr	1,663
Annual Operating Cost	PKR/yr	74,835
Annual maintenance cost	PKR/month	1,440,000
Monthly O&M Cost	PKR/month	126,236
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 320 streetlights operated by municipality out of which 301 are operational. 292 of the operational streetlights were LEDs so they are not recommended for replacement.

Out of the 9 operational non-LED streetlights, all are installed at a height of 20 feet or more.

Recommended Action

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

Saving Assessment

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

Table 51: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	9
Number of functional streetlights (>20 feet)	#	9
Wattage of proposed LED lights	Watt	50

Parameters	Unit	Value
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	0
Wattage of proposed LED lights	Watt	24
Cost of LED light with fittings	PKR	1,200
Upfront investment cost	PKR	484,857
Upfront investment cost	US$	1,730
Annual Operating Electricity unit	kWh/yr	1,553
Annual Electricity Consumption of Existing Lights	kWh/yr	8,281
Financial Savings	US$/yr	1,081
Payback	months	19

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 52: Replacement of inefficient equipment at office buildings

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment (Watt)	Overall Wattage of Proposed Equipment (Watt)	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters (PKR)
Main MC Building											
1	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
2	Electric Rod	3	400	1200	2,995	Flood LED 200 Watts	200	600	1,498	25,000	75,000
	Total										**75,350**

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 53: Saving & cost benefit analysis

Parameters	Unit	Value
Average Operational Days for Building Lighting Equipment	days/year	312
Average Operational Hours for Building Lighting Equipment	Hours/day	8
Energy consumption of inefficient Equipment	kWh/yr	3,055
Energy consumption of Proposed Equipment	kWh/yr	1,530
Energy Savings	kWh/yr	1,525
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	245
Upfront Investment (including change in fixtures)	USD	269
Payback Period	Months	13

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 WC /3 Stages, 30hp Motor

Pump Size		10 WC /3 Stages			
Capacity		152.9 m3/hr	Max. O.D bowl		9.5 Inches
Speed		1450 rpm	I.D tubewell	-	
Pump Input		30 HP	Length of suction pipe		
Prime Mover (SEM/DE)		30 HP			
			Length of bowl assembly		
			Length of column pipe		0
			Length of top pipe		1 Ft
			Total length of column		1 Ft

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

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

Price of pumping unit as specified above

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

8.2 Investment Estimate (including Material Specification/Quantities) Streetlights

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

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 50W	50	7000 Lm	140 Lm/Watt	1	53,873	53,873
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	18	51,061	919,098
3	Accessories	Photocell switch				6	1,000	6,000

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
Lumpsum Price (PKR)								**978,971**
Lumpsum Price (USD)								**3,494**

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 50W	50	7000 Lm	140 Lm/Watt	1	53,873	484,857
Lumpsum Price (PKR)								**484,857**
Lumpsum Price (USD)								**1,730**

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	1	13	350	350
2	Flood LED 200 Watts	200	3	200	25,000	75,000
Lumpsum Price (PKR)						**75,350**
Lumpsum Price (USD)						**269**

9 Summary of Energy Efficiency Measures

MC Hafizabad's annual energy consumption is 2,241,786 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$ 16,877** with an estimated investment of **US$ 46,845**
- Reduce electricity consumption by approx. **105,088 kWh**
- Reduce GHG Emissions by **53 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of GEPCO

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