Khanewal Municipal Committee

Energy Audit Report

June 2023

History of the Document

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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 Khanewal MC Background

Khanewal is the capital of Khanewal District in the Punjab province of Pakistan. According to the 2017 Census of Pakistan, its population is 227,059. It is the 36th biggest city of Pakistan by population. The city is located at 30.3000 N, 71.9333 E.

Khanewal an old subdivision of Multan district was upgraded as district w.e.f 1st July 1985 comprising 4 subdivisions namely Khanewal, Kabirwala, Mian Channu and Jahanian. It was given the status of an area committee which was upgraded as municipal committee in the year 1933. In the year 1904 a railway colony was setup here and Multan Faisalabad railway line was started. Resultantly it became an important railway junction which played an important role in development of this town.

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 Khanewal MC has the following management.

Sr. No.	Name of Officer	Designation
1	Ms. Azhuba Azeem	Administrator
2	Mr. Iftikhar Bangash	Chief Officer
3	Mr. Zain Ali*	Municipal Officer (Infrastructure)
4	Mr. Rehman Latif	Municipal Officer (Regulation)
5	Mr. Abrar Ahmed	Municipal Officer (Finance)
6	Ms. Kaneez Fatima	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Khanewal

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	401,521
Electrical energy used by Wastewater Disposal[2]	kWh/year	345,815
Electrical energy used in Buildings[3]	kWh/year	108,930
Electrical energy used by Streetlights[4]	kWh/year	159,951
Diesel used by Vehicles	liter/year	75,132

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)	0.24
2	Energy Density of Wastewater Disposal	(kWh/m^3)	0.10
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)	10.94
5	Energy Cost on Wastewater Disposal	(PKR/m^3)	4.34
6	Energy Cost on Wastewater Treatment	(PKR/m^3) – if applicable	No wastewater treatment is carried out

1.5.2 Streetlights

Table 3: KPIs for Streetlights

Sr. No.	Description	Unit	KPI
1	Average electricity consumed per kilometer of lit roads	(kWh/km)	2,258
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	99
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	45,282
		PKR/Lighting Equipment	38,283

[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
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)	224,717
6	Average daily duration of operation	(Hour)	10.3
7	Average energy costs per kilometer of lit roads	(PKR/km)	101,615
8	Average energy costs per light pole/fixture	(PKR/ fixture)	4,449
9	Number and percentage of failed public lights		66%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	29.51
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.93
3	Average Energy Cost of Heating	(PKR/m^2)	42
4	Average Energy Cost of Cooling	(PKR/m^2)	545
5	Average Energy Cost of Lighting	(PKR/m^2)	280

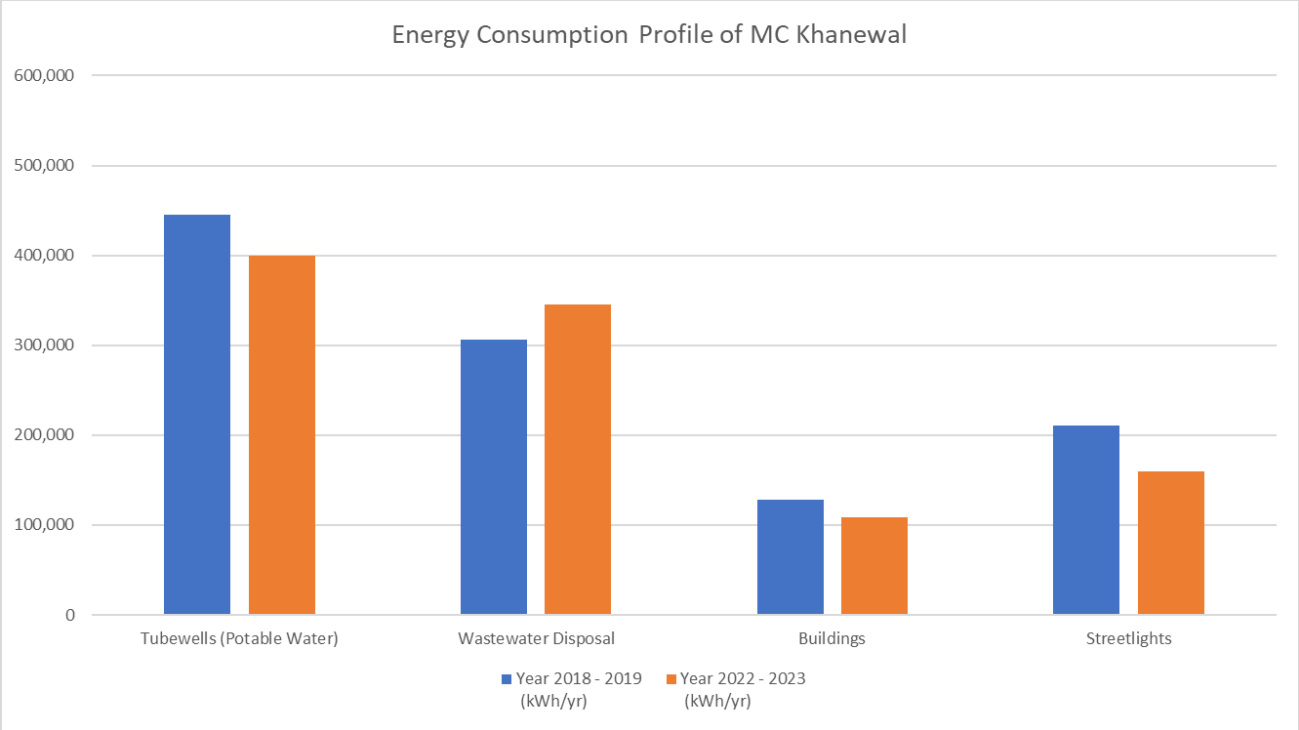
1.5.4 Vehicles

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	3.73
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	79

1.6 Impact of Energy Efficiency Investment

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


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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	7	9	445,425	400,127	45,298	0.18 kWh/m3	0.24 kWh/m3	Replacement of 1 Pumpset was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 4 pump which has resulted in significant reduction in the energy consumption for water supply. All the replaced pumpsets are working efficiently. However, the MC is not currently receiving bills on the newly installed pumpsets due to which the savings are not reflected in the KPIs as these new pumpsets cannot be made part of the KPI calculations.
2	Wastewater Disposal	9	5	305,939	345,815	-39,876	0.08 kWh/m3	0.06 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. The overall energy consumption per cubic meter of wastewater disposed has decreased.
3	Buildings	3	3	119,690	108,930	19,164			The KPI for municipal buildings cannot be

		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
									accurately determined as the two of the three electricity meters in the MC buildings are shared with water supply and disposal pumpsets. The remaining third bill belongs to a slaughterhouse with very low power consumption due to which it has not been included in the KPI calculations.
4	Streetlights	399	608	210,500	159,951	50,549	2,961 kWh/km	2,258 kWh/km	Based on the previous assessment, there were only 399 MC owned operational lights with an average consumption of 527kWh/light/annum, whereas, currently there are 608 operational lights with average energy consumption of 263kWh/light/annum. The MC has significantly improved the 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 (Colony No. 2 water supply - Unique ID: 31206462)	18,742	4,026	1,128,002	3,010	843,378	16	9
Replacement/Installation of Capacitors	Not Quantifiable	1,350	378,270	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	215,477	60,376,702	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	14,633	3,499	980,540	2,350	658,495	18	7
Total:	**33,375**	**224,352**	**62,863,514**	**5,360**	**1,501,872**		**17**

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	32,547	12,614	3,534,457	5,227	1,464,609	29	19
Total:	**32,547**	**12,614**	**3,534,457**	**5,227**	**1,464,609**	**29**	**19**

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	24,868	30,000	8,406,000	0	0	0	Not Quantifiable
Total:	**24,868**	**30,000**	**8,406,000**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Khanewal MC has seventeen (17) tubewells for groundwater, all of which are manually operated. Out of these, 9 pumpsets were found to be in working condition.

The MC has six (6) disposal station having thirteen (13) pumps. Out of these 5 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are four (4) dewatering sets in the MC, out of which 3 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 five (5) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake audit of the following pumpsets as they have been abandoned by the MC
1. Colony No. 2 (Unique ID: 30108041)
2. T-Chowk (Unique ID: 31206443)
3. Nizamabad Water Supply (Unique ID: 31206449)
4. Purana Kohna (Unique ID: 31206454)
5. Peoples Colony - 2 (Unique ID: 31206446-2)
6. Peoples Colony - 3 (Unique ID: 31206446-3)
7. T-Chowk-2 (Unique ID: 31306144+48)
8. Water Works School 11-B (Unique ID: 31207771)

(iv) Undertake assessment of the following pumpset as no flow could be detected by the flowmeter
1. Peoples Colony (Unique ID: 31206446)

(v) Undertake assessment of the following disposal pumpset as the sites are under maintenance
1. Nizamabad (Unique ID: 31206448)
2. Khanewal Kohna Disposal (Unique ID: 31206455-B)
3. Tariqabad Disposal (Unique ID: 31206457-A)
4. Jahaniyan Bypass (Unique ID: 31206458-B)
5. Jahaniyan Bypass (Unique ID: 31206458-D)

(vi) Undertake assessment of the following disposal pumpset as there wasn't enough water in the well
1. Tariqabad Disposal (Unique ID: 31206457-B)

2. Tariqabad Disposal (Unique ID: 31206457-C)
3. Tariqabad Disposal (Unique ID: 31206457-D)

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	30108040	Colony No. 1 Near School No. 4	29-15912-0325900	Turbine	KSB	1986	Siemens	1983	30.29274	71.92442
2	30108041	Colony No. 2	27-15911-0563805	Turbine	KSB	1987	N/A	1087	30.295	71.92879
3	31206441	T-Chowk Fire brigade	28-15911-0173100	Turbine	Peco	1998	Siemens	1998	30.30327	71.92336
4	31206443	T-Chowk		Turbine	N/A	N/A	N/A	N/A	30.30291	71.92324
5	31206446	Peoples Colony	28-15911-0324000	Turbine	KSB	1997	Siemens	1998	30.30607	71.93811
6	31206449	Nizamabad Water Supply	19-15911-0062403	Turbine	KSB	2004	Siemens	2004	30.30583	71.94237
7	31206452	Old Khanewal Water Supply	01-15911-1476900	Turbine	KSB	2016	Siemens	2016	30.31815	71.92357
8	31206453	Khanewal Highway Colony	27-15911-2374912	Turbine	Peco	1998	Peco	1998	30.31476	71.92147
9	31206454	Purana Kohna	27-15911-1476510	Turbine	N/A	N/A	N/A	N/A	30.31291	71.92561
10	31206459	Stadium Water Supply	82-15911-0837100	Turbine	KSB	2020	Siemens	2020	30.29412	71.91627
11	31206460	Sabzi Mandi Water Supply	28-15911-0883100	Turbine	KSB	2020	Siemens	2020	30.29793	71.91941
12	31206461	Thana Ground	28-15911-0645802	Turbine	KSB	2020	Siemens	2020	30.30126	71.9236
13	31206462	Colony No. 2 water supply	27-15911-0563805	Turbine	Meco Pump	2010	Siemens	2010	30.29578	71.92918
14	31206446-2	Peoples Colony - 2	NA	Turbine	N/A	N/A	N/A	N/A	30.30607	71.93811
15	31206446-3	Peoples Colony - 3	NA	Turbine	N/A	N/A	N/A	N/A	30.30607	71.93811
16	31306144+48	T-Chowk-2	27-15911-0173205	Turbine	N/A	N/A	Beco	N/A	30.30324	71.9239
17	31207771	Water Works School 11-B	27-15911-0563806	Turbine	KSB	2020	Siemens	2020	30.28972	71.93

2.1.2 Dewatering Sets

Table 10: Inventory Table of Dewatering Set

Sr. No.	Unique ID	Location	Quantity	Latitude	Longitude
1	31806572 A	Chak Shahana Road, Canal colony Khanewal	1	30.298955	71.932356
2	31806572 B	Girls College Road Khanewal	1	30.300235	71.923283
3	31806572 C	GPO khanewal	2	30.300229	71.922902
4	31806572 D	Sir syed Road Khanewal	1	30.297768	71.91939

2.1.3 Disposal Works

Table 11: 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	31206447	Peoples Colony	28-15911-0313900	Centrifugal	KSB	1.5	Siemens	25	30.30546	71.93938
2	31206448	Nizamabad	28-15911-0015805	Centrifugal	KSB	1.5	Siemens	15	30.30286	71.94571
3	31206466	Malkabad Disposal	28-15911-0497801	Centrifugal	Siemens	1.5	Siemens	20	30.2936	71.94225
4	31206455-A	Khanewal Kohna Disposal	27-15911-1615130	Centrifugal	NA	5	Siemens	60	30.31042	71.91286
5	31206455-B	Khanewal Kohna Disposal	27-15911-1615130	Centrifugal	Local	2	Siemens	60	30.31042	71.91286
6	31206457-A	Tariqabad Disposal	28-15911-0836500	Centrifugal	KSB	5	Siemens	60	30.29413	71.90917
7	31206457-B	Tariqabad Disposal	28-15911-0836500	Centrifugal	KSB	5	Siemens	60	30.29413	71.90917
8	31206457-C	Tariqabad Disposal	28-15911-0836500	Centrifugal	KSB	5	Siemens	60	30.29413	71.90917
9	31206457-D	Tariqabad Disposal	28-15911-0836500	Centrifugal	KSB	10	Siemens	125	30.29413	71.90917
10	31206458-A	Jahaniyan Bypass	27-15912-2371008	Centrifugal	KSB	4	Siemens	40	30.2731	71.90003
11	31206458-B	Jahaniyan Bypass	27-15912-2371008	Centrifugal	KSB	4	Siemens	40	30.2731	71.90003
12	31206458-C	Jahaniyan Bypass	27-15912-2371008	Centrifugal	KSB	4	Siemens	40	30.2731	71.90003
13	31206458-D	Jahaniyan Bypass	27-15912-2371008	Centrifugal	N/A	N/A	N/A	N/A	30.2731	71.90003

2.1.4 Filtration Units

Table 12: Inventory of Filtration Units

Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East
1	30108042	Jaswart Nagar	Centrifugal	1	Pak Punjab	N/A	Pak Punjab	30.29385	71.93159
2	30208043	Habit Kot	Centrifugal	1	Goldamatic Pump	N/A	Goldamatic Motor	30.3079	71.92133
3	30208044	Deene Wala	Centrifugal	1	Asli Punjab	N/A	Asli Punjab	30.33387	71.8978
4	30208045	City Park	Centrifugal	1	Pak Punjab	N/A	Pak Punjab	30.30029	71.91583
5	30208046	Bakhtyar Garden	Centrifugal	1	NA	N/A	NA	30.28066	71.90879
6	31206450	Nizamabad	Centrifugal	1	Golden Pump	N/A	Golden Motor	30.309	71.94389
7	31206451	Zaheerabad	Centrifugal	1	Pak Punjab	N/A	Pak Punjab	30.31576	71.96655
8	80208323	Nasir Park (Tariqabad)	Centrifugal	1	Golden Pump	N/A	Golden Motor	30.29586	71.91241
9	80208324	Kot Ala Singh	Centrifugal	1	Golden Pump	N/A	Golden Motor	30.28507	71.91713
10	80208325	Jami Saedia	Centrifugal	1	Golden Pump	N/A	Golden Motor	30.29102	71.92768
11	30108040-1	Colony No. 1 Near School	Connected with Colony No 1 Near School # 4 (30108040) Pump Station					30.29274	71.92442
12	31206441-1	T-Chowk	Connected with T chowk (31206441) Pump Station					30.30288	71.92339
13	31206446-1	Peoples Colony	Connected with Peoples Colony (31206446) Pump Station					30.30607	71.93811
14	31206453-1	Khanewal Kohana	Connected with Khanewal Highway Colony (31206453) Pump Station.					30.31785	71.92147

Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East
15	31206462-1	Colony No. 2 Water Supply	Connected with Colony No . 2 water Supply (31206462) Pump Station					30.29578	71.92918
16	31207772	Chak No. 84	Have its own Bore.					30.32147	71.98315
17	31207773	Chak No. 88	Have its own Bore.					30.29963	71.93169

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

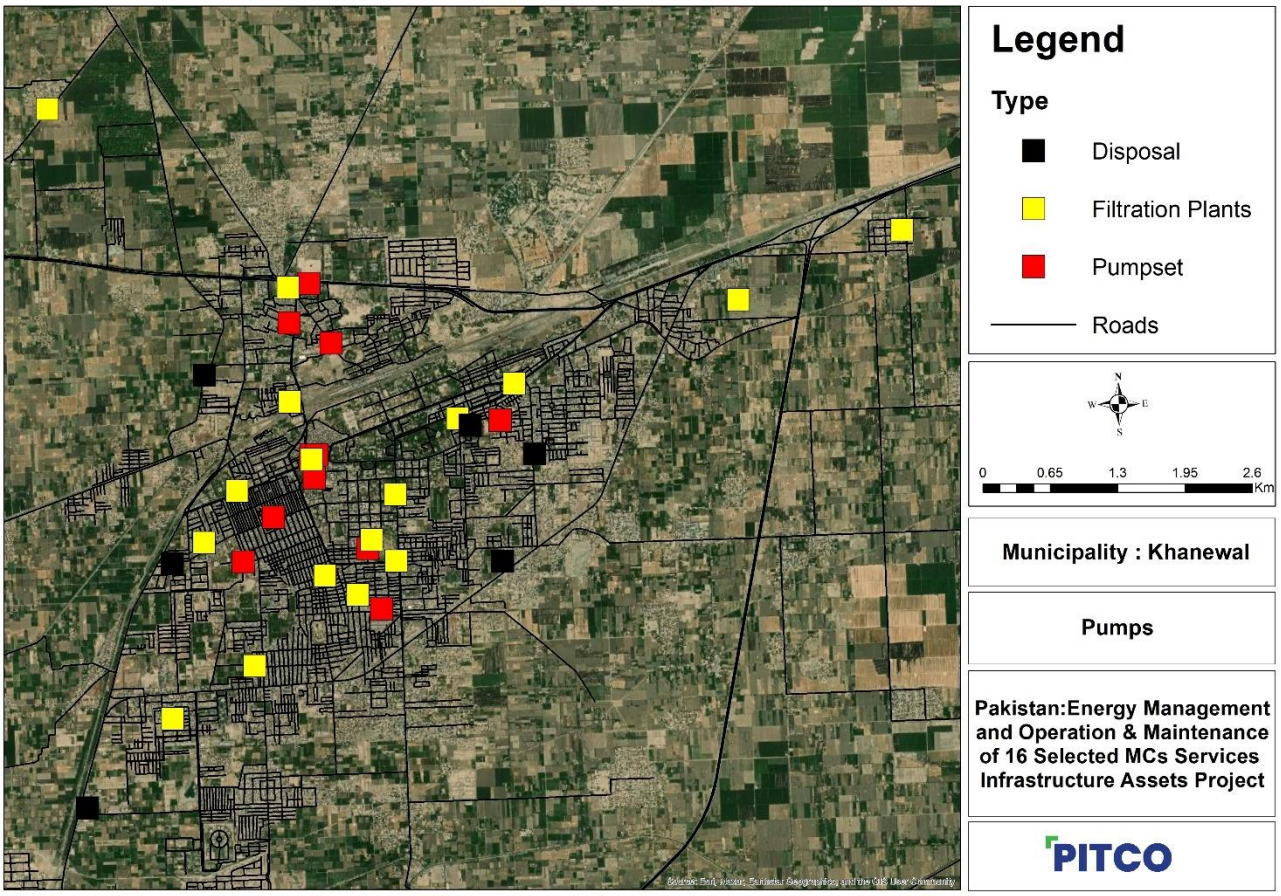


Figure 1: Map for Pumps and Disposal at MC Khanewal

2.3 Baseline Energy Consumption Trend

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

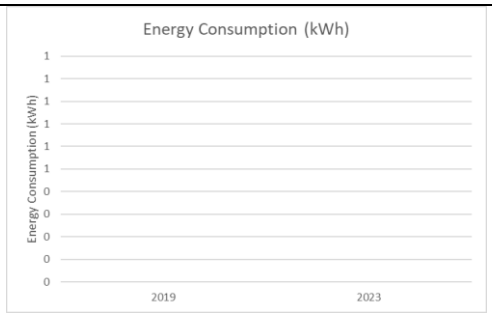
Table 13: Baseline Energy Consumption Trend

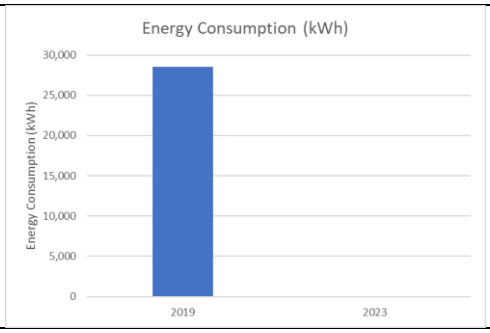
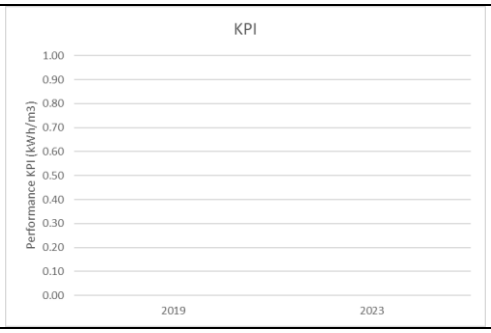
Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	400,127
Electrical energy used by Wastewater Disposal	kWh/y	345,815
Electrical energy used (Total)	kWh/y	745,942

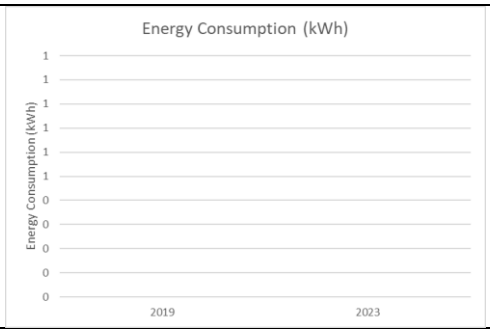
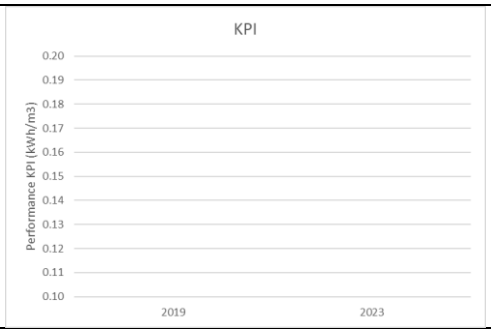
A comparison of current electricity consumption by the MC's water supply and disposal assets compared to results of the energy audit activity carried out in 2019, is presented in the following table:

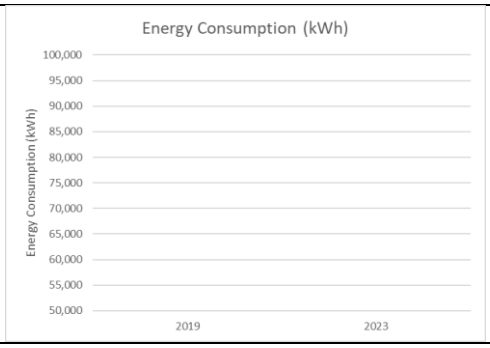
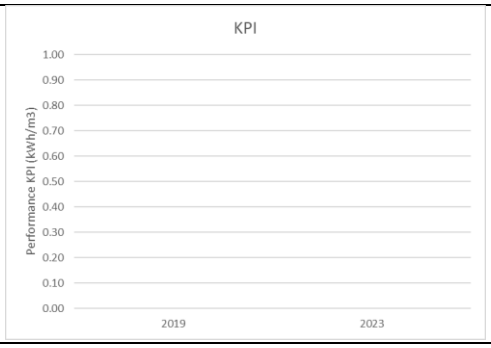
		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	7	9	445,425	400,127	45,298	0.18 kWh/m3	0.24 kWh/m3	Replacement of 1 Pumpset was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 4 pump which has resulted in significant reduction in the energy consumption for water supply. All the replaced pumpsets are working efficiently. However, the MC is not currently receiving bills on the newly installed pumpsets due to which the savings are not reflected in the KPIs as these new pumpsets cannot be made part of the KPI calculations.
2	Wastewater Disposal	9	5	305,939	345,815	-39,876	0.08 kWh/m3	0.06 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. The overall energy consumption per cubic meter of wastewater disposed has decreased.

Replacement of 1 Pumpset 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:

Stadium Water Supply - Unique ID (31206459)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	0 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. Efficiency of the new pumpset is satisfactory. i.e., above 55%. However, the MC is not currently receiving bill on this newly installed pumpset due to which the savings are not reflected in the KPIs. There are no KPI and billing calculations for 2019 audit, as this site was non-functional due to bore choked and there were no billing details available.	

Sabzi Mandi Water Supply - Unique ID (31206460)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
28,551 kWh	0 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. Efficiency of the new pumpset is satisfactory. i.e., above 55%. However, the MC is not currently receiving bill on this newly installed pumpset due to which the savings are not reflected in the KPIs. There is no KPI calculations for 2019 audit, as the flow was not be measured due to rusty condition of the delivery pipe.	

Thana Ground - Unique ID (31206461)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	0 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. Efficiency of the new pumpset is satisfactory. i.e., above 55%. However, the MC is not currently receiving bill on this newly installed pumpset due to which the savings are not reflected in the KPIs. There are no KPI and billing calculations for 2019 audit, as this site was non-functional and there were no billing details available.	

Water Works School 11-B - Unique ID (31207771)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
N/A	1,394 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. However, this site was under maintenance during the audit. Furthermore, the MC is not currently receiving bill on this newly installed pumpset due to which the no energy consumption has been reflected against this pumpset. No baseline data of 2019 audit is available for this 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.

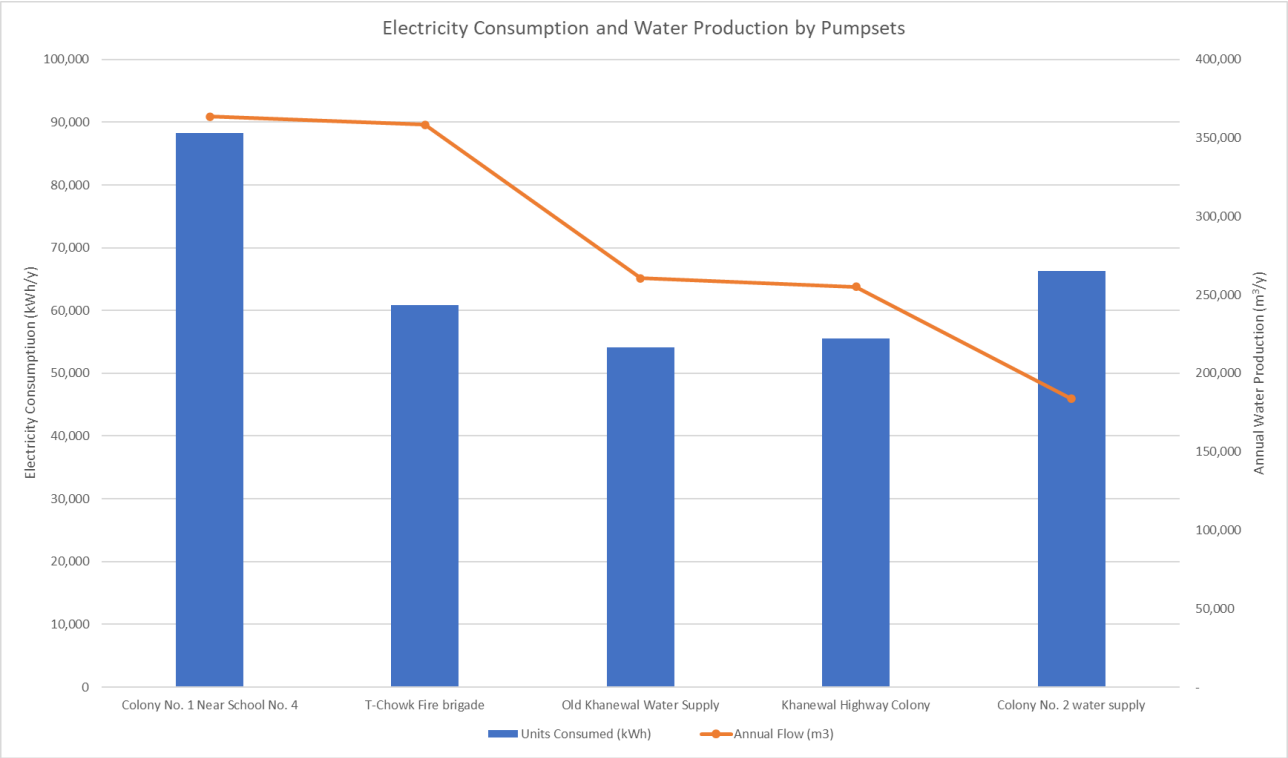
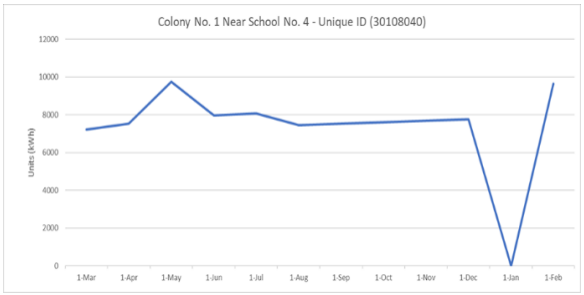


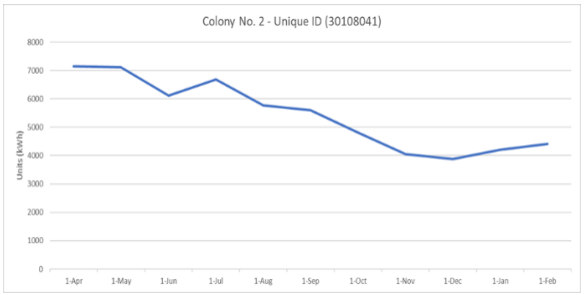
Figure 2: Electricity Consumption and Water Production by Pumpsets

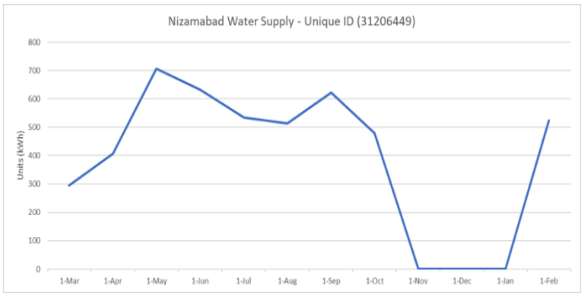
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

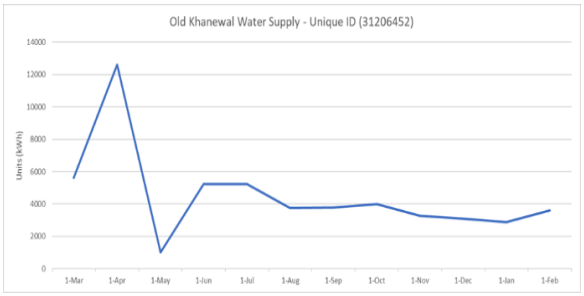
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

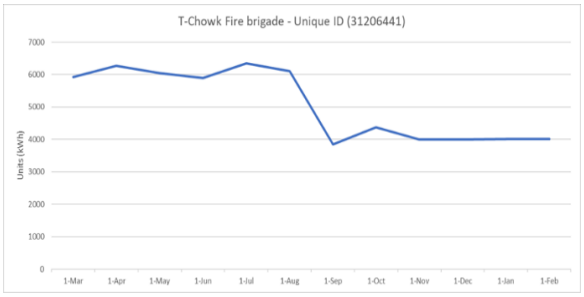
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

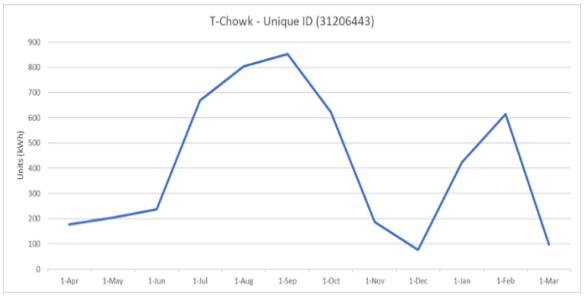


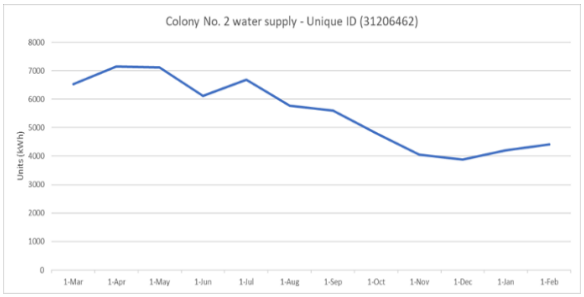


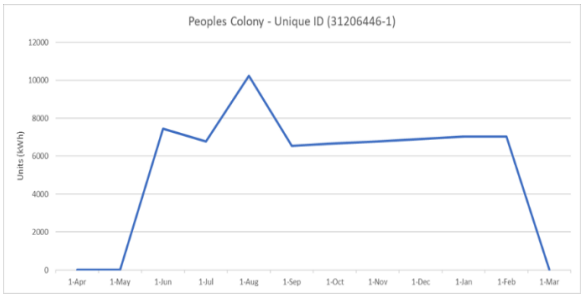

Nizamabad Water Supply - Unique ID (31206449)
Units (kWh)
800
700
600
500
400
300
200
100
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb

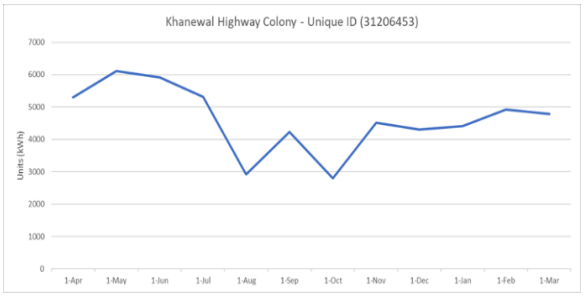

Old Khanewal Water Supply - Unique ID (31206452)
Units (kWh)
14000
12000
10000
8000
6000
4000
2000
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb

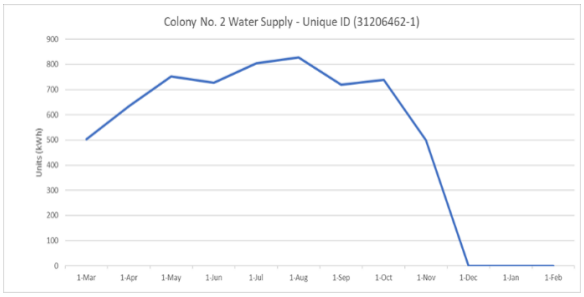

T-Chowk Fire brigade - Unique ID (31206441)
Units (kWh)
7000
6000
5000
4000
3000
2000
1000
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb

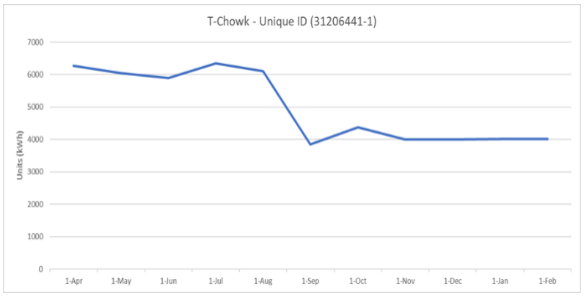

T-Chowk - Unique ID (31206443)
Units (kWh)
900
800
700
600
500
400
300
200
100
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar

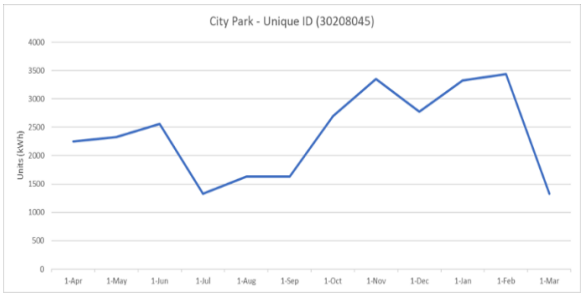

Colony No. 2 water supply - Unique ID (31206462)
Units (kWh)
8000
7000
6000
5000
4000
3000
2000
1000
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb

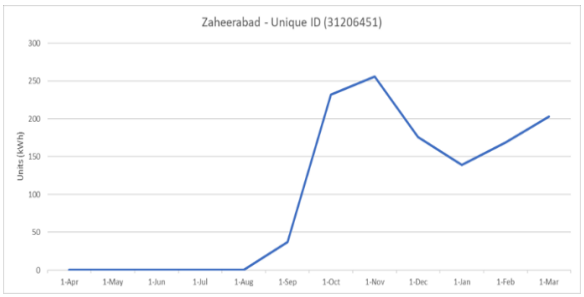

Peoples Colony - Unique ID (31206446-1)
Units (kWh)
12000
10000
8000
6000
4000
2000
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar

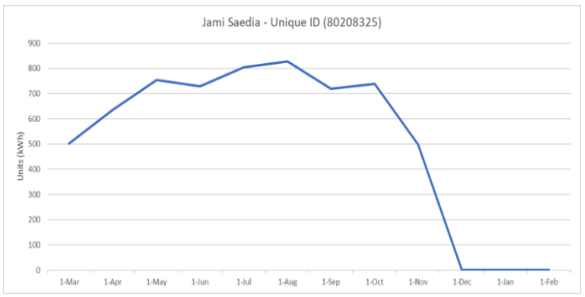

Khanewal Highway Colony - Unique ID (31206453)
Units (kWh)
7000
6000
5000
4000
3000
2000
1000
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar

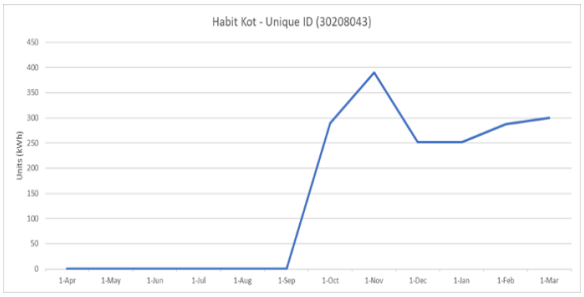

Colony No. 2 Water Supply - Unique ID (31206462-1)
Units (kWh)
900
800
700
600
500
400
300
200
100
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb

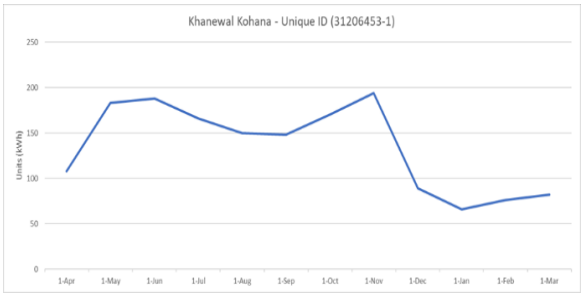

T-Chowk - Unique ID (31206441-1)
Units (kWh)
7000
6000
5000
4000
3000
2000
1000
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb


City Park - Unique ID (30208045)
Units (kWh)
4000
3500
3000
2500
2000
1500
1000
500
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar









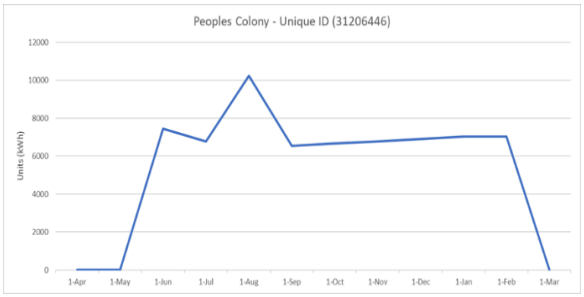
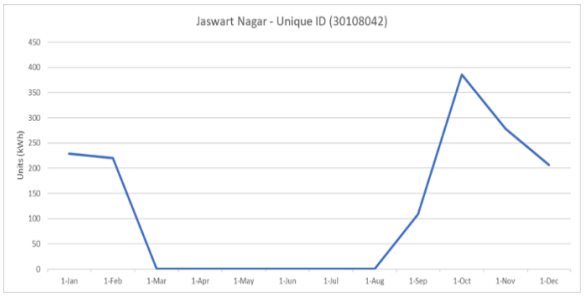
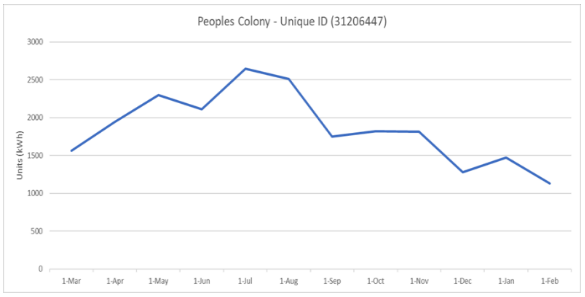
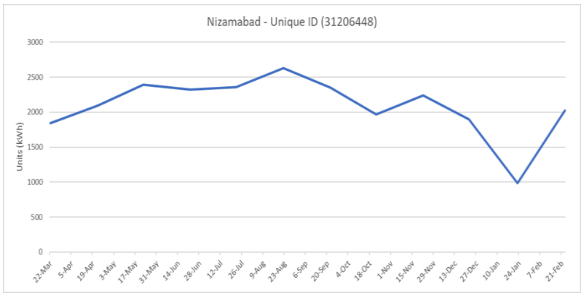


Figure 3: Energy Consumption Trend for Water Pumps







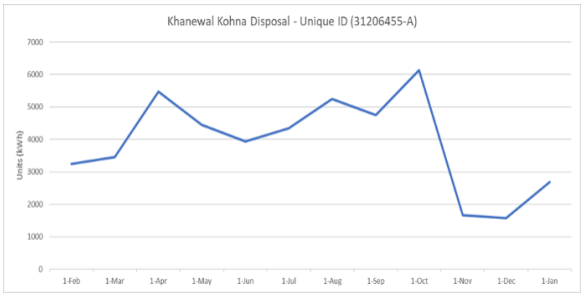


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Khanewal MC has seventeen (17) 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	30108040	Colony No. 1 Near School No. 4	Yes	Yes
2	30108041	Colony No. 2	No	No
3	31206441	T-Chowk Fire brigade	Yes	Yes
4	31206443	T-Chowk	Yes	No
5	31206446	Peoples Colony	Yes	No
6	31206449	Nizamabad Water Supply	Yes	No
7	31206452	Old Khanewal Water Supply	Yes	Yes
8	31206453	Khanewal Highway Colony	Yes	Yes
9	31206454	Purana Kohna	No	No
10	31206459	Stadium Water Supply	Yes	Yes
11	31206460	Sabzi Mandi Water Supply	Yes	Yes
12	31206461	Thana Ground	Yes	Yes
13	31206462	Colony No. 2 water supply	Yes	Yes
14	31206446-2	Peoples Colony - 2	Yes	No
15	31206446-3	Peoples Colony - 3	Yes	No
16	31306144+48	T-Chowk-2	No	No
17	31207771	Water Works School 11-B	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	30108040	Colony No. 1 Near School No. 4	203.9	91.8	29.54	15.87	55%	0.85	Efficiency of the pumpset is satisfactory. Sluice/gate valve is jammed. Previously, the efficiency of the pumpset was 58%.
2	31206441	T-Chowk Fire brigade	203.9	120.7	41.35	28.10	57%	0.75	Efficiency of the pumpset is satisfactory. No gate sluice/gate valve is installed. Previously, the efficiency of the pumpset was 59%.
3	31206452	Old Khanewal Water Supply	152.9	197.3	29.34	33.83	55%	0.84	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 58%.
4	31206453	Khanewal Highway Colony	203.9	193.2	28.84	31.07	57%	0.86	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 65%.
5	31206459	Stadium Water Supply	152.9	183.7	30.14	29.80	60%	0.77	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, this site was non-functional due to bore choked.
6	31206460	Sabzi Mandi Water Supply	152.9	156.3	37.11	29.10	64%	0.84	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, it was recommended to replace the pumpset.
7	31206461	Thana Ground	152.9	191.6	32.74	30.03	67%	0.75	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, this site was non-functional.
8	31206462	Colony No. 2 water supply	152.9	139.2	38.21	36.60	47%	0.59	Efficiency of the pumpset is not satisfactory. Sluice/gate valve is jammed. Previously, the efficiency of the pumpset was 57%.

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

Table 16: Pumpset Secondary Performance Parameters

Unique ID	Motor Vibration Hz	Temperature of Motor	Winter Operational Hours	Summer Operational Hours	Motor Rated kW	Motor Rated Efficiency	Transformer kVA	Elec. Connection	Line Leakage	Motor Rated RPM	Rated Head of Pump	Motor Rated Voltage V	Full Load PF	PF (Measured)	Load factor %	Observations
30108040	73.46	47	3	3	37	-	100	Safe	OK	37	140	-	-	0.85	43%	
31206441	79.58	41	8	10	45	-	100	Safe	Not Ok	45	70	400	0.87	0.75	63%	Low PF
31206452	18.45	43	4	4	37	91	100	Safe	Ok	37	175	400	0.86	0.84	91%	
31206453	265.26	40	4	4	45	-	100	Safe	OK	45	140	365	0.90	0.86	69%	
31206459	79.58	41	8	12	37	91	100	Safe	-	37	175	400	0.86	0.77	80%	Low PF
31206460	185.68	44	4	4	37	91	100	Safe	Ok	37	175	400	0.86	0.84	78%	
31206461	318.31	30	4	4	37	91	100	Safe	Ok	37	175	400	0.86	0.75	81%	Low PF
31206462	0.00	56	3	5	45	-	100	Unsafe	Not Ok	45	200	380	0.86	0.59	82%	Low PF

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	31206452	Old Khanewal Water Supply	153	37.3	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	197.3	29.3	Flow at Existing Operating Conditions	33.83	55%
2	174.6	35.7	Flow nearest to duty point	34.13	58%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
2	31206459	Stadium Water Supply	153	37.3	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	183.72	30.1	Flow at Existing Operating Conditions	29.8	60%
2	154.69	37.2	Flow nearest to duty point	29.1	63%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
3	31206460	Sabzi Mandi Water Supply	153	37.3	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	156.27	37.1	Flow at Existing Operating Conditions is nearest to duty point	29.1	64%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
4	31206461	Thana Ground	153	37.3	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	191.616	32.7	Flow at Existing Operating Conditions	30.03	67%
2	164.63	38.4	Flow nearest to duty point	29.5	69%

2.4.3 Wastewater Disposal System

The MC has six (6) disposal station having thirteen (13) centrifugal 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	31206447	Peoples Colony	152.9	260.1	6.71	14.00	40%	Efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was 39%.
2	31206466	Malkabad Disposal	152.9	137.8	8.53	9.20	41%	Efficiency of the pumpset is satisfactory. Previously, it was suggested to replace the pump impeller.
3	31206455-A	Khanewal Kohna Disposal	203.9	246.2	15.24	31.60	38%	Efficiency of the pumpset is is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, efficiency of the pumpset was 41%.
4	31206458-A	Jahaniyan Bypass	407.8	467.1	3.66	13.30	41%	Efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was 58%.
5	31206458-C	Jahaniyan Bypass	407.8	467.1	3.66	12.20	45%	Efficiency of the pumpset is satisfactory. Previously, this site was non-functional.

Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are four (4) dewatering sets in the MC, out of which 3 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	30108040	Colony No. 1 Near School No. 4	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
2	31206441	T-Chowk Fire brigade	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
3	31206452	Old Khanewal Water Supply	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
4	31206459	Stadium Water Supply	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
5	31206461	Thana Ground	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
6	31206462	Colony No. 2 water supply	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 10 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
7	31206466	Malkabad Disposal	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
8	31206455-A	Khanewal Kohna Disposal	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
9	31206458-A	Jahaniyan Bypass	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
10	31206458-C	Jahaniyan Bypass	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
General Observations				
24	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
25	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 MEPCO during the entire year are given in Annexure 1.
26	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

Sr No.	Unique ID	Location	Comments	Recommendation
				of operation and other maintenance details on a regular basis.
27	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 Khanewal 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	608	608	
Non Operational Street Lights	1,170	1,170	
Total	**1,778**	**1,778**	**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 337 light fixtures installed on PC, 485 fixtures are installed on steel structure, 255 fixtures are installed on tubular structure, 4 fixtures are installed on trees, 510 fixtures are installed on wires, 25 fixtures are installed on wall, and 4 fixtures are installed on the ground. The streetlights' structural classification is tabulated below.

Table 21: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Tree	Wires	Wall	Ground	Grand Total
MC	337	483	255	4	510	25	4	**1,618**
Private								0

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

Table 22: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	T-Chowk	18	28159110978310	0.530
2	LED No. 1 Near Judge Colony	23	#N/A	0.595
3	LED No. 2 Near Babu Welfare	20	#N/A	0.553
4	LED No. 3 Near Jama Abad	18	#N/A	0.492
5	Mujahid Abad	51	28159110044501	2.520
6	Gulberg Town	53	28159110044502	2.750
7	People Colony	87	28159110066401	4.252
8	Basti Zahoorabad Grid Road.	13	05159130359406	0.504
9	Khurram Pura	37	28159110066402	1.851
10	Bilali Masjid	26	28159122370400	1.059
11	Colony No. 2	84	28159122374914	2.735
12	Basti Zahoorabad	4	28159110359404	0.128
13	Kamran Colony	57	28159122370200	1.572

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
14	Old Khanewal	76	28159110051800	2.677
15	Old Camp	4	#N/A	0.143
16	Civil Line	76	28159110507001	3.438
17	Habit Court	26	28159110091900	1.015
18	Islam Park	50	28159110192100	1.576
19	Colony No. 1	38	28159122374913	1.850
20	Basti Chan Shah	13	28159110992901	0.511
21	Gareeb Abad	41	28159122374912	3.141
22	Basti Tariq Abad Gau Shala	43	28159110718301	2.101
23	Bukhtari Garden	76	20159120694715	2.375
24	Fazal park	26	14159120196800	0.693
25	Kot Alla Singh 1	63	28159122370700	2.517
26	Marzi Pura	20	28159122370500	0.770
27	Godam Road Tariqabad	71	28159110722501	3.528
28	Kot Alla Singh 2	7	28159122370600	0.387
29	Court Meebal	28	14159120235100	0.653
30	Block No. 14	41	28159110950501	1.710
31	Laal Masjid Chowk	64	28159110776901	2.194
32	Jannat Road	70	28159110797401	2.261
33	Azeem Town	28	28159110252001	1.168
34	Markazi Jamia Masjid	67	28159110825900	2.538
35	Mushtaq Colony	10	28159122371400	0.362
36	Court Dost Muhammad	19	28159110237500	0.907
37	Yousaf Park	11	#N/A	0.293
38	Chowk Singla Wala	49	28159110822801	2.407
39	S.P Chowk	92	28159110365601	4.164
40	Jaswant Nagar	45	28159110441000	1.722
41	Wood Market	65	28159110258301	2.773
42	City Park	68	28159110295710	1.416

Out of the 1,778 surveyed lights in the MC, 608 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	12	9		10.3	406	-
LED	17	1		10.3	64	
LED	18	154		10.3	10,412	
LED	27	66		10.3	6,693	-
LED	30	44		10.3	4,958	-
LED	50	21		10.3	3,944	
LED	60	18		10.3	4,057	
LED	80	80		10.3	24,039	
LED	100	18		10.3	6,761	
LED	120	127		10.3	57,243	-
LED	200	1		10.3	751	-

[5] Based on Interview with Client.

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours[5]	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
CFL	24	5		10.3	451	
CFL	27	1		10.3	101	
CFL	50	2		10.3	376	
CFL	52	3		10.3	586	
Mercury Bulb	27	6		10.3	608	-
Mercury Bulb	125	22		10.3	10,329	-
Mercury Bulb	150	4		10.3	2,254	
Mercury Bulb	250	2		10.3	1,878	
Sodium Light	250	20		10.3	18,781	
Sodium Light	300	2		10.3	2,254	
Sodium Light	400	2		10.3	3,005	-
Total					**159,951**	**-**


Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

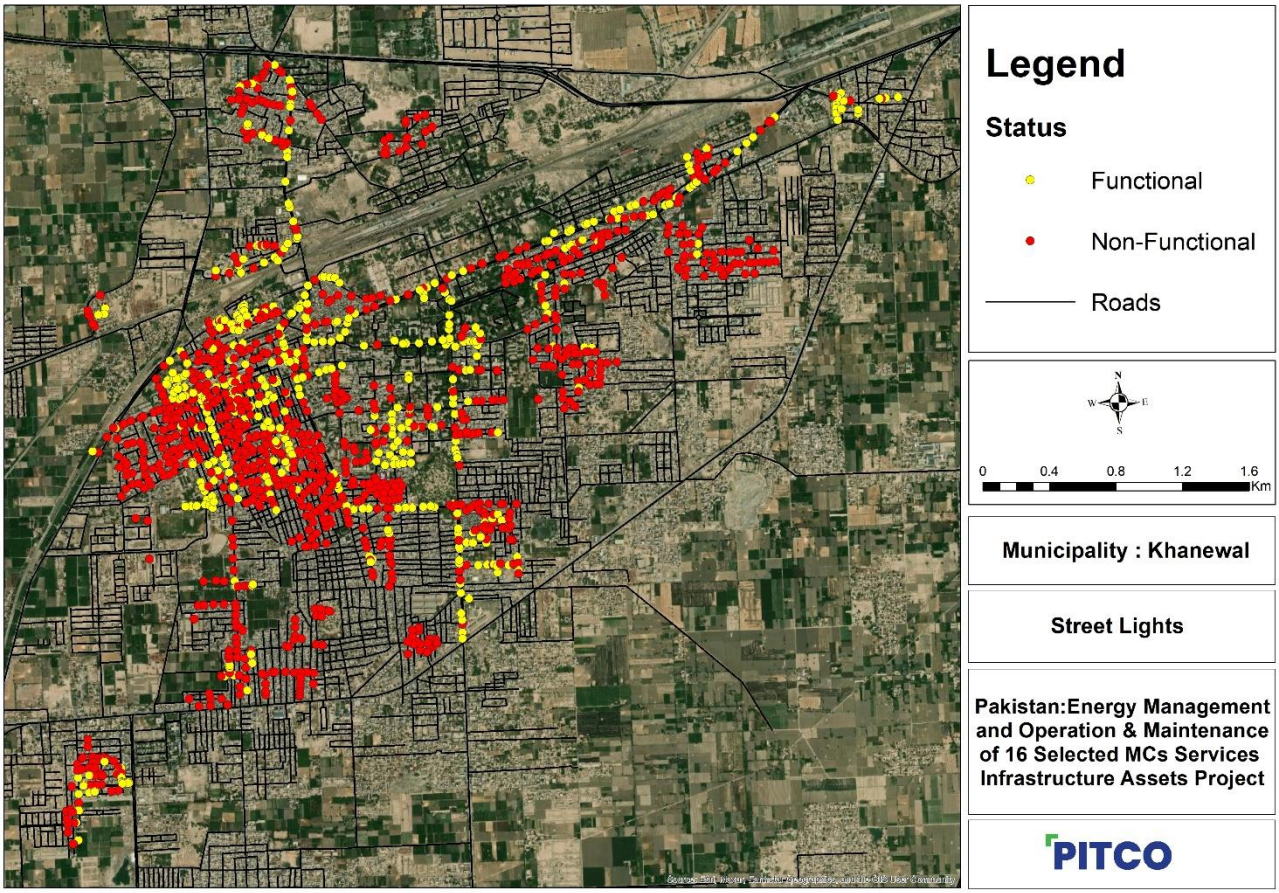


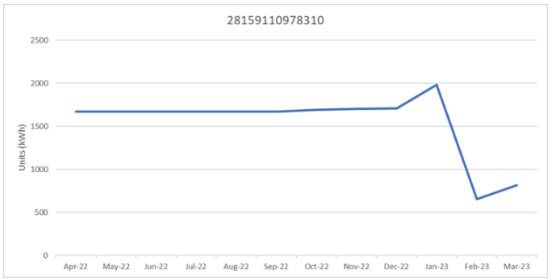
Figure 9: GIS Mapping of street lights in Khanewal MC

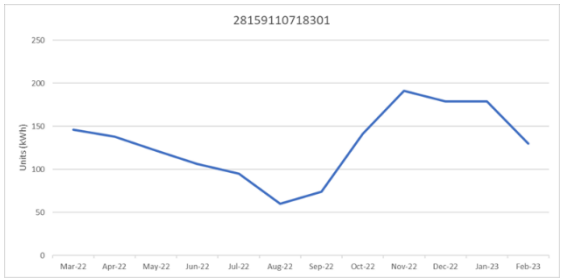
3.3 Baseline Energy Consumption Trend

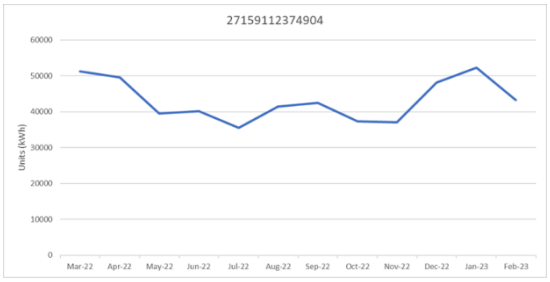
Details of energy consumption by the streetlights in the MC are given below.

Table 24: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy consumed	kWh/y	159,951
Total number of operational lights	No.	608



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40000
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20000
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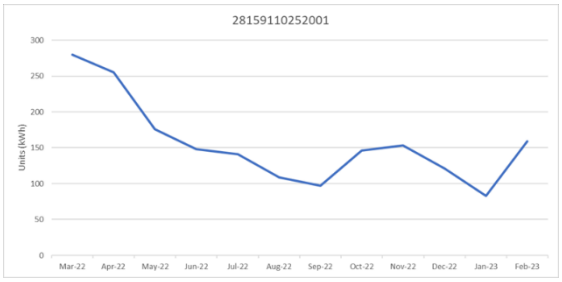
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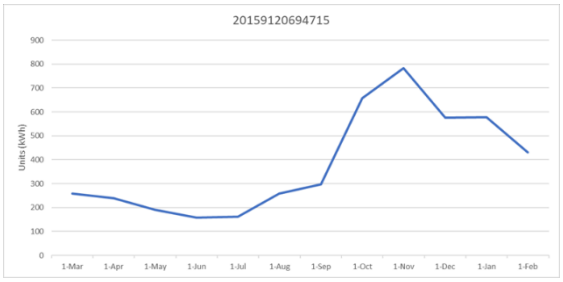
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05159130359406
Units (kWh)
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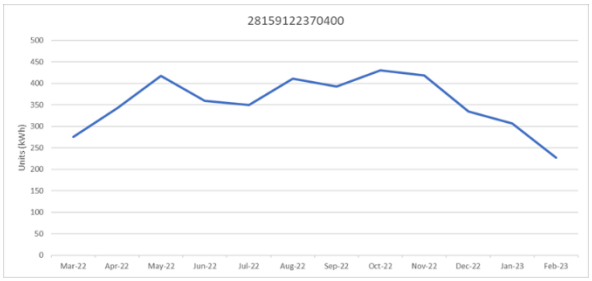
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28159110950501
Units (kWh)
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350
300
250
200
150
100
50
0
Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23 Feb-23


28159110722501
Units (kWh)
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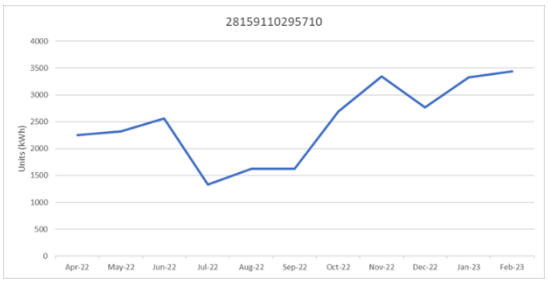
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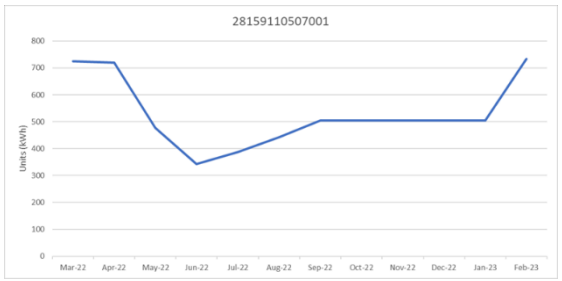
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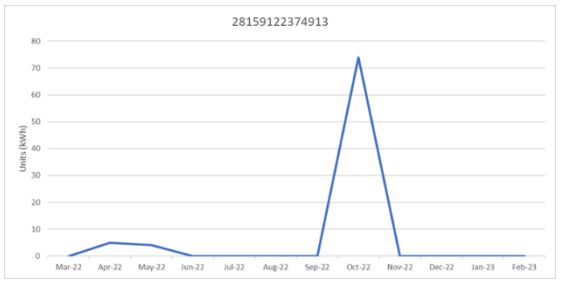
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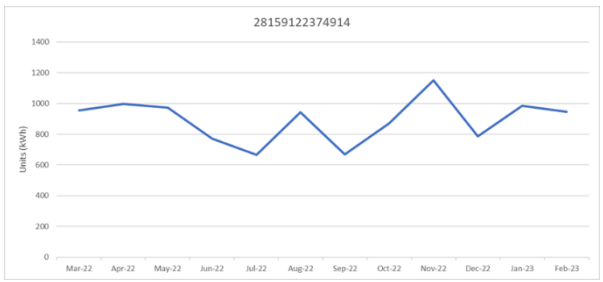
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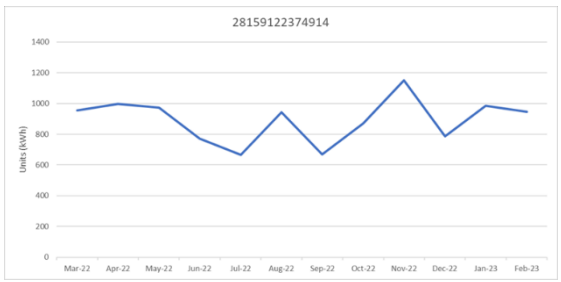
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14159120235100
Units (kWh)
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350
300
250
200
150
100
50
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23


14159120196800
Units (kWh)
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500
400
300
200
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1-Apr
1-May
1-Jun
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1-Aug
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1-Oct
1-Nov
1-Dec
1-Jan
1-Feb


28159110044502
Units (kWh)
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10
8
6
4
2
0
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1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb


28159110091900
Units (kWh)
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500
400
300
200
100
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1-Sep
1-Oct
1-Nov
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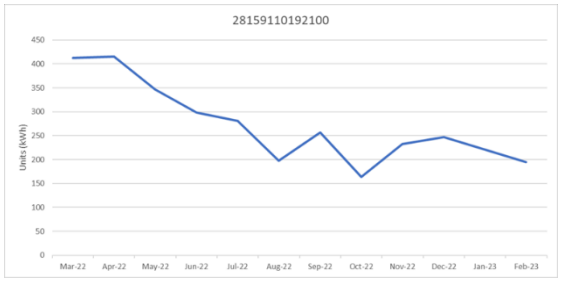
1-Feb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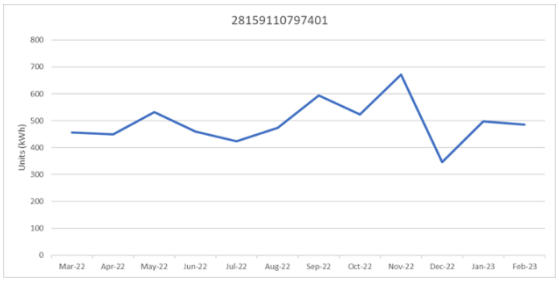
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23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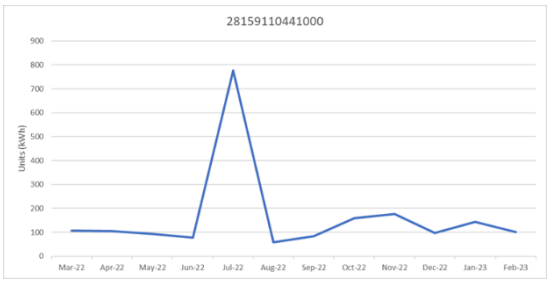
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23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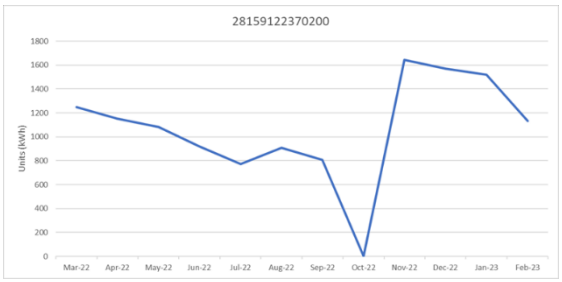
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23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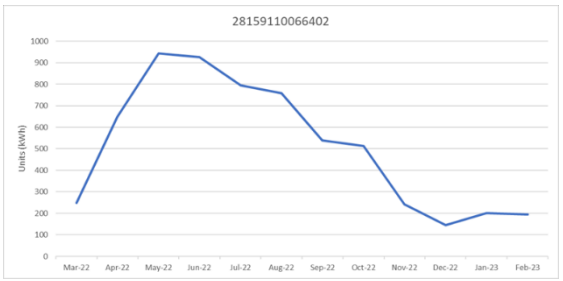
1600
1400
1200
1000
800
600
400
200
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23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Units (kWh)
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800
700
600
500
400
300
200
100
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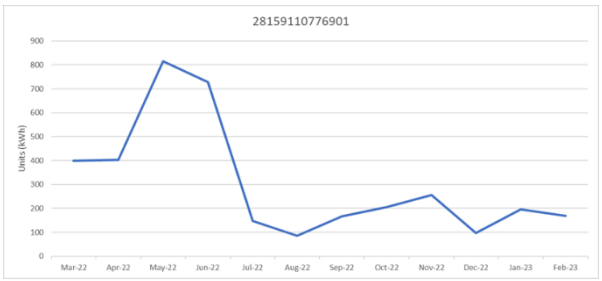
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23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Units (kWh)
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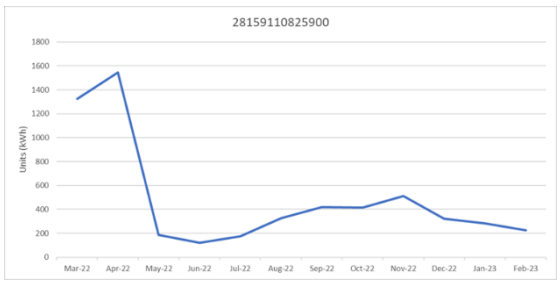
800
700
600
500
400
300
200
100
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23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Units (kWh)
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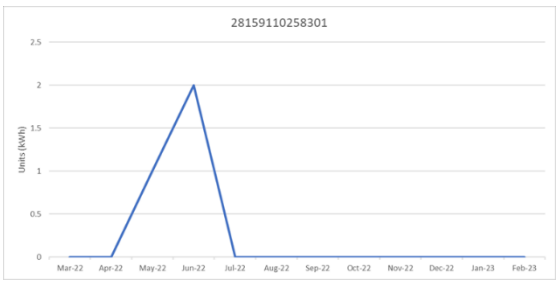
1600
1400
1200
1000
800
600
400
200
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23


28159110258301
Units (kWh)
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1
0.5
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23

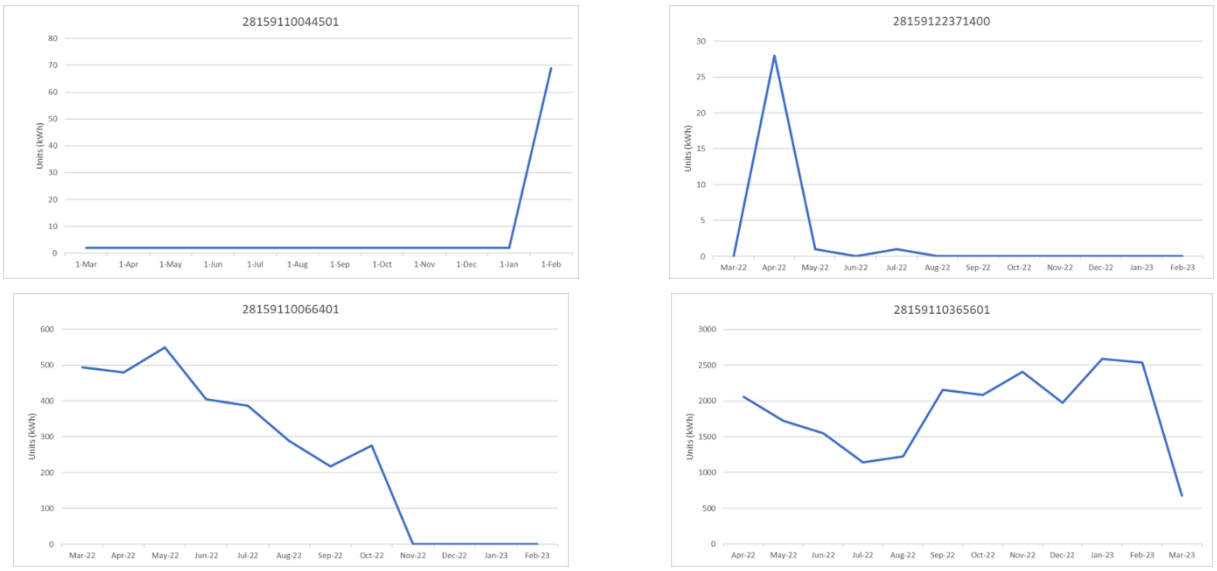

Figure 10: Energy Consumption trend of Streetlights

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Streetlights	399	608	210,500	159,951	50,549	2,961 kWh/km	2,258 kWh/km	Based on the previous assessment, there were only 399 MC owned operational lights with an average consumption of 527kWh/light/annum, whereas, currently there are 608 operational lights with average energy consumption of 263kWh/light/annum. The MC has significantly improved the 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 Khanewal.

3.5 Observations

- All Streetlights in Khanewal MC are operated by MC.
- Most of the operational streetlights are LEDs.
- Approximately 24% of the LED streetlights have a rating of 120 Watts.
- Khanewal 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 Khanewal are MC operated. • Most of the operational streetlights are LEDs	All non-operational streetlights should be repaired to make them functional. As per illuminating engineering society (IES) and Committee for European Standardization (CEN) public areas with dark surroundings should have illumination (lux or lumen/m^2) between 20-50. It is recommended to have lumen method or Zonal cavity method for design of streetlights which means an equal illumination at all areas. This is simple and frequently used method to design street lighting. It is recommended to install LED lights which have effective lux of 20-50 at ground level. With lighting control system for maximum utilization and low energy costs. Reason to recommend LED lights is they have better average rated life & better lamp lumen depreciation.
2	Maintenance & Replacement Log	Khanewal 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 Khanewal 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	GBA 705	Truck	Hino	Dutro	2022	4WD	Water Browser	4CGWM50168	JHHYCK604600151	125HP
2	GBA 706	Truck mechanical sweeper	Hino	Dutro	2022	4WD	Cleaning	4CWGM50173	JHHYCK804600152	125HP
3	GBA 750	Mini Truck, Mini dipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386436	SR308PK491100	796
4	GBA 779	Mini Truck, Mini dipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386315	SR308PK490982	796
5	GBA 890	Mini dipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386142	SR308PK490797	796
6	Unregistered Vehicle 1	Rickshaw	United	Deluxe Plus	2022	2WD	Transport of Solid Waste	162FMJ8MB01514	US150LR02987	150
7	Unregistered Vehicle 2	Rickshaw	United	Deluxe Plus	2022	2WD	Transport of Solid Waste	162FMJ8MB01021	US150LR02972	150
8	Unregistered Vehicle 3	Rickshaw	United	Deluxe Plus	2022	2WD	Transport of Solid Waste	162FMJ8M1301467	45150LR02986	150
9	Unregistered Vehicle 4	Rickshaw	United	Deluxe Plus	2022	2WD	Transport of Solid Waste	162FMJMB00990	45150LR02974	150
10	Unregistered Vehicle 5	Loader Rickshaw	Qingqi	CNE-100	2015	2WD	Transport of Solid Waste	A115497	Nil	100
11	Unregistered Vehicle 6	Truck Sucker	Nissan	Captain-C	2007	2WD	Suction	97505	608	125HP
12	Unregistered Vehicle 7	Truck jetting	Nissan	Captain-C	2008	2WD	Jetting	97541	644	125HP
13	KWJ-15-13	Truck	Isuzu	NPR	2015	4WD	Transport of Solid Waste	04344P	JAANPR66PE-7100596	4334
14	KWJ-15-15	Truck	Isuzu	NPR	2015	4WD	Transport of Solid Waste	04343P	JAANPR66PE-7100595	4334
15	KWJ-15-14	Truck	Isuzu	NPR	2015	4WD	Transport of Solid Waste	04345P	JAANPR66PE-7100597	4334
16	KWJ-15-16	Truck	Isuzu	NPR	2015	4WD	Transport of Solid Waste	04342P	JAANPR66PE-7100594	4334
17	KWJ-15-12	Mini Truck, Mini dipper	Suzuki	Ravi	2015	2WD	Transport of Solid Waste	PKT27998	SR308PK3526675	796
18	KWJ-15-10	Mini Truck, Mini dipper	Suzuki	Ravi	2015	2WD	Transport of Solid Waste	PKT245933	SR308PK350595	796
19	KWB 580	Bike	Honda	Cd-70	1996	2WD	Transport of Staff	55111	10535-4	70
20	Unregistered Vehicle 8	Dengue Van	Suzuki	Ravi	2012	2WD	Light Branch / Dengue van	N/A	N/A	796
21	Unregistered Vehicle 9	Truck	Isuzu	NPR	2016	4WD	Water Browser	N/A	N/A	125HP
22	KWA 52	Car	Nissan	Sunny	1992	2WD	Transport of Staff	N/A	BAAB 13-5 00276	1500
23	KWC 52	Car	Suzuki	Cultus	2003	2WD	Transport of Staff	812311	956718	1000
24	KWB 7172	Jeep	Suzuki	Potohar	1998	4WD	Transport of Staff	N/A	N/A	1000
25	SAJ 382	Tractor	Messy	MF-385	2022	4WD	Transport of Solid Waste	598292H	893902122	85HP
26	SAJ 383	Tractor trolley	Messy	MF-385	2022	2WD	Transport of Solid Waste	598264H	893902222	85HP
27	SAJ 384	Tractor trolley	Messy	MF-240	2022	2WD	Transport of Solid Waste	755559H	447061622	50HP
28	SAJ 385	Tractor front loader	Messy	MF-385	2022	4WD	Transport of Solid Waste	506925H	854450422	85HP
29	SAJ 386	Tractor front loader	Messy	MF-385	2022	4WD	Transport of Solid Waste	506867H	854260222	85HP

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)
30	SAJ 387	Tractor trolley	Messy	MF-240	2022	2WD	Transport of Solid Waste	757154H	447471722	50HP
31	SAJ 388	Tractor	Messy	MF-240	2022	2WD	Loading unloading	757159H	44471822	50HP
32	KWE 8746	Tractor front blade	Messy	MF-385	2006	4WD	Transport of Solid Waste	500560M	0041-03	85HP
33	KWJ 1213	Tractor front loader	Messy	MF-385	2012	4WD	Transport of Solid Waste	502200W	84330312	85HP
34	KWB 1279	Tractor	Messy	MF-240	1996	2WD	Water Browser	5237598	0564-42	50HP
35	KW 5031	Tractor, Carrier	Messy	MF-240	1988	2WD	Transport of Solid Waste	31089V-3314E	0424-22	50HP
36	KWE 8747	Tractor trolley	Messy	MF-240	2006	2WD	Transport of Solid Waste	626978M	1600-77	50HP
37	KWB 8628	Tractor	Messy	MF-240	2000	2WD	Water Browser	569054F	1022-81	50HP
38	MNF 5148	Tractor	Messy	MF-135	1981	2WD	Transport of Solid Waste	22488U-669799-11	319-1	47HP
39	KWJ 5234	Tractor trolley	Messy	MF-240	2009	2WD	Transport of Solid Waste	586059-5	40449-43	50HP
40	KWJ 1314	Tractor trolley	Messy	MF-240	2012	2WD	Transport of Solid Waste	670436X	451901513	50HP
41	Unregistered Vehicle 10	Tractor trolley	Messy	MF-260	2016	2WD	Transport of Solid Waste	549887D	62505-03	60HP
42	Unregistered Vehicle 11	Tractor trolley	Messy	MF-260	2018	2WD	Transport of Solid Waste	549665D	62505-03	60HP
43	KWJ 1414	Tractor	Messy	MF-240	2012	2WD	Grass Cutter	670431X	4219014-13	50HP

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	GBA 705	2:22 PM	3:22 PM	1.22	1.22 Liters/hr	1:20 PM	2:20 PM	15	8	0.53 Liters/km
2	GBA 890	2:25 PM	3:25 PM	0.54	0.54 Liters/hr	1:20 PM	2:20 PM		1.74	1.74 Liters/hr
3	Unregistered Vehicle 5	4:10 PM	5:10 PM	0.15	0.15 Liters/hr	3:10 PM	4:10 PM		0.73	0.73 Liters/hr
4	Unregistered Vehicle 6	2:18 PM	3:18 PM	2.51	2.51 Liters/hr	12:35 PM	2:15 PM		12.01	7.21 Liters/hr
5	Unregistered Vehicle 7	2:05 PM	3:05 PM	1.67	1.67 Liters/hr	12:50 PM	2:00 PM		13	11.14 Liters/hr
6	SAJ 384	3:05 PM	4:05 PM	0.55	0.55 Liters/hr	1:45 PM	3:00 PM		3.76	3.01 Liters/hr
7	SAJ 385	3:00 PM	4:00 PM	1	1 Liters/hr	1:55 PM	2:55 PM		9.01	9.01 Liters/hr
8	Unregistered Vehicle 10	3:52 PM	4:52 PM	0.7	0.7 Liters/hr	2:50 PM	3:50 PM	8	3.1	0.39 Liters/km

Table 28: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook
1	SAJ 383	5
2	SAJ 384	3
3	SAJ 386	5
4	SAJ 387	3
5	SAJ 388	3

Sr. No.	Unique Registration Number	Fuel Usage on logbook
6	KW 5031	3
7	KWE 8747	3
8	KWJ 5234	3
9	KWJ 1314	3
10	KWJ 1414	2

The logbooks of remaining vehicles are not available in MC.

The MC made 19 of its vehicles available to the Consultant for carrying out on-field testing. The average fuel consumption of the vehicles in idle condition was found to be 1.04 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 5.47 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	75,132
Annual Cost of Fuel (Diesel)	PKR/y	22,013,676
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 Khanewal 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 Khanewal has bought enough new vehicles to meet their daily demand. Based on the logbook data, the consultant cannot make any recommendation for replacement of old vehicles. A 6-month exercise should be undertaken in which the distance travelled by each vehicle, its fuel consumption, weight of waste carried (in

case of waste carrying vehicles), and O&M cost should be properly logged to calculate the efficiency of the vehicles. Once this activity is completed, the inefficient vehicles should be sold in the open market through a transparent auction.

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

5 Municipal Buildings

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

5.1 GIS Map

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

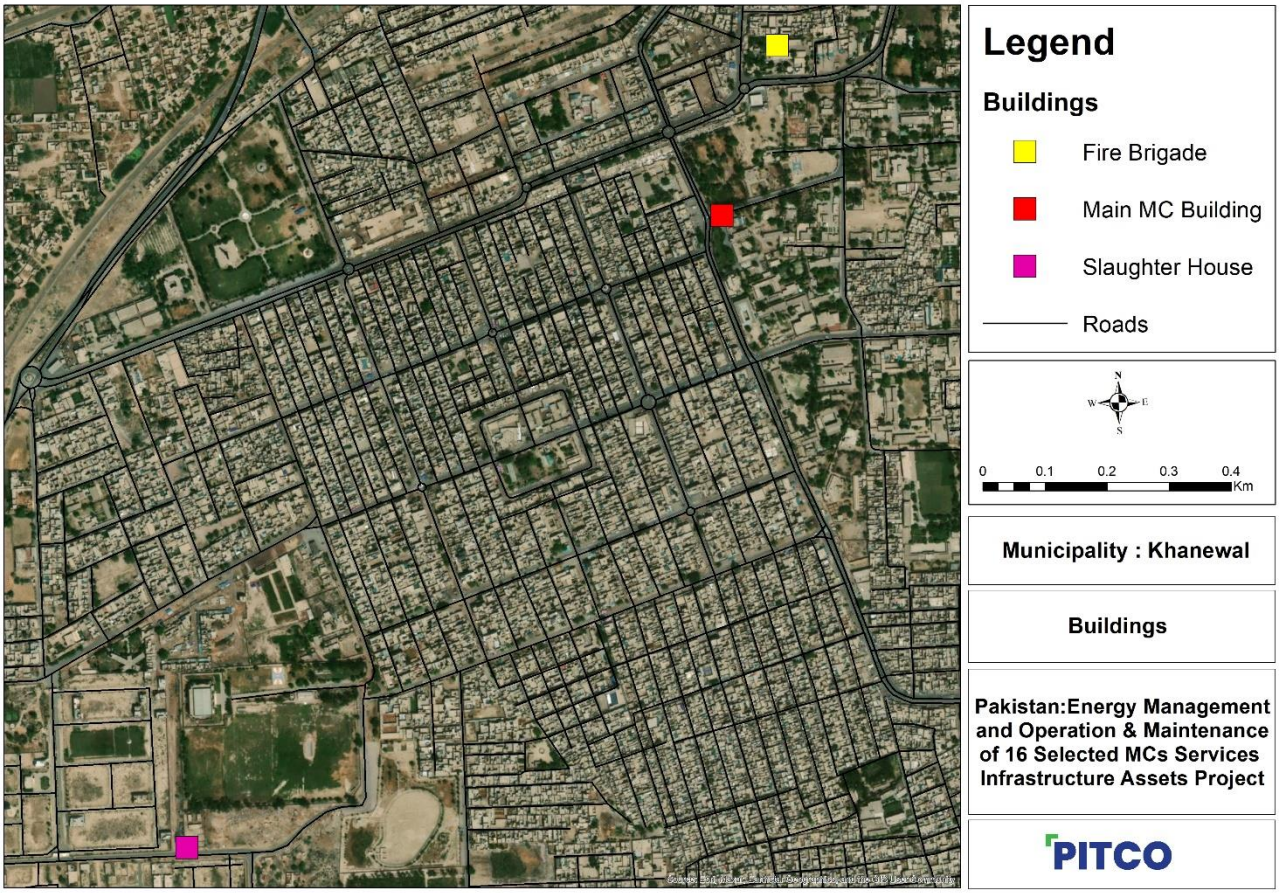

Figure 12: Map for Buildings

5.2 Building Details

Details of the MC buildings are given below.

Table 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 (Main MC Building & Main MC Building)	N:30.30082 E:71.92236	31206467	MC	1964	Satisfactory	2555	No Proper Insulation	1
2	Slaughter House	N:30.29186 E:71.91315	31206469	MC		Satisfactory	311	No Proper Insulation	1
3	Fire Brigade	N:30.30327 E:71.92336	31206441	MC		Satisfactory	825	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 Heating Equipment	Equipment Count	Capacity in Watts	Daily operating hours[6]	No. of months used per year	Operating days per year	Annual Energy consumption (kWh/year)
MC Building & Mosque								
1	**Administrative office**	Electric Heater	2	1000	1	4	104	208
2	**CO Office**	Electric Heater	1	1000	5	4	104	520
3	**Complaint office**	Electric Heater	1	1500	4	4	104	624
4	**Water branch**	Electric Heater	1	1000	2	4	104	208
5	**Masjid Outside**	Gas Geyser	1	0	2	4	104	0
Fire Brigade								
1	**Fire Brigade office**	Electric Heater	1	1000	4	2	52	208
2	**Masjid Outside**	Electric Geyser	1	2000	5	2	52	520
	Total							**2,288**

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

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Main MC Building								
1	**Meeting Hall**	Ceiling Fan	11	80	1	8	208	183
2	**Meeting Hall**	Split AC	1	0	0	0	0	0
3	**Meeting Hall**	Exhaust Fan	5	30	1	12	312	47
4	**Administrative office**	Ceiling Fan	3	80	1	8	208	50
5	**Administrative office**	Split AC	1	1750	1	8	208	364
6	**Administrative office**	Exhaust Fan	1	30	1	12	312	9
7	**Administrative office**	Window AC	1	5000	1	8	208	1,040
8	**CO office**	Ceiling Fan	2	80	2	8	208	67
9	**CO office**	Window AC	1	5000	1	8	208	1,040
10	**CO office**	Window AC	1	5000	1	8	208	1,040
11	**CO Operator**	Ceiling Fan	1	80	8	8	208	133
12	**Pension branch**	Ceiling Fan	1	80	7	8	208	116
13	**Pension branch**	Air Cooler	1	125	8	8	208	208
14	**Tax Branch**	Ceiling Fan	1	80	7	8	208	116
15	**Account Branch**	Ceiling Fan	1	80	7	8	208	116
16	**Account Branch**	Air Cooler	1	125	7	8	208	182
17	**Account Branch**	Split AC	1	0	0	0	0	0
18	**MOF office**	Ceiling Fan	1	80	4	8	208	67
19	**MOF office**	Exhaust Fan	2	30	56	12	312	1,048
20	**Planning branch**	Ceiling Fan	1	80	7	8	208	116
21	**Planning store**	Ceiling Fan	1	80	4	8	208	67
22	**Planning Room**	Ceiling Fan	1	80	8	8	208	133
23	**Planning Room**	Split AC	1	1200	6	7	182	1,310
24	**MOR office**	Ceiling Fan	1	80	8	8	208	133
25	**Store**	Pedestal Fan	1	125	4	8	208	104
26	**Field Office**	Ceiling Fan	2	80	8	8	208	266
27	**Complaint office**	Ceiling Fan	1	80	8	8	208	133
28	**Audit Branch**	Ceiling Fan	1	80	8	8	208	133
29	**Audit Branch**	Ceiling Fan	1	30	8	12	312	75
30	**Audit Branch 2**	Exhaust Fan	1	30	8	12	312	75
31	**Audit Branch 2**	Air Cooler	1	125	0	0	0	0
32	**Audit Branch 2**	Ceiling Fan	1	80	0	0	0	0
33	**Superintendent office**	Ceiling Fan	2	80	5	6	156	125
34	**Superintendent office**	Ceiling Fan	1	30	8	12	312	75
35	**Water branch**	Ceiling Fan	2	80	8	8	208	266
36	**Water branch**	Pedestal Fan	1	125	4	8	208	104
37	**Water branch**	Exhaust Fan	1	30	0	0	0	0

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
38	**Light Superintendent**	Ceiling Fan	1	80	8	8	208	133
39	**Planning officer**	Ceiling Fan	2	80	8	8	208	266
40	**Planning officer**	Window AC	1	5000	4	8	208	4,160
41	**Planning officer**	Exhaust Fan	1	30	8	12	312	75
42	**Sanitation Branch**	Ceiling Fan	2	80	8	8	208	266
43	**Sanitation Branch**	Air Cooler	1	125	8	8	208	208
44	**Sanitation store**	Ceiling Fan	1	80	8	8	208	133
45	**Sanitation store**	Air Cooler	1	125	8	8	208	208
46	**Infrastructure Branch**	Ceiling Fan	2	80	8	8	208	266
47	**Infrastructure Branch**	Air Cooler	1	125	8	8	208	208
48	**Infrastructure Branch**	Bracket Fan	1	50	0	0	0	0
49	**MOI Office**	Ceiling Fan	1	80	4	8	208	67
50	**MOI Office**	Split AC	1	1980	2	7	182	721
51	**Sub-engineer office**	Ceiling Fan	1	80	4	8	208	67
52	**Sub-engineer office**	Air Cooler	1	125	4	8	208	104
53	**Outside 1**	Ceiling Fan	1	80	8	8	208	133
54	**Outside 2**	Bracket Fan	1	50	8	8	208	83
55	**Main Hall**	Ceiling Fan	8	80	4	8	208	532
56	**Main Hall**	Split AC	4	1750	2	7	182	2,548
57	**Main Hall**	Exhaust Fan	2	30	4	12	312	75
58	**Outside of Masjid**	Ceiling Fan	4	80	4	8	208	266
		Slaughter House						
1	**Doctor Room**	Ceiling Fan	1	80	16	8	208	266
2	**Doctor Room**	Exhaust Fan	1	30	12	12	312	112
3	**Doctor Room**	Pedestal Fan	1	125	14	8	208	364
4	**Hall 1**	Ceiling Fan	6	80	12	8	208	1,198
5	**Hall 1**	Exhaust Fan	4	30	12	12	312	449
6	**Hall 2**	Ceiling Fan	3	80	12	8	208	599
7	**Hall 2**	Exhaust Fan	2	30	12	8	208	150
8	**Hall 3**	Ceiling Fan	3	80	12	8	208	599
9	**Hall 3**	Exhaust Fan	1	30	12	12	312	112
10	**Store 1**	Exhaust Fan	1	30	1	12	312	9
11	**Store 2**	Exhaust Fan	1	30	1	12	312	9
		Fire Brigade						
1	**Fire Brigade office**	Ceiling Fan	1	80	12	8	208	200
2	**Fire Brigade office**	Air Cooler	1	125	2	6	156	39
3	**Fire Brigade office**	Exhaust Fan	1	30	3	12	312	28
4	**Staff Room**	Ceiling Fan	1	80	24	8	208	399
5	**Coordinator sub-station**	Ceiling Fan	1	80	8	8	208	133
6	**Coordinator sub-station**	Bracket Fan	1	50	8	8	208	83
7	**Outside of the Office**	Ceiling Fan	1	80	10	8	208	166
8	**Main Hall**	Ceiling Fan	4	80	2	8	208	133

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
9	**Main Hall**	Ceiling Fan	12	80	4	8	208	799
10	**Main Hall**	Split AC	3	2080	3	6	156	2,920
11	**Main Hall**	Exhaust Fan	2	30	4	8	208	50
12	**Masjid outside**	Ceiling Fan	24	80	4	8	208	1,597
	Total Annual kWh							**29,880**

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

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Electricity consumption (kWh/year)
Main MC Building							
1	**Meeting Hall**	Tube light	11	40	1	312	137
2	**Meeting Hall**	Tubelight Pannel	20	72	1	312	449
3	**Administrative office**	Tubelight Pannel	4	72	0	312	0
4	**Administrative office**	CFL	4	0	0	312	0
5	**Administrative office**	LED	1	20	1	312	6
6	**Administrative office**	CFL	5	20	0	312	0
7	**Administrative office**	LED	9	12	1	312	34
8	**CO Office**	Tube light	4	40	7	312	349
9	**CO Office**	CFL	1	52	1	312	16
10	**CO Office**	LED	7	20	1	312	44
11	**CO Office**	Tube light	1	40	0	312	0
12	**CO Operator**	Tube light	2	40	7	312	175
13	**CO Operator**	CFL	2	12	8	312	60
14	**Pension Branch**	CFL	7	12	7	312	183
15	**Pension Branch**	LED	1	32	7	312	70
16	**Tax Branch**	LED	4	12	7	312	105
17	**Account Branch**	CFL	1	12	7	312	26
18	**Account Branch**	LED	4	12	8	312	120
19	**MOF Office**	CFL	1	12	2	312	7
20	**MOF Office**	LED	2	32	5	312	100
21	**MOF Office**	LED	2	12	5	312	37
22	**Planning branch**	Tube light	2	40	7	312	175
23	**Planning branch**	CFL	1	24	7	312	52
24	**Planning store**	Incandescent light Bulb	1	100	4	312	125
25	**Planning store**	Mercury Bulb	1	200	4	312	250
26	**Planning room**	LED	8	18	8	312	359

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

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Electricity consumption (kWh/year)
27	MOR Office	Tube light	2	40	7	312	175
28	Store	Tube light	1	40	7	312	87
29	Store	CFL	1	24	8	312	60
30	Field Office	Tube light	4	40	7	312	349
31	Field Office	LED	4	12	8	312	120
32	Field Office	LED	1	30	8	312	75
33	Complaint office	LED	2	18	8	312	90
34	Audit branch	LED	6	18	8	312	270
35	Audit branch	LED	2	12	8	312	60
36	Audit branch 2	Incandescent light Bulb	1	100	4	312	125
37	Audit branch 2	CFL	6	24	8	312	359
38	Audit branch 2	CFL	2	36	8	312	180
39	Superintendent office	Tube light	2	40	0	312	0
40	Superintendent office	CFL	4	24	8	312	240
41	Superintendent office	LED	5	12	8	312	150
42	Superintendent office	Tubelight Pannel	2	72	0	312	0
43	Water Branch	Tube light	1	40	8	312	100
44	Water Branch	CFL	1	85	8	312	212
45	Light Inspector room	CFL	1	52	8	312	130
46	Light Inspector room	LED	1	18	8	312	45
47	Planning office	LED	5	7	8	312	87
48	Planning office	LED	1	12	8	312	30
49	Sanitation branch	LED	1	12	8	312	30
50	Sanitation branch	Mercury Bulb	1	200	0	312	0
51	Sanitation store	Incandescent light Bulb	1	100	2	312	62
52	Sanitation store	Tube light	2	40	0	312	0
53	Sanitation store	CFL	1	24	8	312	60
54	Infrastructure branch	LED	6	12	8	312	180
55	MOI Office	CFL	2	52	8	312	260
56	MOI Office	LED	3	12	8	312	90
57	MOI Office	Emergency light	1	50	2	312	31
58	Sub-engineer office	LED	1	18	4	312	22
59	Sub-engineer office	LED	1	12	6	312	22
60	Outside 1	Tube light	4	40	12	312	599
61	Outside 1	CFL	2	24	12	312	180
62	Outside 1	LED	1	12	8	312	30
63	Outside 1	Incandescent Bulb	1	18	12	312	67
64	Outside 2	Tube light	9	40	12	312	1,348
65	Outside 2	CFL	2	24	12	312	180
66	Outside 2	LED	4	12	12	312	180
67	Outside 2	CFL	4	52	12	312	779
68	Outside 2	LED	12	18	12	312	809

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Electricity consumption (kWh/year)
69	**Main Hall**	Tube light	1	40	6	312	75
70	**Main Hall**	CFL	1	24	12	312	90
71	**Main Hall**	LED	20	6	6	312	225
72	**Main Hall**	CFL	4	52	6	312	389
73	**Outside of Masjid**	CFL	3	12	12	312	135
			Slaughter House				
1	**Doctor Room**	Tube light	2	40	0	312	0
2	**Doctor Room**	LED	1	12	12	312	45
3	**Hall 1**	Tube light	6	40	0	312	0
4	**Hall 1**	Incandescent Bulb	5	12	12	312	225
5	**Hall 1**	LED	1	18	12	312	67
6	**Hall 2**	Tube light	6	40	0	312	0
7	**Hall 2**	CFL	1	24	12	312	90
8	**Hall 2**	LED	1	12	12	312	45
9	**Hall 3**	Tube light	6	40	7	312	524
10	**Hall 3**	LED	1	12	12	312	45
11	**Outside**	Tube light	1	40	12	312	150
12	**Outside**	LED	5	12	12	312	225
			Training School				
1	**Fire brigade office**	LED	4	24	12	312	359
2	**Fire brigade office**	LED	1	12	12	312	45
3	**Staff Room**	LED	1	12	14	312	52
4	**Coordinator Sub-station**	Tube light	2	40	8	312	200
5	**Coordinator Sub-station**	LED	2	12	8	312	60
6	**Outside of the office**	CFL	1	24	12	312	90
7	**Outside of the office**	LED	1	12	12	312	45
8	**Main Hall**	Tube light	1	40	0	312	0
9	**Main Hall**	LED	1	20	12	312	75
10	**Hall outside**	Tube light	3	40	7	312	262
11	**Hall outside**	CFL	2	23	12	312	172
12	**Masjid main hall**	Tube light	3	40	7	312	262
13	**Masjid main hall**	LED	2	20	4	312	50
14	**Masjid main hall**	LED	2	12	4	312	30
15	**Masjid main hall**	LED	12	7	6	312	157
16	**Masjid outside**	Tube light	1	40	4	312	50
17	**Masjid outside**	LED	36	7	4	312	314
18	**Masjid outside**	LED	2	12	4	312	30
	Total Annual kWh						**15,334**

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

SI No.	Description	Unit	Value[9]
1	Annual Electricity Consumption	kWh	108,930
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[9] Based on Utility Bills

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Buildings	3	3	119,690	108,930	19,164			The KPI for municipal buildings cannot be accurately determined as the two of the three electricity meters in the MC buildings are shared with water supply and disposal pumpsets. The remaining third bill belongs to a slaughterhouse with very low power consumption due to which it has not been included in the 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) Type of Cooling Equipment	Count	Proposed Replacements	Recent Audit (2023) Count
MC Office	Ceiling Fan	55	0	59
MC Office	Air Cooler	11	0	7
MC Office	Split AC	10	0	9
MC Office	Window AC	2	2	4
MC Office	Exhaust Fan	-	-	13
MC Office	Pedestal Fan	-	-	2
MC Office	Bracket Fan	-	-	2
Fire Brigade	Ceiling Fan	24	0	44
Fire Brigade	Bracket Fan	2	0	1
Fire Brigade	Pedestal Fan	1	0	0
Fire Brigade	Air Cooler	2	0	1
Fire Brigade	Split AC	2	0	3
Fire Brigade	Exhaust Fan	-	-	3
Slaughter House	Ceiling Fan	10	0	13
Slaughter House	Exhaust Fan	-	-	10
Slaughter House	Pedestal Fan	-	-	1

Table 36: Lighting Equipment Comparison

Building Name	Initial Audit (2019) Type of Cooling Equipment	Count	Proposed Replacements	Recent Audit (2023) Count
MC Office	Tube Light	23	23	46
MC Office	Tube light Panel	18	18	26
MC Office	Incandescent Light Bulb	3	3	4
MC Office	CFL	73	73	56
MC Office	LED	14	0	114
MC Office	Mercury Bulb	-	-	2
MC Office	Emergency light	-	-	1
Fire Brigade	Tube Light	1	1	10
Fire Brigade	LED	20	0	64
Fire Brigade	CFL	1	1	3
Slaughter House	Tube Light	6	6	21
Slaughter House	LED	1	0	9
Slaughter House	CFL	2	2	1
Slaughter House	Incandescent Light Bulb	-	-	5

Table 37: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh
MC Office	18,980	43,411
Fire Brigade	92,306	60,842
Slaughter House	8,404	4,677
Overall	**119,690**	**108,930**

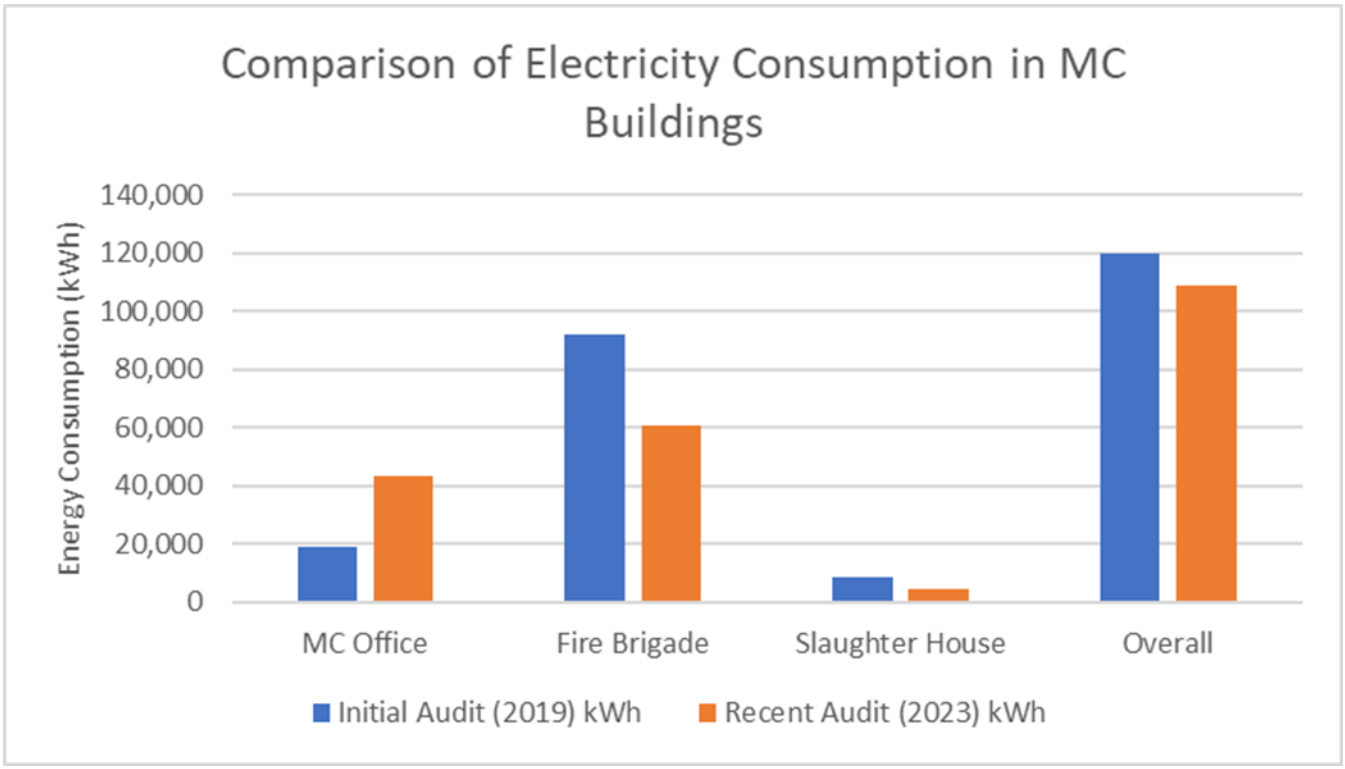

Figure 13:Comparison of Electricity Consumption in MC Buildings

5.4 Maintenance Logs of Buildings

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

6 Solar Assessment for MC Khanewal

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 Khanewal is 100% dependent on the Grid. MEPCO is the distribution company which is responsible for providing electricity to the site. As per the inventory, there are three buildings/sites that are owned and operated by MC.

MC Main Office Building, Slaughterhouse, and Fire Brigade buildings have a Three Phase 400V electrical connection. Metering details of each building is presented below.

Table 38: Metering details at MC Khanewal

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Main MC Building	31206467	10159110944902	16	A-3a (66)
			28159110836500	30	B2b (12)T
2	Slaughterhouse	31206469	28159120638905	12	A-3a (66)
3	Fire Brigade	31206441	27159110173205	41	A-3a (66)

6.1 Main MC Building

The project site i.e Main Office Building is located near National Bank road Khanewal, Punjab, Pakistan while the geographical co-ordinates of location are 30.3006°N (latitude) and 71.9225°E (longitude).

Figure 14:Front view of MC Office Building

Figure 15:Aerial view of MC Office Buildings

6.1.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of MC Office Building is 43,411 kWh. with the peak electricity consumption of 4,733 kWh in August 2022 on meter 2 (28159110836500) and 214 kWh in April 2022 on meter 1 (10159110944902). The annual energy consumption (kWh) for municipal buildings cannot be accurately determined as the meter one of the two electricity meters i.e., 28159110836500 in the MC building are shared with water supply therefore, the Consultant has only carried out the assessment of installation capacity of solar system.

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Building is 27,501 ft^2 whereas, the total area of rooftop available for the solar installation is 4,520 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

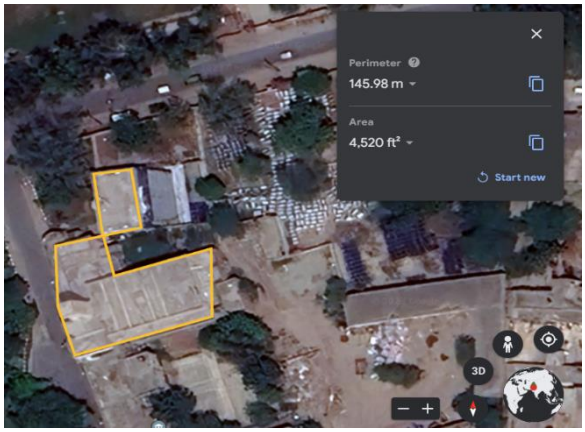

Figure 16: Top View of complete building

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

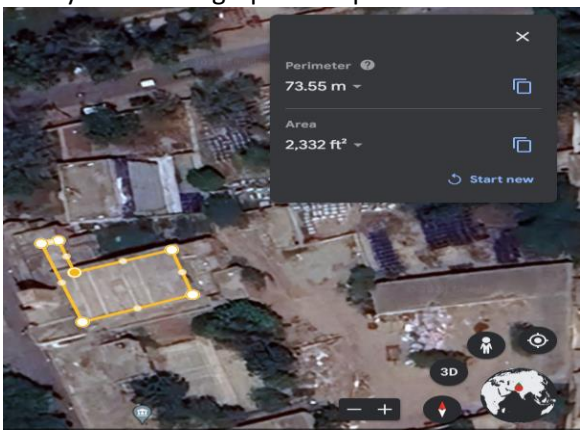

Figure 17: Location for Solar Installation - A

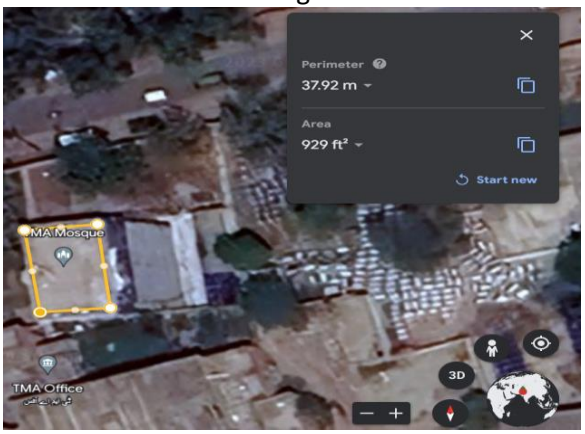

Figure 18: Location for Solar Installation - B

Table 39:System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Total
Area availability (ft^2)	2,332	929	3,261
Solar system capacity (kW)	23	9	32

Note: The Consultant has observed that Main MC Office Building has two different electrical connections. Moreover, based on the analysis of the historical billings it is identified that the total system requirement for this site is 31 kW. It is recommended to shift the Main MC Building on meter 1 and synchronize the solar system with this meter.

6.2 Slaughterhouse

The project site i.e. Slaughter House is located near Stadium Road, Khanewal, Punjab, Pakistan while the geographical co-ordinates of location are 30.29186 °N (latitude) and 71.91315°E (longitude).

Figure 19: Front view of Slaughter House

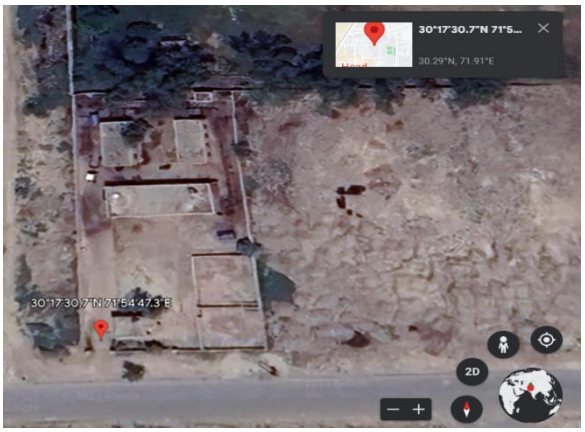

Figure 20: Aerial view of Slaughter House

6.2.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Slaughterhouse 4,677 kWh with the peak electricity consumption of 511 kWh in April 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 40:Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	28159120638905	4,677	389	511	3

Note: Based on the analysis of the historical electricity billing data, it is identified that the solar system requirement for this site is only **3 kW,** it is not recommended to install the solar system at this site.

6.3 Fire Brigade

The project site i.e. Fire Brigade is located near Kachehri road, Civil Lines, Khanewal, Punjab, Pakistan while the geographical co-ordinates of location are 30.30327°N (latitude) and 71.92336°E (longitude).

Figure 21: Front view of Fire Brigade

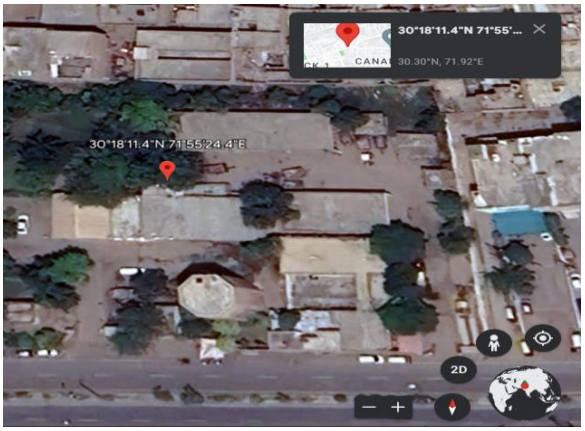

Figure 22: Aerial view of Fire Brigade

6.3.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Fire Brigade meter is 60,842 kWh with the peak electricity consumption of 6,349 kWh in July 2022. The annual energy consumption (kWh) for Fire Brigade cannot be accurately determined as this meter is shared with disposal pumpset therefore, the Consultant has only carried out the assessment of installation capacity of solar system.

6.3.2 Roof Assessment

As per the Consultant's assessment, the total area of the Fire Brigade is 8,880 ft^2 whereas, the total area of rooftop available for the solar installation is 3,580 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.

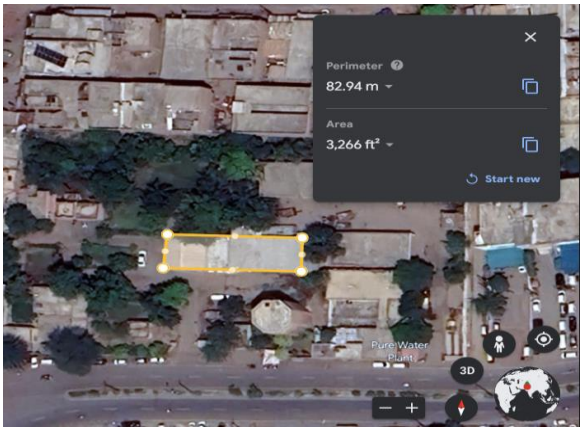

Figure 23: Top View of complete building

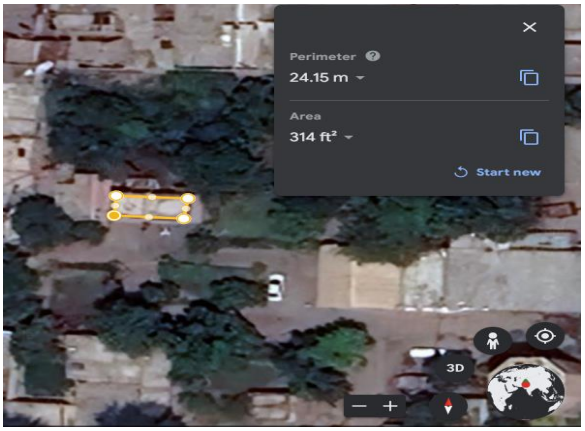

Figure 24: Top View of complete building

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

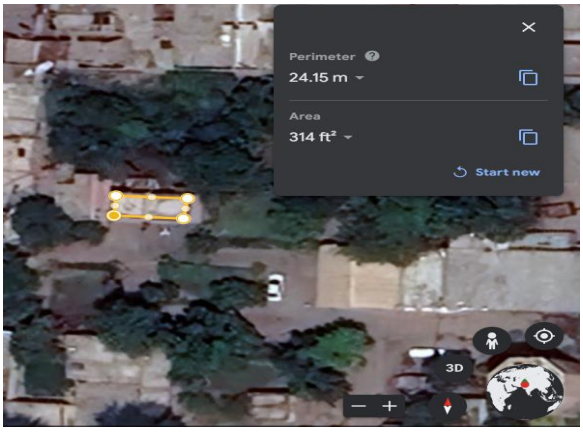

Figure 25:Location for Solar Installation – A

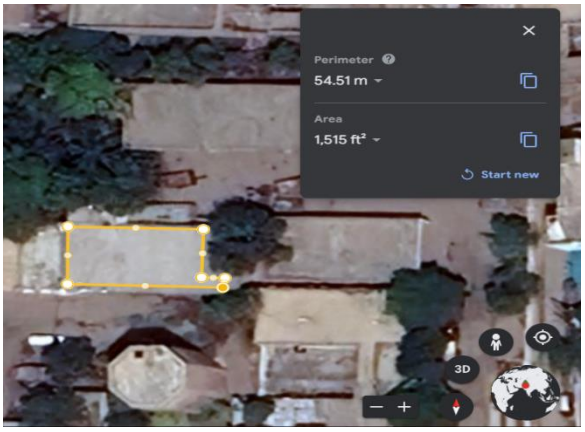

Figure 26:Location for Solar Installation – B

Table 41: System Size Calculation with Respect to Area

Parameters	Location A	Location B	Total
Area availability (ft²)	314	1515	1,829
Solar system capacity (kW)	3	15	18

6.4 Net Metering Consideration

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

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

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

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

6.4.1 Net-metering application procedure

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

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

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

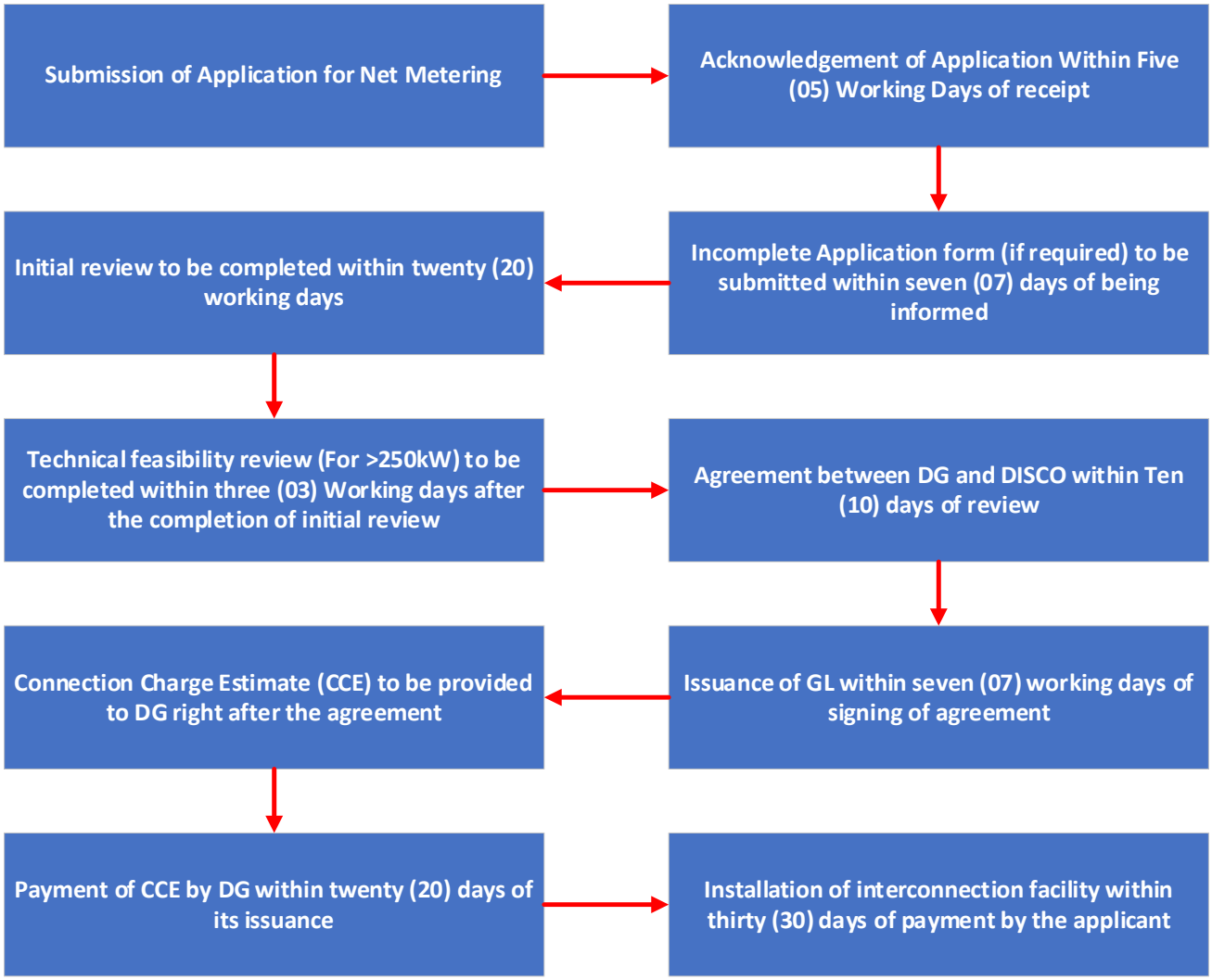

Figure 27:Pakistan Net Metering Application Process

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

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 (Colony No. 2 water supply - Unique ID: 31206462)

Study & Investigation

Efficiency of existing water pumpset could not be determined due to issues with the bore. The savings are calculated based on the network averages.

Recommended Action

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

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

Saving Assessment

Table 42: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	153
Design Head of Existing Pump	ft	200
Design Motor Power of Existing Pump	kW	45
Measured Flow	m^3/h	139
Measured Head	m	38.2
Measured Motor Power	kW	36.60
Pump Efficiency	%	47%
Existing Operational Hours	h	4.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	5.5
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	48,312
Energy Required by Proposed Pump	kWh/y	29,570
Saving Potential	kWh/y	18,742
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,010
Investment	US $	4,026
Simple Payback Period	months	16

7.1.2 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 43: 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	T-Chowk Fire brigade	31206441	2.5	3.0	50	150
2	Stadium Water Supply	31206459	2.5	3.0	50	150
3	Thana Ground	31206461	5.0	3.0	50	150
4	Colony No. 2 water supply	31206462	10.0	3.0	100	300
5	Malkabad Disposal	31206466	2.5	3.0	50	150
6	Khanewal Kohna Disposal	31206455-A	5.0	3.0	50	150
7	Jahaniyan Bypass	31206458-A	5.0	3.0	50	150
8	Jahaniyan Bypass	31206458-C	2.5	3.0	50	150
Total						**1350**

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

Description

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

Study & Investigation

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

Recommended Action & Benefits

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

Saving Assessment

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

Table 44: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	2,486,833
Annual Water consumption (post-implementation)	m^3/y	2,461,965
Annual Water saving per year	m^3/y	24,868
Estimate of Investment (including the cost of the server)	US$	30,000

7.2 Energy Efficiency Measures for Streetlights

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

Project

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

Study & Investigation

During the assessment it was observed that there are 1,778 streetlights are being operated by the municipality. Out of these, 1,170 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 28: 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 45: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	1170
Number of non-functional streetlights (>20 feet)	#	211
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	959

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	60,334,702
Proposed number of photocell switches	#	42
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	42,000
Upfront investment cost	PKR	60,376,702
Upfront investment cost	US$	215,477
Annual Operating Electricity unit	kWh/yr	147,691
Annual Operating Cost	PKR/yr	6,646,095
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	673,841
Monthly diesel cost for operating fork lifter for two days	PKR/month	20,000
Monthly cost of renting Fork Lifter for two days	PKR/month	80,000
Miscellaneous Cost	PKR/month	20,000
Monthly maintenance cost	PKR/month	120,000

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

Project

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

Study & Investigation

During the assessment it was observed that there are 1,778 streetlights operated by municipality out of which 608 are operational. 539 of the operational streetlights were LEDs so they are not recommended for replacement.

Out of the 86 operational non-LED streetlights, 6 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 46: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	69
Number of functional streetlights (>20 feet)	#	4
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)	#	65
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Upfront investment cost	PKR	3,534,457
Upfront investment cost	US$	12,614
Annual Operating Electricity unit	kWh/yr	8,076
Annual Electricity Consumption of Existing Lights	kWh/yr	40,623
Financial Savings	US$/yr	5,227
Payback	months	29

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 47: Replacement of inefficient equipment at office buildings

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment (Watt)	Overall Wattage of Proposed Equipment (Watt)	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters (PKR)
Main MC Building											
1	Tube light	11	40	440	1,098	LED Rod 20 Watts	20	220	549	2,900	31,900
2	Tubelight Pannel	20	72	1440	3,594	LED Pannel 36 Watt	36	720	1,797	6,200	124,000
3	Tubelight Pannel	4	72	288	719	LED Pannel 36 Watt	36	144	359	6,200	24,800
4	CFL	5	20	100	250	LED Bulb 13 Watts	13	65	162	350	1,750
5	Tube light	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
6	CFL	1	52	52	130	LED Bulb 20 Watts	20	20	50	830	830
7	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
8	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
9	CFL	2	12	24	60	LED Bulb 8 Watts	8	16	40	330	660
10	CFL	7	12	84	210	LED Bulb 8 Watts	8	56	140	330	2,310
11	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
12	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
13	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
14	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
15	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
16	Mercury Bulb	1	200	200	499	LED Bulb 13 Watts	13	13	32	350	350
17	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
18	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
19	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
20	Tube light	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
21	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
22	CFL	6	24	144	359	LED Bulb 13 Watts	13	78	195	350	2,100
23	CFL	2	36	72	180	LED Bulb 20 Watts	20	40	100	830	1,660
24	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
25	CFL	4	24	96	240	LED Bulb 13 Watts	13	52	130	350	1,400
26	Tubelight Pannel	2	72	144	359	LED Pannel 36 Watt	36	72	180	6,200	12,400
27	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
28	CFL	1	85	85	212	LED Bulb 50 Watts	50	50	125	6,800	6,800
29	CFL	1	52	52	130	LED Bulb 20 Watts	20	20	50	830	830
30	Mercury Bulb	1	200	200	499	LED Bulb 13 Watts	13	13	32	350	350
31	Incandescent light Bulb	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
32	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
33	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
34	CFL	2	52	104	260	LED Bulb 20 Watts	20	40	100	830	1,660
35	Tube light	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
36	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment (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)
37	Incandescent Bulb	1	18	18	45	LED Bulb 13 Watts	13	13	32	350	350
38	Tube light	9	40	360	899	LED Rod 20 Watts	20	180	449	2,900	26,100
39	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700
40	CFL	4	52	208	519	LED Bulb 20 Watts	20	80	200	830	3,320
41	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
42	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
43	CFL	4	52	208	519	LED Bulb 20 Watts	20	80	200	830	3,320
44	CFL	3	12	36	90	LED Bulb 8 Watts	8	24	60	330	990
45	Window AC	1	5000	5000	1,820	Inverter 1.5 ton	1,452	1,452	529	143,000	143,000
46	Window AC	1	5000	5000	1,820	Inverter 1.5 ton	1,452	1,452	529	143,000	143,000
47	Window AC	1	5000	5000	1,820	Inverter 1.5 ton	1,452	1,452	529	143,000	143,000
48	Window AC	1	5000	5000	1,820	Inverter 1.5 ton	1,452	1,452	529	143,000	143,000
Slaughter House											
1	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
2	Tube light	6	40	240	599	LED Rod 20 Watts	20	120	300	2,900	17,400
3	Incandescent Bulb	5	12	60	150	LED Bulb 13 Watts	13	65	162	350	1,750
4	Tube light	6	40	240	599	LED Rod 20 Watts	20	120	300	2,900	17,400
5	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
6	Tube light	6	40	240	599	LED Rod 20 Watts	20	120	300	2,900	17,400
7	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
Fire Brigade											
1	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
2	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
3	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
4	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 48: Saving & cost benefit analysis

Parameters	Unit	Value
Average Operational Days for Building Lighting Equipment	days/year	312
Average Operational Hours for Building Lighting Equipment	Hours/day	8
Average Operational Days for Building Cooling Equipment	days/year	208
Average Operational Hours for Building Cooling Equipment	Hours/day	1.75
Energy consumption of inefficient Equipment	kWh/yr	24,999
Energy consumption of Proposed Equipment	kWh/yr	10,366
Energy Savings	kWh/yr	14,633
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	2,350
Upfront Investment (including change in fixtures)	USD	3,499
Payback Period	Months	18

8 Investment Estimate (including Material Specification/Quantities)

8.1 Potable Water Pump

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

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

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

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

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

Price of pumping unit as specified above

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

8.2 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	211	53,873	11,367,203
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	959	51,061	48,967,499
3	Accessories	Photocell switch				42	1,000	42,000
Lumpsum Price (PKR)								**60,376,702**
Lumpsum Price (USD)								**215,477**

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	4	53,873	215,492
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	65	51,061	3,318,965
Lumpsum Price (PKR)								**3,534,457**
Lumpsum Price (USD)								**12,614**

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 Rod 20 Watts	20	73	1,460	2,900	211,700
2	LED Pannel 36 Watt	36	26	936	6,200	161,200
3	LED Bulb 13 Watts	13	36	468	350	12,600
4	LED Bulb 20 Watts	20	14	280	830	11,620
5	LED Bulb 8 Watts	8	14	112	330	4,620
6	LED Bulb 50 Watts	50	1	50	6,800	6,800
7	Inverter 1.5 ton	1,452	4	5,808	143,000	572,000
Lumpsum Price (PKR)						**980,540**
Lumpsum Price (USD)						**3,499**

9 Summary of Energy Efficiency Measures

MC Khanewal's annual energy consumption is 1,774,226 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$ 10,587** with an estimated investment of **US$ 266,966**
- Reduce electricity consumption by approx. **65,922 kWh**
- Reduce GHG Emissions by **36 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of MEPCO

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