Jaranwala Municipal Committee

Energy Audit Report

June 2023

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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 Jaranwala MC Background

Jaranwala is located at 31.33333 N 73.41667 E with an altitude of 184 meters (606 feet). It is 35 km southeast from Faisalabad and 110 km from Lahore. The city serves as the headquarters of Jaranwala Tehsil.

Jaranwala is about 400 years old city. There was a well with big roots hanging in it of an old willow tree. In Punjabi language roots are called "Jaraan" and place is called "Wala". So, these both words combined and formed the shape of a name "Jaranwala". By the passage of time, the place called Jaranwala and later on this name became famous and the city was also called Jaranwala.

Existing city was founded by British in 1908. Mr. Micheal Ferrar deputy commissioner of Faisalabad has inaugurated this town in 1909. Rai Ahmad Khral and Bhagat Singh two famous freedom fighters were sons of historic city of Jaranwala. Mian Abdul Bari a freedom fighter and President of All India Muslim League District Paghwara and then Lyallpur district was settled in Jaranwala after partition.

Jaranwala is an agriculture-based city. Major crops in this area are sugarcane, wheat, corn and rice. Jaranwala hosts the 3rd largest jute mill in the world (it is closed now a days). The city of Jaranwala shares in growth of Pakistan with sugar, chemical, textile, wheat and rice industry. Surroundings of Jaranwala are also famous for its dairy products.

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 Jaranwala MC has the following management.

Sr. No.	Name of Officer	Designation
1	Mr. Shoukat Mashi	Administrator
2	Mr. Ashfaq Ali	Chief Officer
3	Mr. Saddam Rasool*	Municipal Officer (Infrastructure)
4	Mr. Ashfaq Ali	Municipal Officer (Regulation)
5	Mr. Javid Hussain	Municipal Officer (Finance)
6	Ms. Shereen Newton	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Jaranwala

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	159,693
Electrical energy used by Wastewater Disposal[2]	kWh/year	244,765
Electrical energy used in Buildings[3]	kWh/year	33,660
Electrical energy used by Streetlights[4]	kWh/year	337,407
Diesel used by Vehicles	liter/year	55,896

1.5 Key Performance Indicators

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

1.5.1 Potable Water & Wastewater Pumps

Table 2: KPIs for Potable Water & Wastewater pumps

Sr. No.	Description	Unit	KPI
1	Energy Density of Potable Water Production	(kWh/m3)	0.11
2	Energy Density of Wastewater Disposal	(kWh/m3)	0.04
3	Energy Density of Wastewater Treatment	(kWh/m3)	No wastewater treatment is carried out
4	Energy Cost for Potable Water Production	(PKR/m3)	5.10
5	Energy Cost for Wastewater Disposal	(PKR/m3)	1.97

[1]Based on 12-month historical billing data
[2]Based on 12-month historical billing data
[3]Based on 12-month historical billing data
[4]Based on 12-month historical billing data

Sr. No.	Description	Unit	KPI
6	Energy Cost for Wastewater Treatment	(PKR/m3)	No wastewater treatment is carried out

1.5.2 Streetlights

Table 3: KPIs for Streetlights

Sr. No.	Description	Unit	KPI
1	Average electricity consumed per kilometer of lit roads	(kWh/km)	4,742
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	314
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	45,675
		PKR/Lighting Equipment	37,163
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)	168,907
6	Average daily duration of operation	(Hour)	12.0
7	Average energy costs per kilometer of lit roads	(PKR/km)	213,386
8	Average energy costs per light pole/fixture	(PKR/ fixture)	14,124
9	Number and percentage of failed public lights		63%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	3.88
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.03
3	Average Energy Cost of Heating	(PKR/m^2)	1
4	Average Energy Cost of Cooling	(PKR/m^2)	73
5	Average Energy Cost of Lighting	(PKR/m^2)	40

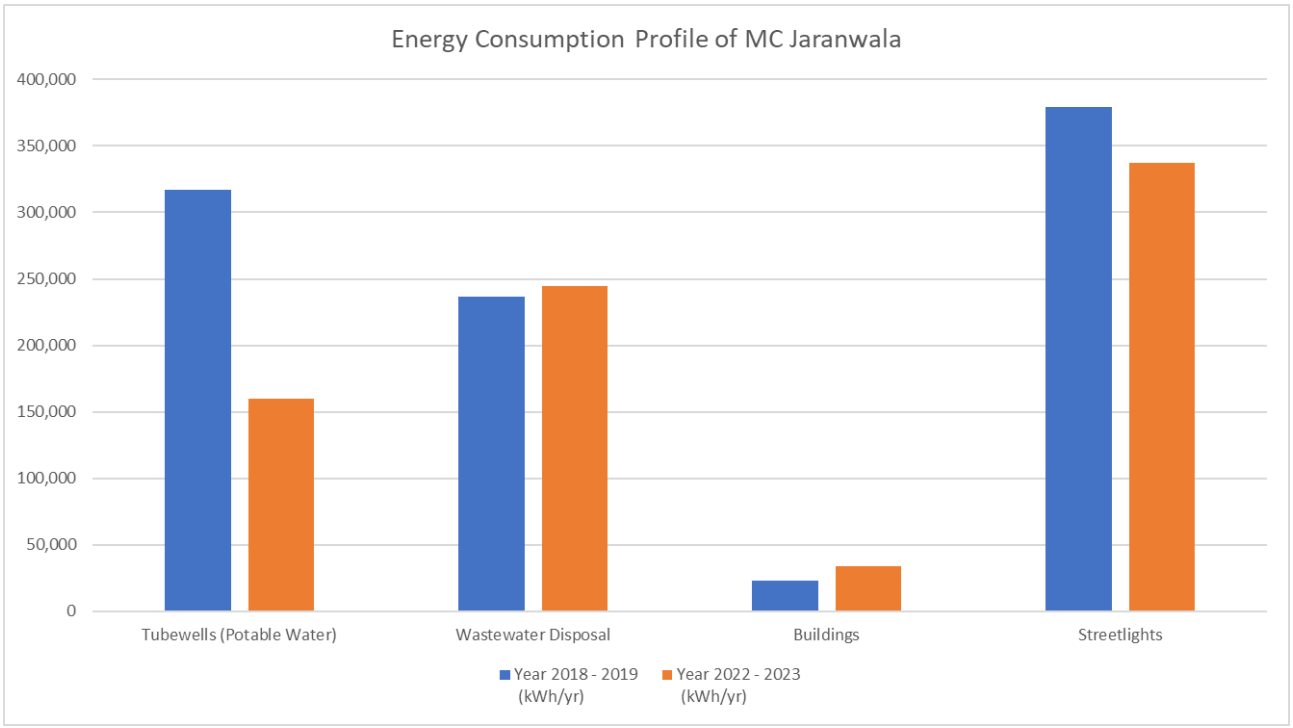
1.5.4 Vehicles

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	1.06
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	278

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 Jaranwala
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
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)	15	18	316,910	159,693	157,217	0.14 kWh/m3	0.11 kWh/m3	Replacement of 3 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 2 out 3 pumpsets proposed by the Consultant and 1 abandoned pumpset which has resulted in significant reduction in the KPI for water supply. The effect of this reduction is reflected in the energy bills for the MC as well.
2	Wastewater Disposal	7	7	236,862	244,765	-7,903	0.06 kWh/m3	0.04 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal has improved as well. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.
3	Buildings	6	8	23,373	33,660	-10,287	2.69 kWh/m2	3.88 kWh/m2	General bus stand building and water supply branch building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Furthermore, MC library building has shared electricity meter with

		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
									streetlight, Ramzan bazar has shared meter with water supply pumpset and slaughter house building has shared meter with disposal station so, for the purpose of this comparison, their energy consumptions are also not considered in the overall energy consumption and KPI calculations. Electricity units (kWh) are increased due to a significant increase in electric appliances in MC Office buildings.
4	Streetlights	46	457	379,274	337,407	41,867	10,889 kWh/km	4,742 kWh/km	Based on the previous assessment, there were only 46 MC owned operational lights with an average consumption of 8,245kWh/light/annum, whereas, currently there are 457 operational lights with average energy consumption of 738kWh/light/annum. The MC has significantly improved its energy consumption per light fixture.

1.7 Energy Efficiency Recommendations Matrix

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

1.7.1 Energy Efficiency Recommendations Matrix

Table 6: High Priority Measures

High Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Replacement of Pumpset at (Alvi Park No. 2 - Unique ID: 51006193)	3,496	3,237	907,000	561	157,300	69	2
Replacement of Pumpset at (Canal Road No. 19 - Unique ID: 51006196)	4,668	3,794	1,063,000	750	210,082	61	2
Replacement of Pumpset at (Canal Road No. 20A - Unique ID: 51006202)	7,972	3,794	1,063,000	1,280	358,758	36	4
Replacement of Pumpset at (Canal Road No. 20B - Unique ID: 51006203)	7,606	3,237	907,000	1,222	342,268	32	4
Replacement of Pumpset at (Sitayana Road No. 20C - Unique ID: 51106204)	8,735	3,794	1,063,000	1,403	393,097	32	4
Replacement of Pumpset at (Canal Pump No. 5 Lahore More - Unique ID: 51106205)	5,238	3,794	1,063,000	841	235,725	54	3
Replacement of Pumpset at (Canal Road No. 14 - Unique ID: 71106101)	4,132	3,794	1,063,000	664	185,922	69	2
Replacement of Pumpset at (Jinnah Park Water Works - Unique ID: 71106103)	23,192	4,657	1,305,000	3,725	1,043,624	15	12
Replacement of Pumpset at (Jinnah Park Water Works - Unique ID: 71106103-1)	23,619	4,657	1,305,000	3,793	1,062,871	15	12
Replacement/Installation of Capacitors	Not Quantifiable	1,775	497,355	Not Quantifiable	Months	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	142,395	39,899,058	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	7,084	1,014	284,030	1,138	318,764	11	4
Total:	**95,742**	**179,941**	**50,419,443**	**15,376**	**4,308,411**		**48**

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	60,269	47,198	13,224,799	9,679	2,712,096	59	35
Total:	**60,269**	**47,198**	**13,224,799**	**9,679**	**2,712,096**	**59**	**35**

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	31,676	32,000	8,966,400	0	0	0	Not Quantifiable
Total:	**31,676**	**32,000**	**8,966,400**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Jaranwala MC has nineteen (19) tubewells for groundwater, all of which are manually operated. Out of these, 18 pumpsets were found to be in working condition.

The MC has four (4) disposal station having thirteen (13) pumps. Out of these 7 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are eleven (11) dewatering sets in the MC and all are functional. No record of their fuel consumption and operational hours is being maintained by the MC.

During the onsite audits, inventories of all water supply and disposal pumps installed/operated by the MCs were developed, which carried details of GPS Location/geo-tag, primary function (classification between water and wastewater pumps) and name plate data of each pump-motor set, where available (see Section 2.1 for details). The audit team recorded details of design parameters for each pumpset, such as pump efficiency at design flow and head, pump performance curve, motor rated power, motor efficiency at design load, motor power factor at full load from the plates if attached or legible; it performed field performance tests for each pumpset starting with measurement of flow, static water level & pumping water level; furthermore, the draw down, system head and frictional losses were also computed; the team also measured motor power factor, power inputs (Volts, Power Factor, Amperes and Kilowatts), motor & bearing vibrations, motor winding and bearing temperature.

The team was unable to

(i) Determine site load (water demand) and its comparison with pump capacities due to unavailability of relevant data.

(ii) Determine system resistance and duty point on six (6) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake assessment of the following pumpsets as they were under maintenance
   1. Canal Road No. 18 (Unique ID: 51006197)

(iv) Undertake assessment of the following disposal pumpsets as the sites are under maintenance
   1. 240 More Muhallah Mustafabad (Unique ID: 51206209-D)
   2. 240 More Muhallah Mustafabad (Unique ID: 51206209-E)
   3. 240 More Muhallah Mustafabad (Unique ID: 51206209-F)
   4. 128-G.B (Unique ID: 51206212-B)
   5. Alvi Park (Unique ID: 51206216-A)
   6. Alvi Road Housing Colony (Unique ID: 51206217-A)

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	51006193	Alvi Park No. 2	27-13143-6300306	Turbine	KSB	2003	Siemens	2003	31.357062	73.419634
2	51006196	Canal Road No. 19	27-13143-6330400	Turbine	KSB	2003	Siemens	2003	31.350439	73.416755
3	51006199	Canal Road No. 3	27-13143-6330301	Turbine	Peco	2003	Peco	2003	31.343046	73.413599
4	51006194	Alvi Road No. 1	27-13143-6300303	Turbine	KSB	2003	Siemens	2003	31.358632	73.420535
5	71106101	Canal Road No. 14	27-13143-6330201	Turbine	KSB	2005	Siemens	2005	31.340115	73.410678
6	51006198	Canal Road No. 17	27-13143-6330501	Turbine	KSB	2020	Siemens	2020	31.34468	73.414062
7	71106102	Canal Road No. 5	27-13143-6330700	Turbine	KSB	2003	Siemens	2003	31.34132	73.41131
8	51006200	Canal Road No. 16	27-13143-6330500	Turbine	KSB	2003	Siemens	2003	31.342315	73.413055
9	51006202	Canal Road No. 20A	27-13143-6330400	Turbine	KSB	2005	Siemens	2005	31.318785	73.39691
10	51006203	Canal Road No. 20B	27-13143-6330401	Turbine	KSB	2005	Siemens	2005	31.317813	73.396032
11	51106205	Canal Pump No. 5 Lahore More	27-13143-6329901	Turbine	KSB	2005	Siemens	2005	31.327242	73.405473
12	51106206	Gillani Mohallah No. 4	27-13143-6330100	Turbine	KSB	2005	Siemens	1991	31.335815	73.411207
13	21106207	Canal Road No. 12	27-13143-6330401	Turbine	KSB	2020	Siemens	2020	31.336901	73.40919
14	51106208	Canal Road No. 13	27-13143-6330201	Turbine	KSB	2020	Siemens	2020	31.338355	73.409818
15	51106204	Sitayana Road No. 20C	27-13143-6329702	Turbine	KSB	2006	Siemens	2006	31.316632	73.394975
16	51006197	Canal Road No. 18	27-13143-6330608	Turbine	KSB	2003	Siemens	2003	31.349109	73.416069
17	71106103	Jinnah Park Water Works	27-13141-6100590	Centrifugal	KSB	2003	Siemens	2003	31.339904	73.409282
18	71106103-1	Jinnah Park Water Works	27-13141-6100590	Centrifugal	KSB	2003	Siemens	2003	31.340267	73.413617
19	71106103-2	Jinnah Park Water Works	27-13141-6100590	Centrifugal	KSB	2003	Siemens	2003	31.339975	73.41352

2.1.2 Disposal Works

Table 10: Inventory Table of Disposal Works

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Pump Capacity (Cusec)	Motor Manufacturer	Motor Capacity (Hp)	Latitude	Longitude
1	51206217-A	Alvi Road Housing Colony	27-13141-6100780	Centrifugal	KSB	1.5	Siemens	20	31.346151	73.423052
2	51206217-B	Alvi Road Housing Colony	27-13141-6100780	Centrifugal	KSB	2	Siemens	15	31.346151	73.423052
3	51206217-C	Alvi Road Housing Colony	27-13141-6100780	Centrifugal	KSB	1.5	Siemens	20	31.346151	73.423052
4	51206209-A	240 More Mauhallah Mustafabad	24-13141-5104100	Centrifugal	KSB	4	Siemens	40	31.322381	73.424062

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Pump Capacity (Cusec)	Motor Manufacturer	Motor Capacity (Hp)	Latitude	Longitude
5	51206209-B	240 More Mauhallah Mustafabad	24-13141-5104100	Centrifugal	KSB	4	Siemens	40	31.322381	73.424062
6	51206209-C	240 More Mauhallah Mustafabad	24-13141-5104100	Centrifugal	KSB	1.5	Siemens	30	31.322381	73.424062
7	51206209-D	240 More Mauhallah Mustafabad	24-13141-5104100	Centrifugal	KSB	4	Siemens	40	31.322381	73.424062
8	51206209-E	240 More Mauhallah Mustafabad	24-13141-5104100	N/A	KSB	4	Siemens	40	31.322381	73.424062
9	51206209-F	240 More Mauhallah Mustafabad	24-13141-5104100	Centrifugal	KSB	4	KAM	40	31.322381	73.424062
10	51206212-A	128-G.B	24-13146-5600403	Centrifugal	KSB	3	KAM	30	31.312077	73.418205
11	51206212-B	128-G.B	24-13146-5600403	Centrifugal	KSB	3	Siemens	30	31.312077	73.418205
12	51206216-A	Alvi Park	27-13141-6100820	Centrifugal	KSB	1	Siemens	10	31.311443	73.413417
13	51206216-B	Alvi Park	27-13141-6100820	Centrifugal	KSB	2	Siemens	15	31.311443	73.413417

2.1.3 Dewatering Sets

Table 11: Inventory of Dewatering Sets

Sr. No.	Unique ID	Location	Quantity	Latitude	Longitude
1	51206213 A	Al madina Colony	2	31.346082	73.423137
2	51206213 B	Waryam Nagar	2	31.331174	73.41749
3	51206213 C	Faislabad Road	1	31.32921	73.412116
4	51206213 D	Mehmood colony Road	2	31.332705	73.412057
5	51206213 E	Ismail abad	1	31.327926	73.410434
6	51206213 F	Quaid e Azam Road	1	31.316205	73.40284
7	51206217 D	Alvi Road Housing Colony	1	31.346151	73.423052
8	51206217 E	Alvi Road Housing Colony	1	31.346151	73.423052

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	7110696	Ghalani Mohallah Umer Masjid	Centrifugal	1	Faisal Motor Pump	N/A	Gold Matic	31.333873	73.40889
2	7110695	Jhal Faisalabad Road	Centrifugal	1	Golden Pumps	N/A	Golden Motors	31.320531	73.399108
3	51006201	Karma wala Chowk	Centrifugal	1	Faisal Motor Pump	N/A	Gold Matic	31.341422	73.412359
4	71106100	Naseem Bagh Bilal masjid	Connected with Turbine # 16 (51006200) & 17 Pumps ((51006198)					31.341643	73.422063
5	7110698	Katchery Road	Centrifugal	1	Faisal Pumps	N/A	Faisal Motors	31.331598	73.429058
6	7110699	Islampura	Centrifugal	1	Gold Matic	N/A	Gold Matic	31.335036	73.42621
7	7110697	Chamra Mandi	Centrifugal	1	Faisal Pumps	N/A	Faisal Motors	31.334519	73.416201
8	51006195	Mohalla Shehraona	Centrifugal	1	Gold Matic	N/A	Gold Matic	31.356062	73.419413
9	71107771	Faisal Park	Centrifugal	1	N/A	N/A	N/A	31.331629	73.42904

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

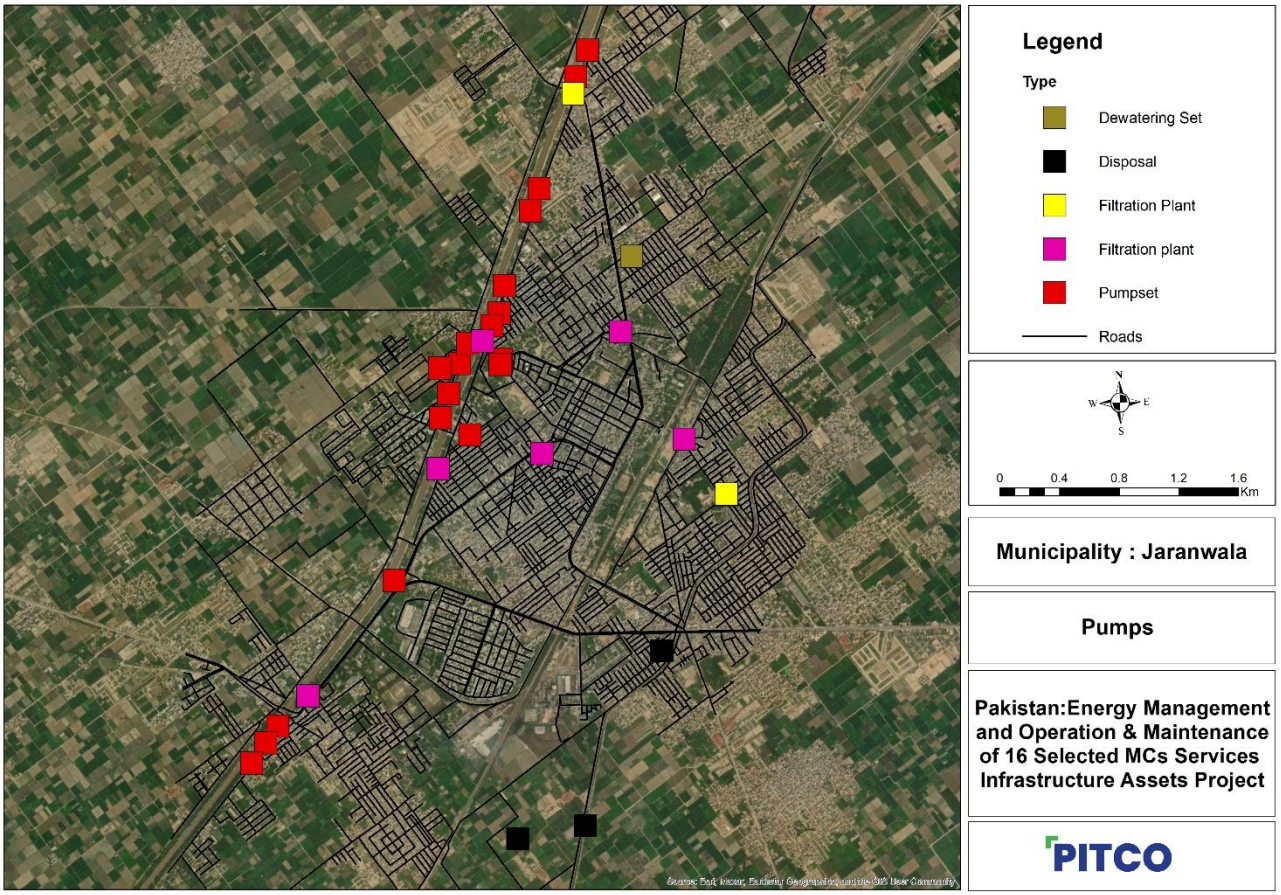


Figure 1: Map for Pumps and Disposal at MC Jaranwala

2.3 Baseline Energy Consumption Trend

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

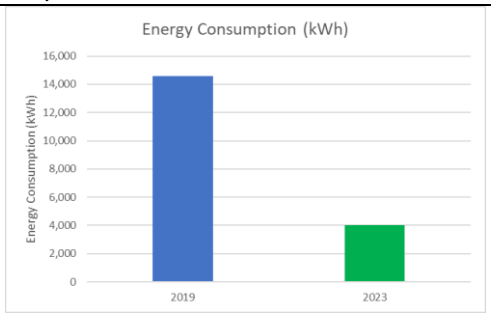
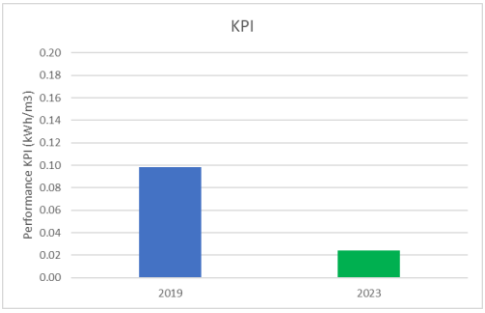
Table 13: Baseline Energy Consumption Trend

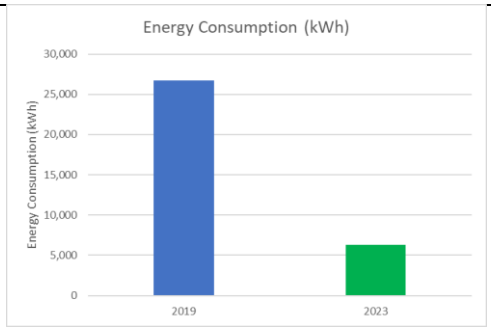
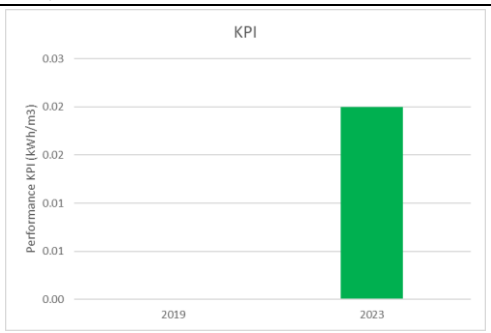
Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	159,693
Electrical energy used by Wastewater Disposal	kWh/y	244,765
Electrical energy used (Total)	kWh/y	404,458

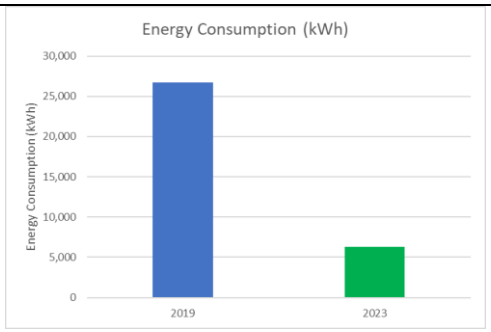
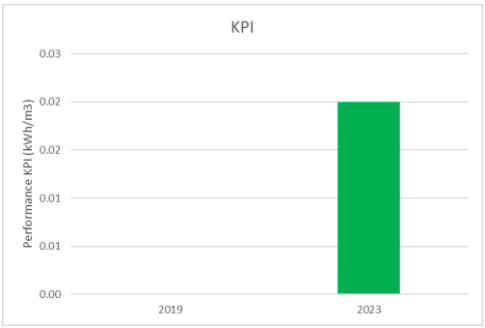
A comparison of current electricity consumption by the MC's water supply and disposal assets compared to results of the energy audit activity carried out in 2019, is presented in the following table:

		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)	15	18	316,910	159,693	157,217	0.14 kWh/m3	0.11 kWh/m3	Replacement of 3 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 2 out 3 pumpsets proposed by the Consultant and 1 abandoned pumpset which has resulted in significant reduction in the KPI for water supply. The effect of this reduction is reflected in the energy bills for the MC as well.
2	Wastewater Disposal	7	7	236,862	244,765	-7,903	0.06 kWh/m3	0.04 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal has improved as well. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.

Replacement of 3 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken installation of 2 new pumpsets. A discussion on each newly installed asset is presented below:

Canal Road No. 12 - Unique ID (21106207)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
14,579 kWh	4,030 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.10 kWh/m3	0.02 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of pumpset was recommended due to the low efficiency. Annual energy consumption of this pumpset in 2019 was 14,579 kWh whereas, annual energy consumption of this pumpset of current year is 4,030 kWh with an annual energy savings of 10,549 kWh. As seen from the KPI, the new pumpset is performing efficiently and the corresponding water supply to the MC from this pumpset has increased significantly.	

Canal Road No. 17 - Unique ID (51006198)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
26,681 kWh	6,321 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.02 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Annual energy consumption of this pumpset in 2019 was 26,681 kWh whereas, annual energy consumption of this pumpset of current year is 6,321 kWh with an annual energy savings of 20,360 kWh. As seen from the KPI, the new pumpset is performing efficiently. No KPI has been calculated for 2019 audit, as this pumpset was found to be non-operational.	

Canal Road No. 17 - Unique ID (51006198)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
26,681 kWh	6,321 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.02 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Annual energy consumption of this pumpset in 2019 was 26,681 kWh whereas, annual energy consumption of this pumpset of current year is 6,321 kWh with an annual energy savings of 20,360 kWh. As seen from the KPI, the new pumpset is performing efficiently. No KPI has been calculated for 2019 audit, as this pumpset was found to be non-operational.	

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.

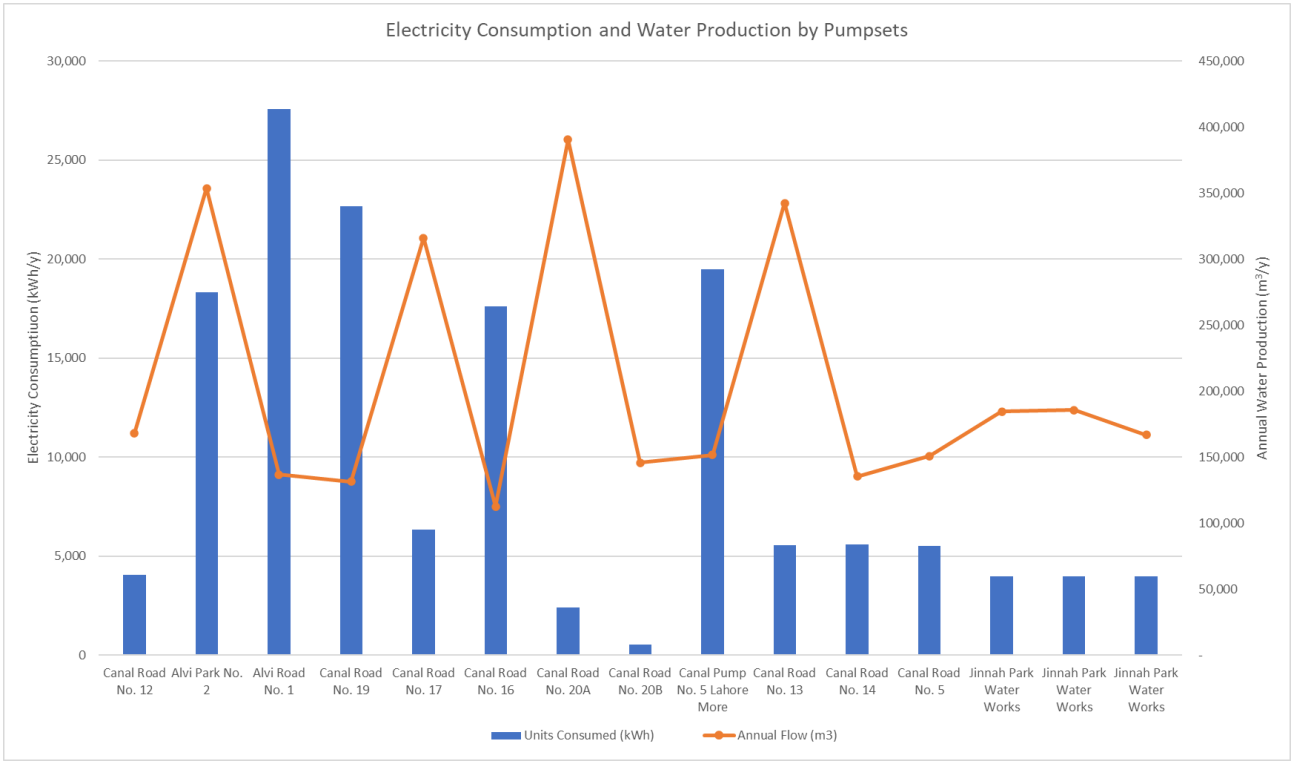
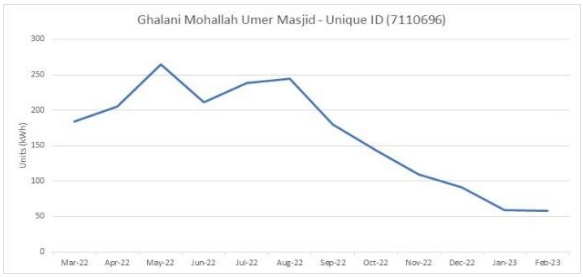


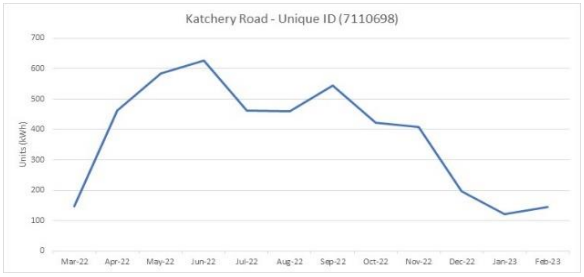
Figure 2: Electricity Consumption and Water Production by Pumpsets

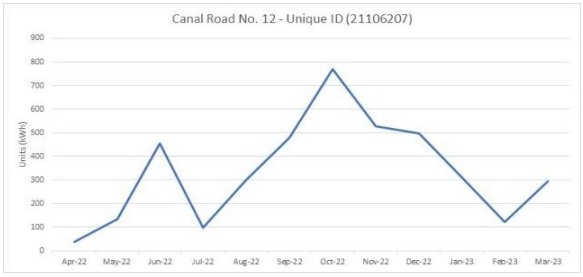
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

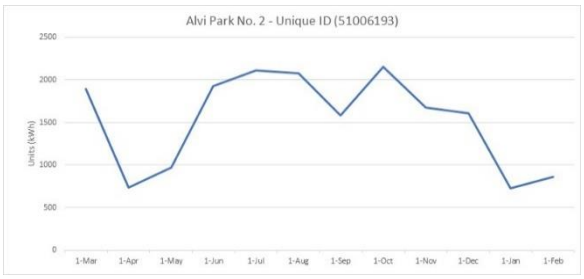
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

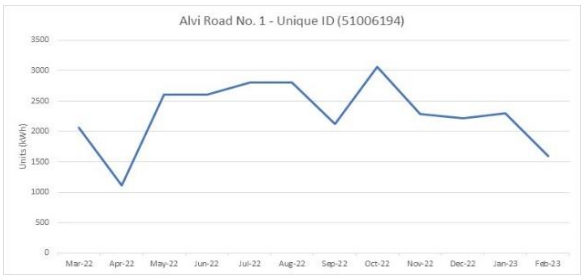
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

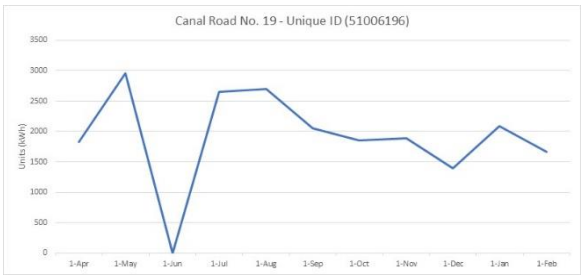


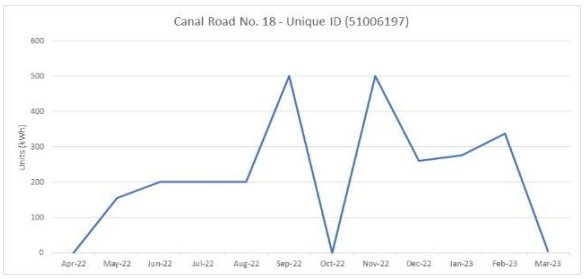

Katchery Road - Unique ID (7110698)
Units (kWh)
700
600
500
400
300
200
100
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23

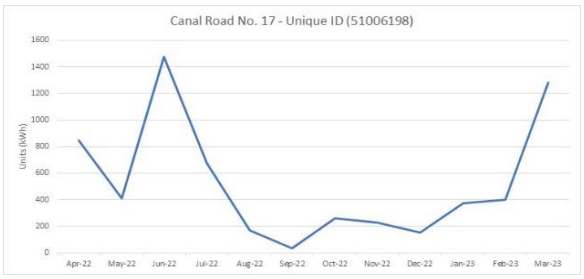

Canal Road No. 12 - Unique ID (21106207)
Units (kWh)
900
800
700
600
500
400
300
200
100
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23

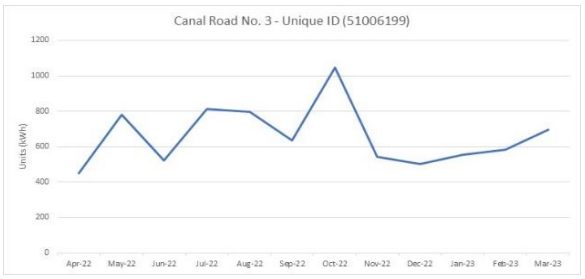

Alvi Park No. 2 - Unique ID (51006193)
Units (kWh)
2500
2000
1500
1000
500
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb

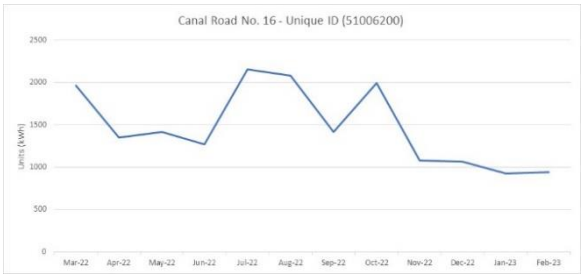

Alvi Road No. 1 - Unique ID (51006194)
Units (kWh)
3500
3000
2500
2000
1500
1000
500
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23

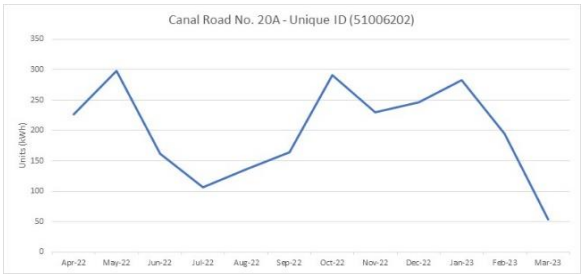

Canal Road No. 19 - Unique ID (51006196)
Units (kWh)
3500
3000
2500
2000
1500
1000
500
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb

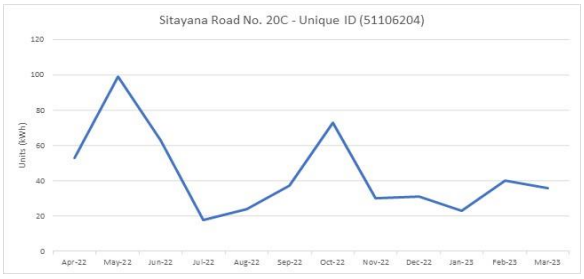

Canal Road No. 18 - Unique ID (51006197)
Units (kWh)
600
500
400
300
200
100
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23

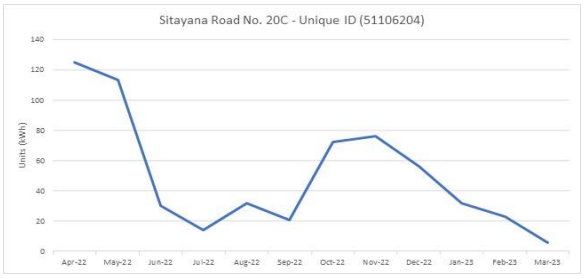

Canal Road No. 17 - Unique ID (51006198)
Units (kWh)
1600
1400
1200
1000
800
600
400
200
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23

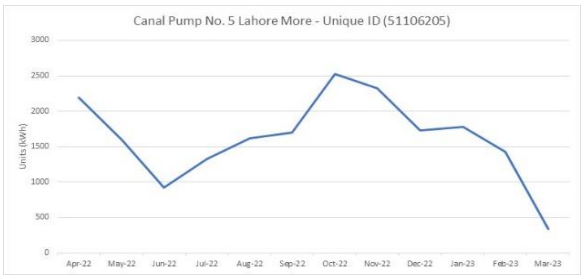

Canal Road No. 3 - Unique ID (51006199)
Units (kWh)
1200
1000
800
600
400
200
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23

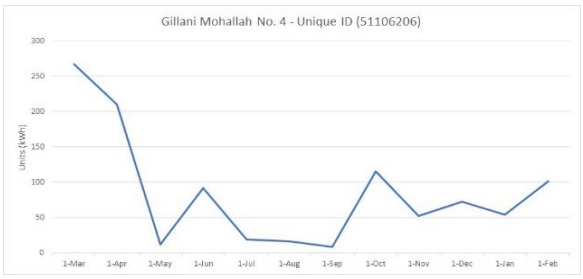

Canal Road No. 16 - Unique ID (51006200)
Units (kWh)
2500
2000
1500
1000
500
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23

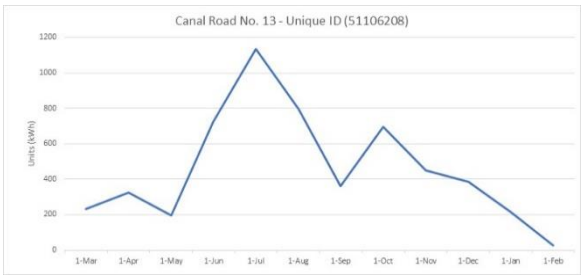

Canal Road No. 20A - Unique ID (51006202)
Units (kWh)
350
300
250
200
150
100
50
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23

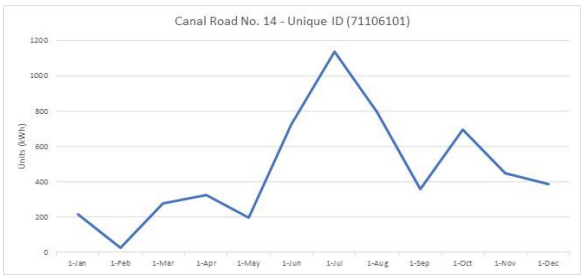

Sitayana Road No. 20C - Unique ID (51106204)
Units (kWh)
120
100
80
60
40
20
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23

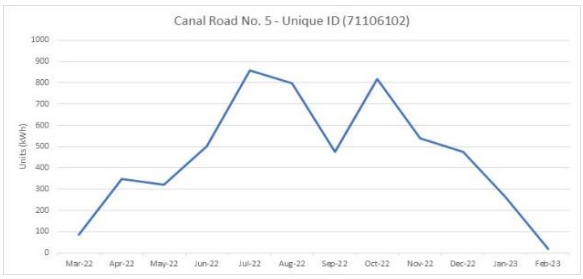

Sitayana Road No. 20C - Unique ID (51106204)
Units (kWh)
140
120
100
80
60
40
20
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23

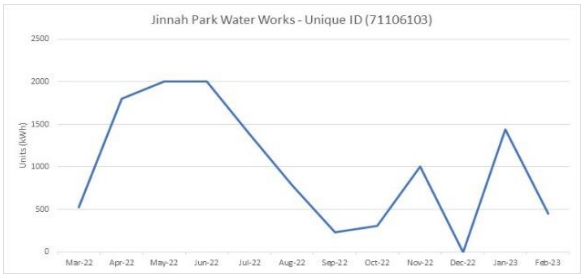












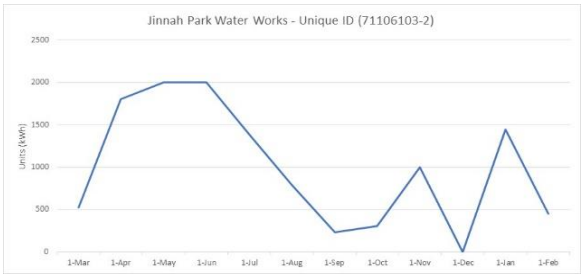
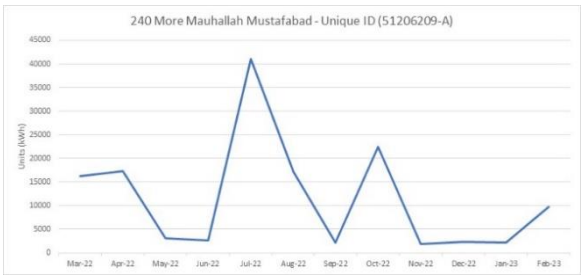
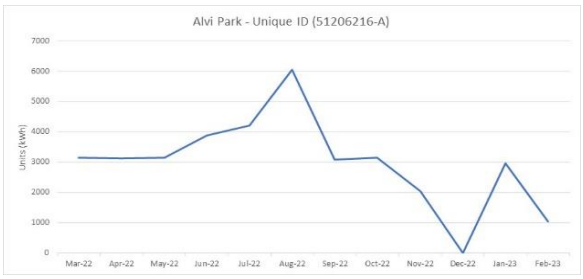


Figure 3: Energy Consumption Trend for Water Pumps





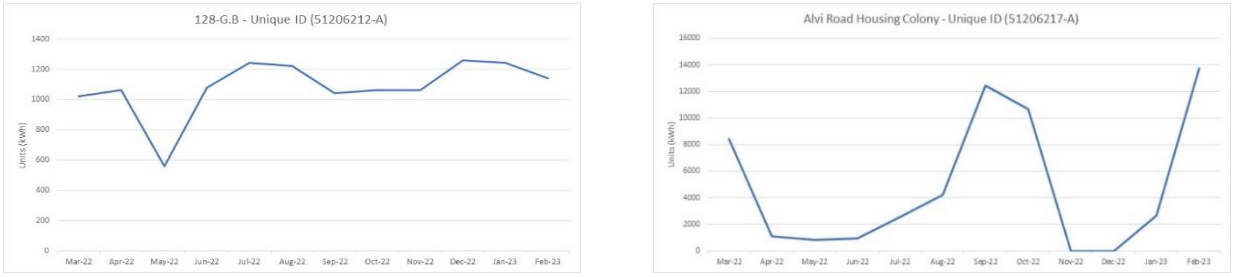


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Jaranwala MC has nineteen (19) tubewells for groundwater, all of which are manually operated. Out of these, 18 pumpsets were found to be in working condition.

Performance evaluation of pumpsets could be carried out at only 16 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	21106207	Canal Road No. 12	Yes	Yes
2	51006193	Alvi Park No. 2	Yes	Yes
3	51006194	Alvi Road No. 1	Yes	Yes
4	51006196	Canal Road No. 19	Yes	Yes
5	51006197	Canal Road No. 18	Yes	No
6	51006198	Canal Road No. 17	Yes	Yes
7	51006199	Canal Road No. 3	Yes	No
8	51006200	Canal Road No. 16	Yes	Yes
9	51006202	Canal Road No. 20A	Yes	Yes
10	51006203	Canal Road No. 20B	Yes	Yes
11	51106204	Sitayana Road No. 20C	Yes	Yes
12	51106205	Canal Pump No. 5 Lahore More	Yes	Yes
13	51106206	Gillani Mohallah No. 4	Yes	No
14	51106208	Canal Road No. 13	Yes	Yes
15	71106101	Canal Road No. 14	Yes	Yes
16	71106102	Canal Road No. 5	Yes	Yes
17	71106103	Jinnah Park Water Works	Yes	Yes
18	71106103-1	Jinnah Park Water Works	Yes	Yes
19	71106103-2	Jinnah Park Water Works	Yes	Yes

Table 15: Pumpset Primary Performance Parameters

Sr No.	Unique ID	Location	Rated Pump Flow m3/hr	Measured Flow m3/hr	Dynamic Head m	Power Consumption kW	Pump Efficiency %	Measured Power Factor	Comments
1	21106207	Canal Road No. 12	101.9	169.8	24.73	21.20	63%	0.79	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, it was recommended to replace the pumpset due to the lower efficiency of 38%.
2	51006193	Alvi Park No. 2	51.0	89.3	14.49	14.60	28%	0.88	Efficiency of the pumpset is unsatisfactory. Previously, the efficiency of the pumpset was 52%.
3	51006194	Alvi Road No. 1	51.0	92.0	32.06	16.50	57%	0.83	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 60%.
4	51006196	Canal Road No. 19	76.5	88.4	15.40	18.67	23%	0.83	Efficiency of the pumpset is unsatisfactory. Previously, the efficiency of the pumpset was 59%.
5	51006198	Canal Road No. 17	101.9	136.8	28.55	21.20	59%	0.78	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, the pump site was abandoned by the MC.
6	51006200	Canal Road No. 16	76.5	75.8	29.77	13.03	56%	0.83	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 53%.
7	51006202	Canal Road No. 20A	51.0	98.6	16.17	15.00	34%	0.82	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve was not working properly. Previously, the efficiency of the pumpset was 55%.
8	51006203	Canal Road No. 20B	51.0	98.2	22.13	20.21	34%	0.83	Efficiency of the pumpset is unsatisfactory. Previously, the efficiency of the pumpset was 53%.
9	51106204	Sitayana Road No. 20C	76.5	77.1	23.81	20.60	29%	0.77	Efficiency of the pumpset is unsatisfactory. Previously, the efficiency of the pumpset was 54%.
10	51106205	Canal Pump No. 5 Lahore More	76.5	102.2	13.57	21.47	21%	0.83	Efficiency of the pumpset is unsatisfactory. Previously, no flow was detected due to extremely rusty condition of the delivery line.
11	51106208	Canal Road No. 13	101.9	173.0	22.60	21.70	58%	0.81	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, it was recommended to replace the pumpset due to the lower efficiency of 47%.

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
12	71106101	Canal Road No. 14	76.5	82.0	14.18	16.90	22%	0.72	Efficiency of the pumpset is unsatisfactory. Previously, this pumpset was non-functional.
13	71106102	Canal Road No. 5	76.5	101.6	29.16	17.20	55%	0.82	Efficiency of the pumpset is satisfactory. Previously, no flow was detected due to extremely rusty condition of the delivery line.
14	71106103	Jinnah Park Water Works	229.4	186.4	19.55	40.47	29%	0.93	Efficiency of the pumpset is unsatisfactory. Gate/sluice valve is jammed. Previously, the efficiency of the pumpset was 52%.
15	71106103-1	Jinnah Park Water Works	229.4	187.5	19.55	41.00	29%	0.92	Efficiency of the pumpset is unsatisfactory. Gate/sluice valve is jammed.
16	71106103-2	Jinnah Park Water Works	229.4	168.6	33.61	32.57	56%	0.88	Efficiency of the pumpset is satisfactory. Gate/sluice valve is jammed.

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

Table 16: Pumpset Secondary Performance Parameters

Unique ID	Motor Vibration Hz	Temperature of Motor	Motor Rated kW	Motor Rated Efficiency	Transformer kVA	Elec. Connection	Line Leakage	Rated Head of Pump	Motor Rated Voltage V	Full Load PF	PF (Measured)	Load factor %	Observations
21106207	0.00	33	22	90	50	Safe	Not ok	150	400	0.85	0.79	95%	Low PF
51006193	0.69	39	15	-	50	Safe	ok	175	-	-	0.88	98%	
51006194	79.58	59	15	-	25	Safe	ok	175	380	0.88	0.83	111%	Overloaded Motor
51006196	146.91	47	19	-	50	Safe	ok	100	380	0.84	0.83	100%	Full Load
51006198	0.00	38	22	90	50	Safe	ok	150	-	0.85	0.78	95%	Low PF
51006200	5.31	36	19	-	50	Safe	ok	175	380	0.84	0.83	70%	
51006202	53.05	53	15	-	50	Safe	ok	175	380	0.88	0.82	101%	Overloaded Motor
51006203	0.00	42	15	-	50	Safe	ok	175	-	-	0.83	136%	Overloaded Motor
51106204	0.00	38	22	-	50	Safe	ok	200	380	0.84	0.77	92%	Low PF
51106205	208.13	30	22	-	50	Safe	ok	21	380	0.84	0.83	96%	
51106208	79.58	35	22	90	50	Safe	ok	150	400	0.88	0.81	97%	
71106101	0.00	38	19	-	50	Safe	ok	175	380	384.00	0.72	91%	Low PF
71106102	7.40	48	19	-	50	Safe	ok	175	380	0.84	0.82	92%	
71106103	919.56	36	45	-	200	Safe	Not ok	140	400	0.88	0.93	90%	
71106103-1	205.36	26	45	-	200	Safe	Not ok	140	400	0.88	0.92	92%	
71106103-2	107.12	27	45	-	200	Safe	Not ok	140	400	0.88	0.88	73%	

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

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

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
1	21106207	Canal Road No. 12	102	22.371	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	169.77	24.7	Flow at Existing Operating Conditions	21.20	63%
2	114.25	37.4	Flow nearest to duty point	20.5	67%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
2	51006193	Alvi Park No. 2	51	14.914	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	89.296	14.5	Flow at Existing Operating Conditions	14.60	28%
2	52.2665	32.1	Flow nearest to duty point	14.43333333	37%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
3	51006194	Alvi Road No. 1	51	14.914

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	92.04	32.1	Flow at Existing Operating Conditions	16.50	57%
2	62.89	46.8	Flow nearest to duty point	15.70	60%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
4	51006196	Canal Road No. 19	76	18.6425

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	88.4189	15.4	Flow at Existing Operating Conditions	18.67	23%
2	75.2237	22.4	Flow nearest to duty point	18.57	29%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
5	51006198	Canal Road No. 17	102	22.371

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	136.82	28.5	Flow at Existing Operating Conditions	21.20	59%
2	102.55	39.1	Flow nearest to duty point	20.3	63%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
6	51006200	Canal Road No. 16	76	18.6425

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	75.8457	29.8	Flow at existing operating conditions is nearest to duty point	13.03	56%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
7	51006203	Canal Road No. 20B	51	14.914

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	98.22	22.1	Flow at Existing Operating Conditions	20.21	34%
2	68.31	29.2	Flow nearest to duty point	15.90	40%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
8	51106204	Sitayana Road No. 20C	76	22.371

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	77.13	23.8	Flow at existing operating conditions is nearest to duty point	20.60	29%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
9	51106205	Canal Pump No. 5 Lahore More	76	22.371

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	102.182	13.6	Flow at Existing Operating Conditions	21.47	21%
2	75.6452	24.1	Flow nearest to duty point	22.17	26%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)
10	51106208	Canal Road No. 13	102	22.371

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	172.98	22.6	Flow at Existing Operating Conditions	21.70	58%
2	101.28	29.6	Flow nearest to duty point	15.80	61%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
11	71106101	Canal Road No. 14	76	18.6425	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	82	14.2	Flow at existing operating conditions is nearest to duty point	16.90	22%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
12	71106102	Canal Road No. 5	76	18.6425	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	101.591	29.2	Flow at Existing Operating Conditions	17.20	55%
2	74.4263	38.3	Flow nearest to duty point	15.80	58%

2.4.3 Wastewater Disposal System

The MC has four (4) disposal station having thirteen (13) 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	51206209-A	240 More Mauhallah Mustafabad	407.8	313.1	12.19	28.00	44%	Efficiency of the pumpset is satisfactory. Previously, it was recommended to repair/replace the impeller of the pumpset.
2	51206209-B	240 More Mauhallah Mustafabad	407.8	106.5	12.19	11.00	38%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, the efficiency of the pumpset was 38%.
3	51206209-C	240 More Mauhallah Mustafabad	152.9	213.3	4.57	8.00	39%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, the efficiency of the pumpset was 42%.
4	51206212-A	128-G.B	305.8	315.0	4.88	12.60	39%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, the efficiency of the pumpset was 65%.
5	51206216-B	Alvi Park	203.9	168.1	9.14	12.39	40%	Efficiency of the pumpset is satisfactory. Previously, this pumpset was non-functional.
6	51206217-B	Alvi Road Housing Colony	203.9	118.8	7.01	6.90	39%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, the efficiency of the pumpset was 56%.
7	51206217-C	Alvi Road Housing Colony	152.9	163.4	4.88	6.10	42%	Efficiency of the pumpset is satisfactory. Previously, this pumpset was non-functional.

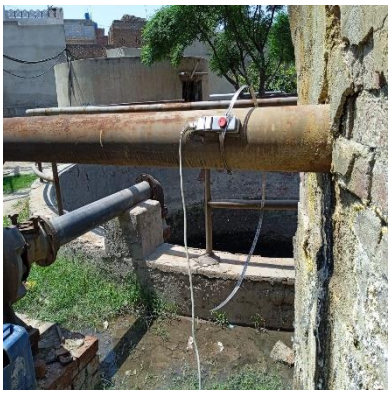


Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are eleven (11) dewatering sets in the MC, out of which six 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	21106207	Canal Road No. 12	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
2	51006193	Alvi Park No. 2	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
3	51006196	Canal Road No. 19	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
4	51006198	Canal Road No. 17	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
5	51006202	Canal Road No. 20A	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
6	51006203	Canal Road No. 20B	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
7	51106204	Sitayana Road No. 20C	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
8	51106205	Canal Pump No. 5 Lahore More	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
9	71106101	Canal Road No. 14	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
10	71106103	Jinnah Park Water Works	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
11	71106103-1	Jinnah Park Water Works	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
12	51206209-A	240 More Mauhallah Mustafabad	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
13	51206209-B	240 More Mauhallah Mustafabad	The power factor at the site is below 0.8.	A 7.5 kVAr capacitor should be installed on each phase.

Sr No.	Unique ID	Location	Comments	Recommendation
14	51206209-C	240 More Mauhallah Mustafabad	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
15	51206212-A	128-G.B	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
16	51206217-B	Alvi Road Housing Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
17	51206217-C	Alvi Road Housing Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
General Observations				
18	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
19	General	Operating Time	Pumps should not be run during Peak electricity consumption hours.	Operational hours of pump should be scheduled keeping in mind the varying peak hours across the year to avoid peak charges. Peak hours for FESCO during the entire year are given in Annexure 1.
20	General	Dewatering Sets	Dewatering sets were in satisfactory condition, but no O&M logs were available with the MC	It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.
21	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 Jaranwala 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	457	457	-
Non-Operational Street Lights	778	778	-
Total	**1,235**	**1,235**	**0**

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

Out of total 1,235 streetlights operated by MC, 422 fixtures are installed on PC, 377 fixtures are installed on steel structure, 178 fixtures are installed on tubular structure, and 16 fixtures are installed on Wire, and 82 fixtures are installed on walls. The streetlight's structural classification is tabulated below.

Table 21: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Wire	Wall	Grand Total
MC	422	377	178	16	82	**1,075**
Private	-	-	-	-	-	**0**

Streetlights of Jaranwala 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 Jaranwala are shown in table below.

Table 22: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Office Town Counsel Hall TMA	13	10-13141-0741901	0.43
2	Ahambra Road	50	24-13141-5102900	2.82
3	Madni Park Chak No. 127	64	24-13141-5102801	3.47
4	Fatima Jinnah Lady Garden Park	11	06-13141-0476200	0.38
5	Office Municipal Committee Water Works Road	27	24-13141-5102500	0.58
6	Zam Zam Hotel, New Bazar Circular Road	30	24-13141-5102700	1.60
7	Mandir Chowk	20	24-13141-5102600	1.75
8	Millad Chowk	29	24-13141-5103400	1.37
9	Municipal Colony	26	24-13141-5102800	0.92
10	Water Purification Plant Muhammad Ali Park	31	21-13141-7100831	1.94
11	Alvi Park	19	24-13141-5102901	1.27
12	Housing Colony	16	24-13141-5103000	0.96
13	Waryam Nagar	41	24-13141-5103600	1.62
14	Madrasa Lahore Road Jaranwala	22	24-13141-5103300	0.96
15	Farooq Park	54	24-13141-5103500	3.34
16	Faisalabad Road Near Hassan Travel	136	24-13141-5103700	8.96
17	Chowk Bachayana Mor	13	10-13141-0736902	0.79
18	Muhammad BiBi Colony	94	24-13141-5102400	5.06

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
19	240 Mor	11	24-13141-5103703	0.75
20	Islam Pura Near Chaki	36	24-13141-5103100	1.72
21	Ahmad Park	15	24-13141-5103704	0.75
22	Anwar Abad Near Wapda Office	93	24-13141-5103102	6.30
23	Faisal Park	12	01-13141-0087003	0.56
24	Benazir Shaheed Bhutto Park Islam Pura Phase-2	80	24-13141-5104101	4.82
25	Jaal Faisalabad Road	32	27-13141-6102260	1.53
26	I.I Chandrighar Colony	48	24-13141-5103702	3.35
27	Feroz Colony	56	24-13141-5103901	3.26
28	City Water Works Jinnah Park	26	24-13141-5100100	0.83
29	Arban Scheme No. 8/16 Abuzar Colony	6	27-13143-6330500	0.35
30	Arban Scheme No. 5 Near Dera Chaudry Abid	39	27-13143-6330702	3.07
31	Qarmaan Wala Chowk	14	06-13141-0470209	0.71
32	Chak No. 128 GB	59	24-13141-5103800	4.31
33	Bihari Colony	12	24-13141-5103900	0.62

Out of the 1,235 surveyed lights in the MC, 457 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	50	6		12.0	1,314	0
LED	100	1		12.0	438	0
LED	12	2		12.0	105	0
LED	120	189		12.0	99,338	0
LED	18	54		12.0	4,257	0
LED	25	5		12.0	548	0
LED	40	11		12.0	1,927	0
Tube Light	40	132		12.0	23,126	0
Sodium Light	250	49		12.0	53,655	0
Halogen Rod	500	8		12.0	17,520	0
LED	50	6		12.0	1,314	0
Total					**202,229**	**0**

[5] Based on Interview with Client.

Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

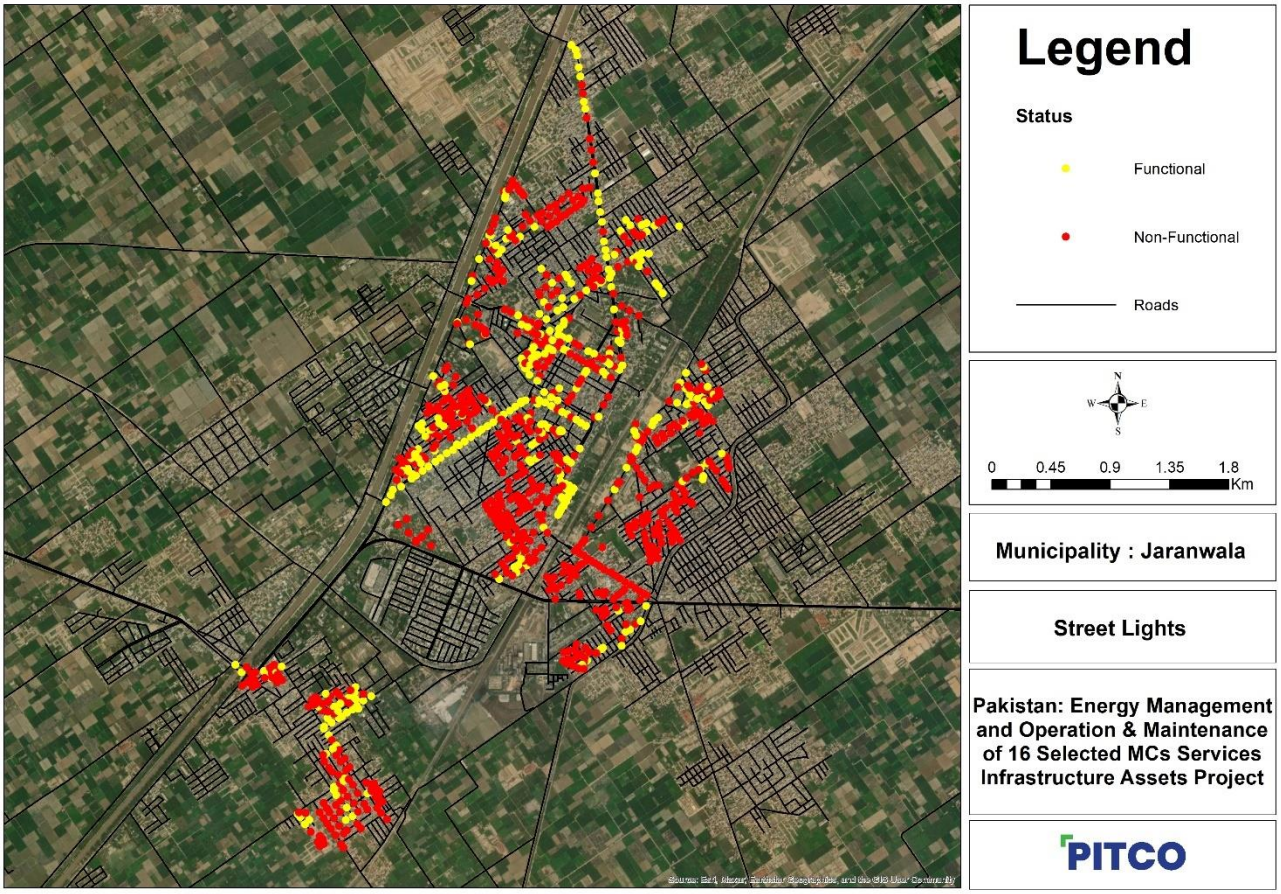


Figure 9: GIS Mapping of street lights in Jaranwala MC

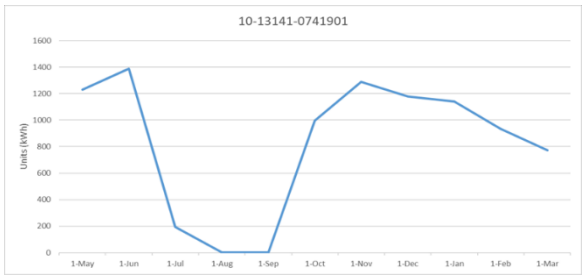
3.3 Baseline Energy Consumption Trend

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	**321,022**[6]
Total number of operational lights	No.	**457**

[6] Based on electricity bills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Units (kWh)
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1400
1200
1000
800
600
400
200
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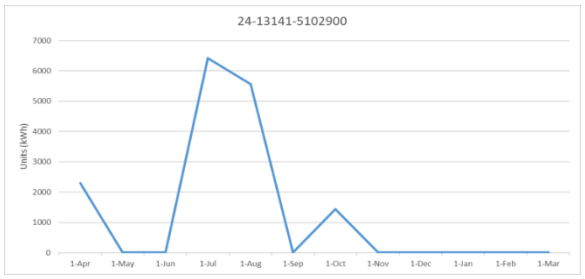
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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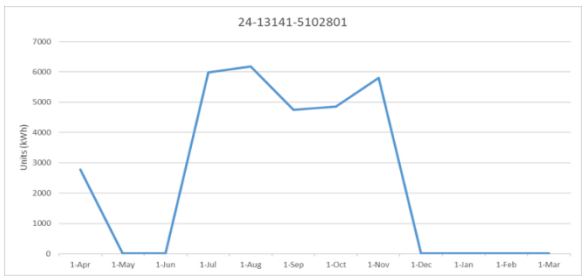
6000
5000
4000
3000
2000
1000
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


24-13141-5102801
Units (kWh)
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4000
3000
2000
1000
0
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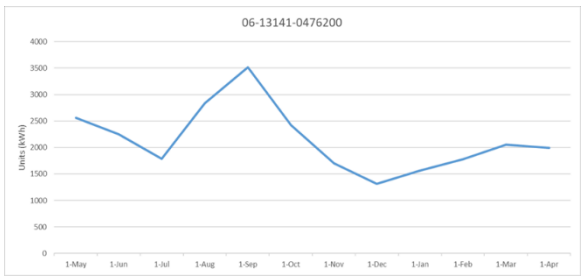
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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2500
2000
1500
1000
500
0
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1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr


24-13141-5102500
Units (kWh)
1200
1000
800
600
400
200
0
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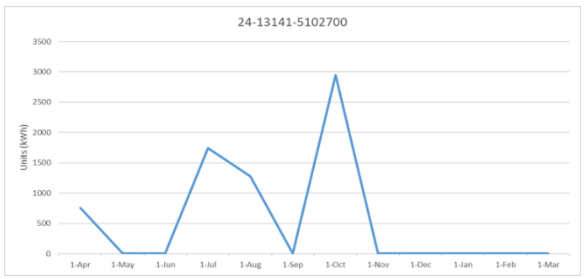
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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2500
2000
1500
1000
500
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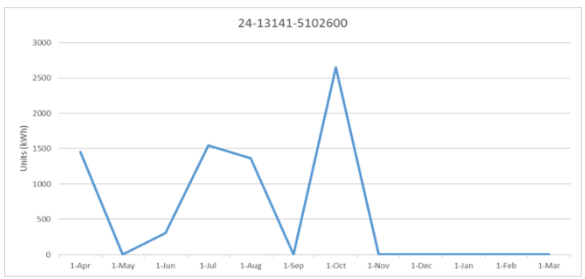
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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2000
1500
1000
500
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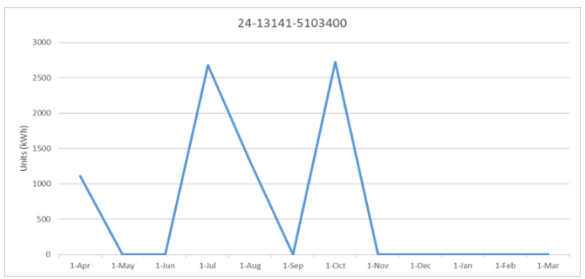
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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2000
1500
1000
500
0
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1-Jun
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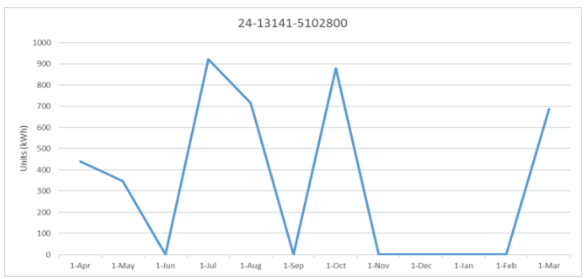
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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500
400
300
200
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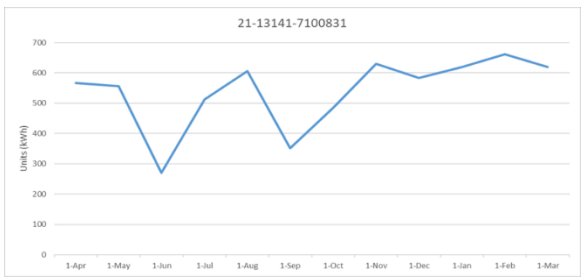
1-Feb
1-Mar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400
300
200
100
0
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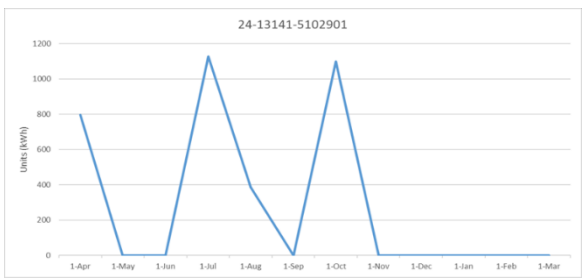
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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400
200
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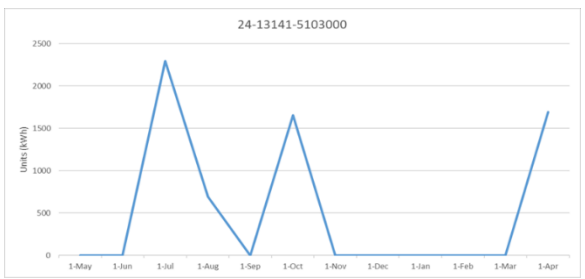
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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2000
1500
1000
500
0
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1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr


24-13141-5103600
Units (kWh)
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1500
1000
500
0
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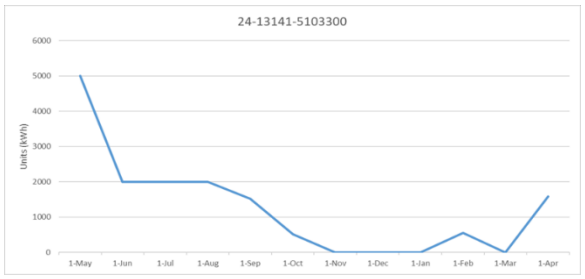
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Units (kWh)
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4000
3000
2000
1000
0
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24-13141-5103500
Units (kWh)
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300
200
100
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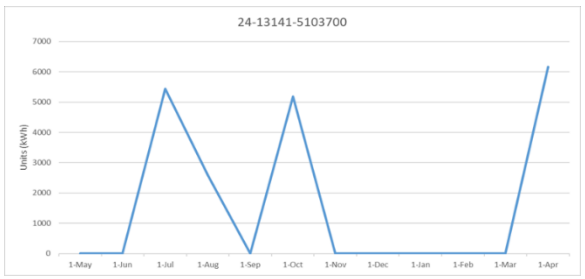
24-13141-5103700
Units (kWh)
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4000
3000
2000
1000
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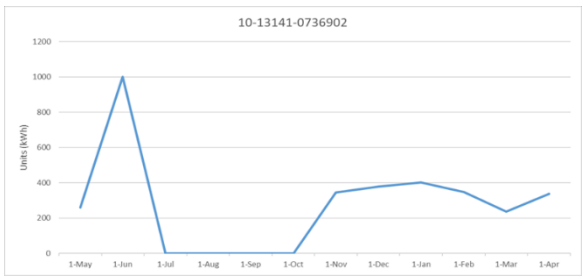
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr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Units (kWh)
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600
400
200
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24-13141-5102400
Units (kWh)
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1000
800
600
400
200
0
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr


24-13141-5103703
Units (kWh)
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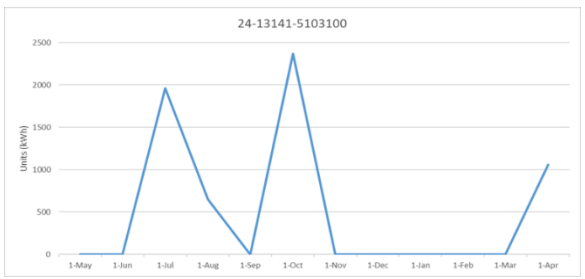
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500
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24-13141-5103704
Units (kWh)
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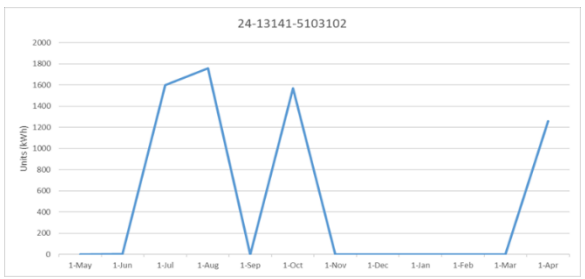
5000
4000
3000
2000
1000
0
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr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Units (kWh)
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1600
1400
1200
1000
800
600
400
200
0
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01-13141-0087003
Units (kWh)
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1000
800
600
400
200
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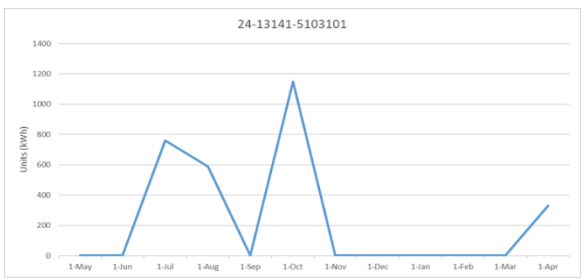
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr


24-13141-5103101
Units (kWh)
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1000
800
600
400
200
0
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr

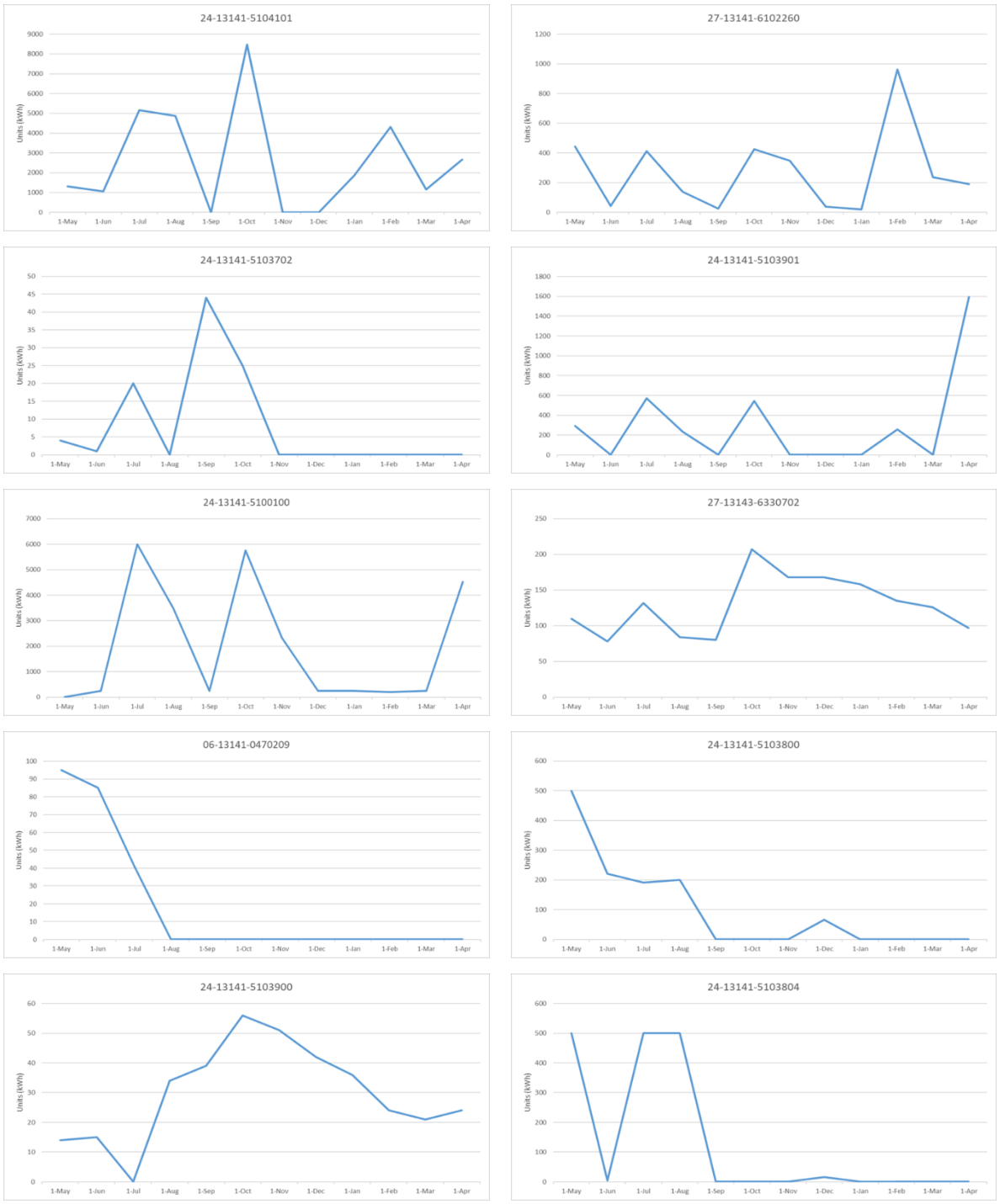

Figure 10: Energy Consumption trend of Streetlights

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	46	457	379,274	337,407	41,867	10,889 kWh/km	4,742 kWh/km	Based on the previous assessment, there were only 46 MC owned operational lights with an average consumption of 8,245kWh/light/annum, whereas, currently there are 457 operational lights with average energy consumption of 738kWh/light/annum. The MC has significantly improved its energy consumption per light fixture.

3.4 Maintenance & Replacement of Streetlights

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

3.5 Observations

- Streetlights in Jaranwala MC are operated by MC.
- Most of the operational streetlights are LEDs.
- Approximately 70% of the LED streetlights have a rating of more than 120 Watts.
- Jaranwala 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 Jaranwala 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	Jaranwala 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 Jaranwala 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	FDJ-39-12	Tractor	Millat	MF-385	2007	4WD	Front loader	LM9B570V512691N	0515-05	85HP
2	Unregistered Vehicle 1	Tractor Back-hoe	Millat	MF-385	2020	4WD	Back-hoe	LM9B572V504928F	84978/4/20	85HP
3	FDJ-83-14	Tractor Front loader	Millat	MF-385	2014	4WD	Front loader	LM9B570V529440Y	81219/11/14	85HP
4	FDJ-84-14	Tractor Front blade	Millat	MF-385	2014	4WD	Front blade	LM9B570V528037Y	81223/06/14	85HP
5	FDS-6749	Tractor trolley	Millat	MF-385	1995	4WD	Transport of Solid Waste	LD97041V5048Y	485/15	85HP
6	FDJ-36	Tractor Grass Cutter	Millat	MF-240	2012	2WD	Grass Cutter	CE99001V540062N	9413/94	50HP
7	FDJ-98-12	Tractor trolley	Millat	MF-385	2007	4WD	Transport of Solid Waste	LM9B570V512564M	0515/11	85HP
8	FS-1546	Tractor trolley	Millat	MF-375	2002	2WD	Transport of Solid Waste	LM9B600V500360H	05/14	75HP
9	FS-1566	Tractor trolley	Millat	MF-375	2002	2WD	Transport of Solid Waste	LM9B600V500360H	05/02	75HP
10	FDG-6265	Truck/ Water Bowser	Bedford	N/A	1981	4WD	No Task Assigned	LS12722	6-4-83 CJQ 611983	107HP
11	FDJ-7420	Tractor	Fiat	Fiat - 480	N/A	4WD	No Task Assigned	N/A	N/A	60HP
12	Unregistered Vehicle 2	Mini Truck	Master	N/A	N/A	4WD	No Task Assigned	N/A	N/A	4200
13	FDJ-35	Mini Truck Lifter	Master	BJT036B	2016	4WD	Light Branch	J1000B-1A-AAB14000582	MMC0207788	4200
14	FDL-1647	Jeep	Suzuki	Potohar	N/A	4WD	No Task Assigned	N/A	N/A	1000
15	FS-1266	Car	Suzuki	Cultus	N/A	2WD	No Task Assigned	N/A	N/A	1000
16	FDM-9252	Jeep	Mitsubishi	Pajero	N/A	4WD	No Task Assigned	N/A	N/A	2500
17	FDG-665	Car	Suzuki	Cultus	2007	2WD	Transport of Staff	P400438	402597	1000
18	FDG-565	Car	Suzuki	Cultus	2007	2WD	Transport of Staff	400448	402682	1000
19	Unregistered Vehicle 3	Bike	Honda	CD70	2022	2WD	Transport of Staff	E653531	HA393029	70
20	Unregistered Vehicle 4	Bike	Honda	CD70	2022	2WD	Transport of Staff	N/A	HA395746	70
21	Unregistered Vehicle 5	Bike	Honda	CD70	2022	2WD	Transport of Staff	E655669	HA395612	70
22	Unregistered Vehicle 6	Bike	Honda	CD70	2022	2WD	Transport of Staff	E655653	HA395747	70
23	FDJ-30	Mini Truck	Master	B90	2016	4WD	Encroachment	4100QB-1A-AAB140004	MV00207777	4200
24	Unregistered Vehicle 7	Mini Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	SR308PK492762	PKT388100	796
25	Unregistered Vehicle 8	Mini Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	SR308PK492760	PKT388098	796
26	Unregistered Vehicle 9	Mini Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	SR308PK492767	PKT388102	796
27	Unregistered Vehicle 10	Mini Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	SR308PK492763	PKT388101	796
28	Unregistered Vehicle 11	Mini Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	SR308PK492764	PKT388102	796
29	Unregistered Vehicle 12	Mini Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	SR308PK492761	PKT388099	796

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	Unregistered Vehicle 13	Dump Truck	Hino	NR-500	2022	4WD	No Task Assigned	JO8EVUM10701	FG8JKLB-10347	4465
31	Unregistered Vehicle 14	Dump Truck	Hino	NR-500	2022	4WD	No Task Assigned	J08EVUM10702	FG8JKLB-10348	4465
32	Unregistered Vehicle 15	Truck Compactor	Hino	NR-300	2022	4WD	No Task Assigned	N04CWGH50228	JHHYCKOF404600195	4009
33	Unregistered Vehicle 16	Truck Compactor	Hino	NR-300	2022	4WD	No Task Assigned	N04CWGM50233	JHHYCKOF604600196	4009
34	Unregistered Vehicle 17	Truck	Hino	NR-300	2022	4WD	No Task Assigned	N04CWGM50235	JHHYCKOFX04600198	4009
35	Unregistered Vehicle 18	Truck Compactor	Hino	NR-300	2022	4WD	No Task Assigned	N04CWGM50234	JHHYCKOF804600197	4009
36	Unregistered Vehicle 19	Truck/ Water Bowser	Hino	NR-300	2022	4WD	No Task Assigned	N04CWGM50251	JHHYCKOF504600206	4009
37	Unregistered Vehicle 20	Truck/ Water Bowser	Hino	NR-300	2022	4WD	No Task Assigned	N04CWGM50252	JHHYCKOF704600207	4009
38	Unregistered Vehicle 21	Tractor Front loader	Hino	MF-385	2022	4WD	No Task Assigned	507184-H	85502/01/22	85HP
39	Unregistered Vehicle 22	Tractor Front loader	Millat	MF-385	2022	4WD	No Task Assigned	507228-H	85509/04/22	85HP
40	Unregistered Vehicle 23	Tractor Front blade	Millat	MF-385	2022	4WD	No Task Assigned	507225-H	85509/03/22	85HP
41	Unregistered Vehicle 24	Tractor Mechanical Sweeper	Millat	MF-385	2022	4WD	No Task Assigned	507226-H	85509/02/22	85HP
42	Unregistered Vehicle 25	Pickup/ Mobile Workshop	Suzuki	Bolan	2020	2WD	No Task Assigned	PKT1028030	SV308PK01144532	796
43	FDJ 85	Truck	Hino	NR-300	2014	4WD	Suction Jetting machine	JM13642	JHHYFJOHX02000344	4009

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	FDJ-39-12	9:36 AM	10:36 AM	4.01	4.01 Liters/hr	8:05 AM	9:36 AM		13	8.57 Liters/hr
2	Unregistered Vehicle 1	9:55 AM	10:55 AM	2.14	2.14 Liters/hr	8:15 AM	9:55 AM		8.74	5.24 Liters/hr
3	FDJ-83-14	9:38 AM	10:38 AM	3.01	3.01 Liters/hr	8:25 AM	9:38 AM		11.02	9.06 Liters/hr
4	FDS-6749	9:35 AM	10:35 AM	3.01	3.01 Liters/hr	8:08 AM	9:35 AM		8.04	5.54 Liters/hr
5	FDJ-98-12	10:00 AM	11:00 AM	3	3 Liters/hr	8:10 AM	10:00 AM		18.02	9.83 Liters/hr

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
6	FS-1546	9:45 AM	10:45 AM	2.01	2.01 Liters/hr	8:17 AM	9:45 AM		6.67	4.55 Liters/hr
7	FS-1566	9:56 AM	10:56 AM	2	2 Liters/hr	8:12 AM	9:56 AM		8	4.62 Liters/hr
8	FDJ-35	9:37 AM	10:37 AM	3.01	3.01 Liters/hr	8:20 AM	9:35 AM		7.01	5.61 Liters/hr
9	FDJ 85	9:30 AM	10:30 AM	9.98	9.98 Liters/hr	8:00 AM	9:30 AM		10.02	6.68 Liters/hr

Table 28: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	FDJ-39-12	1.0
2	Unregistered Vehicle 1	1.0
3	FDJ-83-14	0.9
4	FDJ-84-14	1.1
5	FDS-6749	1.1
6	FDJ-36	1.1
7	FDJ-98-12	1.1
8	FS-1546	1.1
9	FS-1566	1.0
10	FDJ-35	1.1
11	FDJ 85	1.1

The logbooks of remaining vehicles are not available in MC.

The MC made 9 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 3.57 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 6.63 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	55,896
Annual Cost of Fuel (Diesel)	PKR/y	16,377,528
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 Jaranwala 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 Jaranwala 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 eight MC owned buildings in the MC. Detailed assessment of these is given in the following section

5.1 GIS Map

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

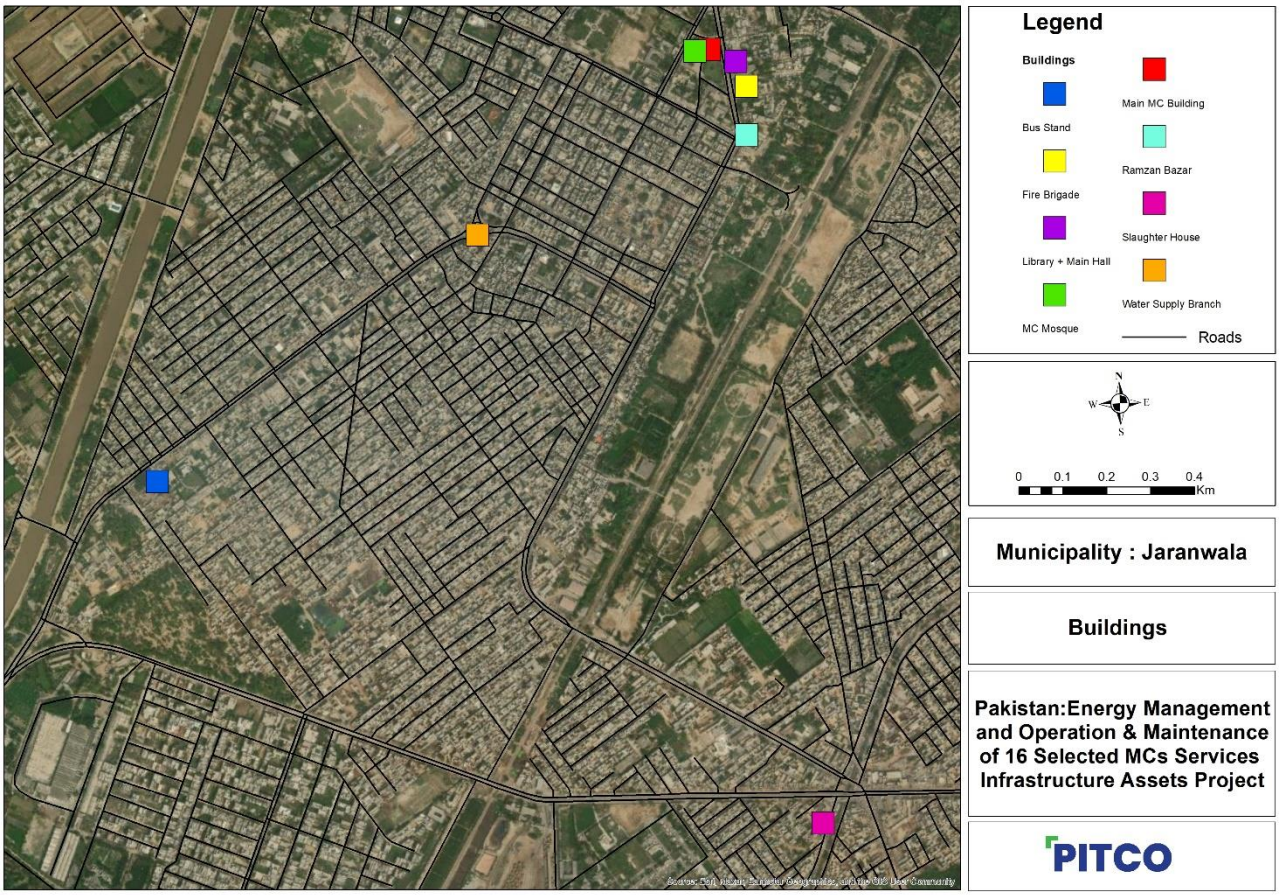

Figure 12: Map for Buildings

5.2 Building Details

Details of the MC buildings are given below.

Table 30: Buildings' Details

Sr. No.	Address	GPS	Unique ID	Ownership	Age of Building	Condition of Building	Total Area (m2)	Insulation of Building	Number of Floors
1	Main MC Building	N:31.33878 E:73.42275	1206221	MC	26	Satisfactory	15,174	No Proper Insulation	2
2	Library + Main Hall	N:31.338516 E:73.423365	51206225	MC	N/A	Satisfactory	1,501	No Proper Insulation	2
3	Bus Stand	N:31.330410 E:73.409189	1206221-1	MC	N/A	Satisfactory	1,251	No Proper Insulation	1
4	Fire Brigade	N:31.337998 E:73.423598	51206223	MC	N/A	Satisfactory	625	No Proper Insulation	2
5	MC Mosque	N:31.33876 E:73.4224	51206224	MC	24	Satisfactory	1,151	No Proper Insulation	1
6	Ramzan Bazar	N:31.33701 E:73.42356	51206222	MC	N/A	Satisfactory	1,000	No Proper Insulation	1
7	Slaughter House	N:31.32289 E:73.42472	51206210	MC	N/A	Satisfactory	1,501	No Proper Insulation	1
8	Water Supply Branch	N:31.33518 E:73.41705	1206221-2	MC	N/A	Satisfactory	200	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[7]	No. of months used per year	Operating days per year	Annual Energy consumption (kWh/year)
Main MC Building								
1	Record Room	Electric Heater	1	1000	3	4	104	312
2	Tax Branch	Electric Heater	1	1000	3	4	104	312
	Total							**624**

[7] 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[8]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Main MC Building								
1	Head Clean	Ceiling Fan	1	80	8	8	208	133.12
2	Store 1	Ceiling Fan	1	80	4	8	208	66.56
3	Town Officer	Ceiling Fan	4	80	6	8	208	399.36
4	Town Officer	Split AC	1	1800	4	8	208	1497.6
5	Town Officer	Exhaust Fan	1	30	6	8	208	37.44
6	Sub-Engineer Office	Ceiling Fan	1	80	6	8	208	99.84
7	Sub-Engineer Office	Air Cooler	1	125	4	8	208	104
8	Draft Room office	Ceiling Fan	1	80	6	8	208	99.84
9	Regulation Room	Ceiling Fan	1	80	6	8	208	99.84
10	Divorce Section	Ceiling Fan	1	80	6	8	208	99.84
11	Divorce Section	Split AC	1	1650	4	8	208	1372.8
12	General Branch	Ceiling Fan	1	80	6	8	208	99.84
13	Finance Branch	Ceiling Fan	1	80	6	8	208	99.84
14	Finance Branch	Ceiling Fan	1	80	6	8	208	99.84
15	Computer Branch	Ceiling Fan	1	80	6	8	208	99.84
16	Computer Branch	Pedestal Fan	1	125	2	8	208	52
17	Registrar Branch	Ceiling Fan	1	80	6	8	208	99.84
18	Record Branch	Ceiling Fan	1	80	6	8	208	99.84
19	MOR office	Ceiling Fan	1	80	6	8	208	99.84
20	Map Branch	Ceiling Fan	1	80	6	8	208	99.84
21	Map Branch	Bracket Fan	1	50	6	8	208	62.4
22	MOP Office	Ceiling Fan	1	80	6	8	208	99.84
23	MOP Office	Split AC	1	0	0	0	0	0
24	Tax Branch	Ceiling Fan	1	80	6	8	208	99.84
25	IT Office	Ceiling Fan	1	80	6	8	208	99.84
26	Audit Branch	Split AC	1	2700	4	8	208	2246.4
27	Assistant Director Officer	Ceiling Fan	1	80	6	8	208	99.84
28	MOI Office	Ceiling Fan	1	80	6	8	208	99.84
29	MOI Office	Bracket Fan	1	50	6	8	208	62.4
30	MOI Office	Split AC	1	2700	4	8	208	2246.4
31	CO Office	Ceiling Fan	2	80	6	8	208	199.68
32	CO Office	Inverter AC	1	1452	4	8	208	1208.064
33	CO Office	Exhaust Fan	1	30	6	8	208	37.44
34	Administrative office	Bracket Fan	1	50	0	0	0	0
35	Administrative office	Inverter AC	2	1452	4	8	208	2416.128
36	Retiring Room	Bracket Fan	1	50	6	8	208	62.4
37	Retiring Room	Split AC	1	1800	4	8	208	1497.6

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
38	Kitchen	Ceiling Fan	1	80	6	8	208	99.84
39	Kitchen	Exhaust Fan	1	30	6	8	208	37.44
40	Encroachment office	Ceiling Fan	2	80	6	8	208	199.68
41	Pension office	Ceiling Fan	1	80	6	8	208	99.84
42	Water Supply office	Ceiling Fan	1	80	6	8	208	99.84
Library + Main Hall								
1	Main hall	Ceiling Fan	12	80	2	8	208	399.36
2	Returning office	Ceiling Fan	1	80	6	8	208	99.84
3	Open Hall	Ceiling Fan	1	80	3	8	208	49.92
4	Room 1	Ceiling Fan	2	80	3	8	208	99.84
5	Room 2	Ceiling Fan	1	80	4	8	208	66.56
6	Store	Ceiling Fan	1	80	3	8	208	49.92
7	LG & CT office	Bracket Fan	2	50	6	8	208	124.8
8	LG & CT office	Exhaust Fan	1	30	6	8	208	37.44
9	Store Room	Bracket Fan	1	50	2	8	208	20.8
10	Store Room	Exhaust Fan	1	30	2	8	208	12.48
11	AGCC office	Bracket Fan	1	50	6	8	208	62.4
12	AGCC office	Split AC	1	1650	4	6	156	1029.6
13	AGCC office	Exhaust Fan	2	30	6	8	208	74.88
14	Washroom	Exhaust Fan	1	30	2	8	208	12.48
15	MC Hall	Bracket Fan	13	50	2	8	208	270.4
16	MC Hall	Split AC	5	0	0	0	0	0
Bus Stand								
1	Eating Area	Ceiling Fan	3	80	14	8	208	698.88
2	Store	Ceiling Fan	2	80	4	8	208	133.12
3	Ticket Area	Ceiling Fan	2	80	12	8	208	399.36
Fire Brigade								
1	Outside	Ceiling Fan	1	80	12	8	208	199.68
2	Rescue Office	Ceiling Fan	2	80	12	8	208	399.36
3	Garden Superintendent	Ceiling Fan	2	80	8	8	208	266.24
4	Prosecution criminal	Ceiling Fan	1	80	5	8	208	83.2
5	Washroom	Air Cooler	1	125	4	7	182	91
6	Rescue Rest Room	Ceiling Fan	1	80	4	8	208	66.56
7	Store 2	Ceiling Fan	2	80	4	8	208	133.12
MC Mosque								
1	Mosque inside	Ceiling Fan	21	80	4	8	208	1397.76
2	Mosque inside	Inverter AC	2	1452	2	6	156	906.048
3	Mosque inside	Split AC	3	2700	2	6	156	2527.2
4	Mosque outside	Ceiling Fan	24	80	4	8	208	1597.44
5	Wazu Area	Ceiling Fan	2	80	2	8	208	66.56
Ramzan Bazar								
1	Complaint office	Ceiling Fan	2	80	0	0	0	0

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
2	All shops	Ceiling Fan	31	80	8	8	208	4126.72
3	All shops	Air Cooler	2	125	7	8	208	364
4	All shops	Exhaust Fan	1	30	0	0	0	0
Water Supply Branch								
1	Office	Ceiling Fan	2	80	8	8	208	266.24
	Total Annual kWh							**32,069**

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

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Energy consumption (kWh/year)
Main MC Building							
1	Head Clerk	Tube light	1	40	0	312	0
2	Head Clerk	LED	2	18	8	312	89.856
3	Store 1	LED	1	12	8	312	29.952
4	Town Hall officer	ILB	1	100	0	312	0
5	Town Hall officer	Tube light	6	40	8	312	599.04
6	Town Hall officer	LED	2	24	8	312	119.808
7	Town Hall officer	LED	4	12	8	312	119.808
8	Sub-Engineer Office	Tube light	1	40	8	312	99.84
9	Sub-Engineer Office	LED	3	12	8	312	89.856
10	Gallery 1	Tube light	1	40	8	312	99.84
11	Gallery 1	LED	1	12	8	312	29.952
12	Draft Main office	Tube light	1	40	8	312	99.84
13	Draft Main office	LED	1	18	8	312	44.928
14	Regulation Branch	Tube light	2	40	8	312	199.68
15	Regulation Branch	CFL	1	24	0	312	0
16	Divorce Section	Tube light	1	40	0	312	0
17	Divorce Section	LED	2	12	8	312	59.904
18	General Branch	Tube light	2	40	8	312	199.68
19	Finance Branch	Tube light	1	40	8	312	99.84
20	Finance office	Tube light	1	40	8	312	99.84
21	Computer Branch	LED	2	12	8	312	59.904
22	Registration Branch	LED	1	12	8	312	29.952
23	Registration Branch	LED	1	18	8	312	44.928
24	Record Room 1	Tube light	2	40	0	312	0
25	Record Room 1	LED	1	12	0	312	0
26	MOR office	Tube light	1	40	0	312	0
27	MOR office	LED	1	12	8	312	29.952
28	Map Branch	Tube light	2	40	8	312	199.68

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

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Energy consumption (kWh/year)
29	Map Branch	LED	1	12	0	312	0
30	MOP office	CFL	1	12	8	312	29.952
31	MOP office	LED	3	12	8	312	89.856
32	Gallery 2	Tube light	1	40	12	312	149.76
33	Tax Branch	Tube light	1	40	0	312	0
34	Tax Branch	LED	1	30	8	312	74.88
35	Tax Branch	LED	1	12	8	312	29.952
36	Gallery 3	Tube light	4	40	12	312	599.04
37	Gallery 3	LED	1	12	12	312	44.928
38	IT office	Tube light	1	40	8	312	99.84
39	IT office	LED	1	12	0	312	0
40	Audit Branch	ILB	1	100	0	312	0
41	Audit Branch	Tube light	2	40	0	312	0
42	Audit Branch	CFL	1	24	0	312	0
43	Audit Branch	LED	4	12	8	312	119.808
44	Assistant Director office	LED	4	12	8	312	119.808
45	MOI Office	Tube light Panel	4	72	0	312	0
46	MOI Office	CFL	1	9	4	312	11.232
47	MOI Office	LED	1	12	8	312	29.952
48	MOI Office	Tube light	2	40	0	312	0
49	CO-Office	Tube light	2	40	2	312	49.92
50	CO-Office	LED	3	12	8	312	89.856
51	CO-Office	LED	1	18	8	312	44.928
52	Administrative office	LED	24	18	3	312	404.352
53	Retaining Room	LED	1	12	3	312	11.232
54	Kitchen	ILB	2	100	5	312	312
55	Gallery 4	ILB	1	100	0	312	0
56	Gallery 4	LED	2	18	10	312	112.32
57	Gallery 4	LED	2	12	10	312	74.88
58	Encroachment office	LED	1	12	8	312	29.952
59	Encroachment office outside	LED	3	12	8	312	89.856
60	Open Area	CFL	4	24	12	312	359.424
61	Open Area	LED	5	130	12	312	2433.6
62	Open Area	LED	6	18	12	312	404.352
63	Open Area	LED	4	12	12	312	179.712
64	Pension office	Tube light	1	40	0	312	0
65	Pension office	LED	1	18	7	312	39.312
66	Store 1	Electric Rod	1	400	0	312	0
67	Tax Branch	Electric Rod	1	400	2	312	249.6
Library + Main Hall							
1	Main Hall	ILB	6	100	6	312	1123.2
2	Main Hall	LED	3	18	6	312	101.088
3	Retiring Room	CFL	1	24	2	312	14.976

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Energy consumption (kWh/year)
4	Retiring Room	LED	1	18	6	312	33.696
5	Open Area	LED	1	18	4	312	22.464
6	Hall	ILB	1	60	0	312	0
7	Hall	CFL	1	24	0	312	0
8	Hall	LED	1	18	6	312	33.696
9	Room 1	LED	1	12	2	312	7.488
10	Room 2	LED	1	12	8	312	29.952
11	Store	LED	1	12	8	312	29.952
12	Washroom	LED	1	12	8	312	29.952
13	Outside	CFL	3	12	7	312	78.624
14	Open Area	Tube light	7	40	6	312	524.16
15	LG & CT office	Tube light	1	40	8	312	99.84
16	LG & CT office	CFL	1	12	8	312	29.952
17	LG & CT office	Tube light Panel	4	72	0	312	0
18	Store	Tube light	1	40	2	312	24.96
19	Store	Tube light	8	20	0	312	0
20	AGCC office	Tube light	3	40	6	312	224.64
21	AGCC office	Tube light Panel	4	72	0	312	0
22	Washroom	Tube light	1	40	2	312	24.96
23	MC Hall	Tube light Panel	30	72	0	312	0
24	MC Hall	Tube light	12	40	2	312	299.52
25	Outside	LED	1	125	12	312	468
Bus Stand							
1	Open Area	LED	1	12	12	312	44.928
2	Eating Area	LED	2	50	12	312	374.4
3	Store	LED	2	12	12	312	89.856
4	Ticket Area	LED	2	18	12	312	134.784
Fire Brigade							
1	Outside	ILB	2	200	0	312	0
2	Outside	Tube light	7	40	14	312	1223.04
3	Outside	LED	1	12	14	312	52.416
3	Outside	Electric Rod	3	400	0	312	0
4	Rescue Office	Tube light	1	40	10	312	124.8
6	Garden Superintendent	Tube light	4	40	8	312	399.36
7	Garden Superintendent	CFL	1	24	4	312	29.952
8	Criminal Prosecution	Tube light	6	40	4	312	299.52
9	Washroom	Tube light	1	40	4	312	49.92
10	Rescue Rest Room	LED	1	12	12	312	44.928
11	Store	Tube light	2	40	2	312	49.92
12	Store 2	Tube light	2	40	2	312	49.92
13	Store 2	CFL	1	24	2	312	14.976
14	Water house	Tube light	6	40	2	312	149.76
15	Store 3	Tube light	3	40	2	312	74.88

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Energy consumption (kWh/year)
16	Open Area	Tube light	2	40	2	312	49.92
17	Open Area	LED	1	12	12	312	44.928
MC Mosque							
1	Mosque Inside	LED	1	30	2	312	18.72
2	Mosque Inside	LED	2	40	2	312	49.92
3	Mosque Inside	LED	21	18	2	312	235.872
4	Mosque Outside	LED	6	18	10	312	336.96
5	Mosque Outside	LED	3	50	10	312	468
6	Wazu Area	LED	4	12	10	312	149.76
7	Washroom	LED	3	18	10	312	168.48
8	Washroom	LED	1	12	10	312	37.44
Ramzan Bazar							
1	Complaint office	LED	1	18	8	312	44.928
2	Complaint office	LED	1	12	0	312	0
3	Washroom	ILB	1	100	0	312	0
4	Washroom	CFL	1	12	6	312	22.464
5	All Shops	CFL	13	12	8	312	389.376
6	All Shops	CFL	1	30	0	312	0
Slaughter House							
1	Doctor Room	LED	1	12	8	312	29.952
2	Open Area	LED	2	12	8	312	59.904
Water Supply Branch							
1	Office	ILB	1	100	4	312	124.8
2	Office	Tube light	1	40	4	312	49.92
3	Office	LED	1	12	8	312	29.952
4	Office	LED	1	30	8	312	74.88
5	Washroom	CFL	1	9	3	312	8.424
6	Outside	LED	1	12	4	312	14.976
						Total Annual kWh	**17,548**

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[10]
1	Annual Electricity Consumption	kWh	58,183
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[10] Based on Utility Bills

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Buildings	6	8	23,373	33,660	-10,287	2.69 kWh/m2	3.88 kWh/m2	General bus stand building and water supply branch building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Furthermore, MC library building has shared electricity meter with streetlight, Ramzan bazar has shared meter with water supply pumpset and slaughter house building has shared meter with disposal station so, for the purpose of this comparison, their energy consumptions are also not considered in the overall energy consumption and KPI calculations. Electricity units (kWh) are increased due to a significant increase in electric appliances in MC Office buildings.

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

Table 35: Cooling Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
Main MC Building	Bracket Fan	3	0	4
Main MC Building	Ceiling Fan	29	0	30
Main MC Building	Exhaust Fan	2	0	3
Main MC Building	Split AC	9	0	6
Main MC Building	Air Cooler	-	-	1
Main MC Building	Pedestal Fan	-	-	1
Main MC Building	Inverter	-	-	3
Fire Brigade	Ceiling Fan	13	0	9
Fire Brigade	Air Cooler	-	-	1
MC Mosque	Ceiling Fan	47	0	47
MC Mosque	Split AC	5	0	3
MC Mosque	Air Cooler	3	0	0
MC Mosque	Inverter	-	-	2

Table 36: Lighting Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
Main MC Building	Tube Light	56	56	36
Main MC Building	CFL	64	64	8
Main MC Building	Led Spot Light	20	0	0
Main MC Building	Tube light panel	-	-	4
Main MC Building	Rod light	-	-	2
Main MC Building	LED	12	0	92
Main MC Building	Incandescent Light Bulb	11	11	5
Fire Brigade	CFL	37	37	2
Fire Brigade	Tube Light	11	11	34
Fire Brigade	Incandescent Light Bulb	-	-	2
Fire Brigade	LED	-	-	3
Fire Brigade	Rod light	-	-	3
MC Mosque	CFL	14	14	0
MC Mosque	LED	28	0	41

Table 37: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh	Comments
Main MC Building	15,892	20,253	General bus stand building and water supply branch building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Furthermore, MC library building has shared electricity meter with streetlight, Ramzan bazar has shared meter with water supply pumpset and slaughter house building has shared meter with disposal station so, for the purpose of this comparison, their energy consumptions are also not considered in the overall energy consumption and KPI calculations. Electricity units (kWh) are increased due to a significant increase in electric appliances in MC Office buildings.
Fire Brigade	2,218	6,846	
MC Mosque	5,263	6,561	
Overall	**23,373**	**33,660**	

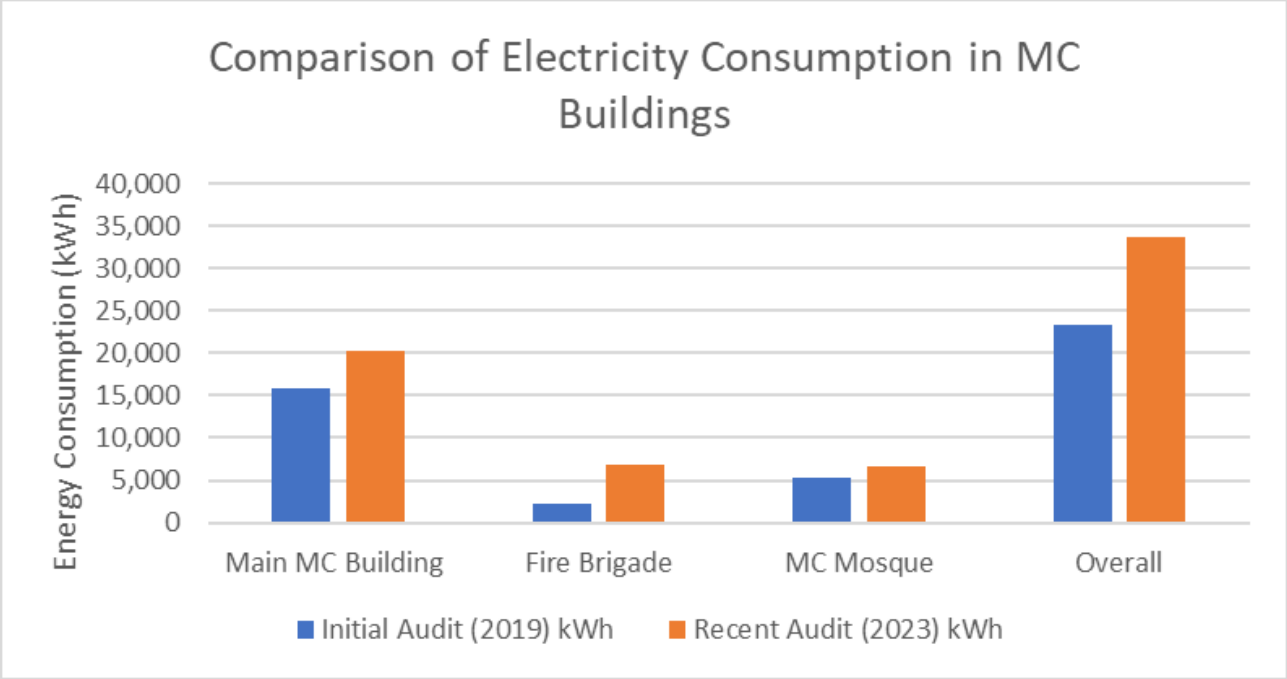

Figure 13:Comparison of Electricity Consumption in MC Buildings

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 Jaranwala

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

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

Meter (06131410478801) from Main MC Building, Slaughterhouse, Library & Main Hall and Ramzan Bazar Building have a Three Phase 400V electrical connection whereas, Fire Brigade, Bus Stand, MC Mosque, Water Supply Branch and Meter (06131410478500) from Main MC Building have single phase 220V electrical connection. As single-phase connections are not eligible for net metering, therefore, the Consultant has only carried out detailed assessment of system size requirement for the three phase connection buildings only. However, if the system requirement of any site with single-phase connection exceeds above 5 kW based on the historical electricity bill, the Consultant has provided the detailed assessment of available solar system capacity. Metering details of each building is presented below.

Table 38:Metering details at MC Jaranwala

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Main MC Building	1206221	06131410478801 (3ϕ)	6.37	A-3a (66)
			06131410478500 (1ϕ)	1	A-3a (66)
2	Library & MC Hall	51206225	10131410741901[11] (3ϕ)	32.14	A-3a (66)
3	Bus Stand	1206221-1	24131415103701 (1ϕ)	2	G-1 (72)
4	Fire Brigade	51206223	10131410743501 (1ϕ)	1	A-3a (66)
5	MC Mosque	51206224	06131410477600 (1ϕ)	3	A-3a (66)
6	Ramzan Bazar	51206222	27131416100590[12] (3ϕ)	31	A-3a (66)
7	Slaughter House	51206210	24131415104100[13] (3ϕ)	97.4	B2b (12)T
8	Water Supply Branch	1206221-2	24131415102601 (1ϕ)	2.6	G-1 (72)

6.1 Main MC Building

The project site i.e. Main MC Building is located near Committee Bagh Jaranwala, Faisalabad, Punjab, Pakistan while the geographical co-ordinates of location are 31.33878°N (latitude) and 73.42275°E (longitude).

[11] Electrical connection i.e. (10131410741901) is shared between Library + MC Hall and Streetlights.
[12] Electrical connection i.e. (27131416100590) is shared between Ramzan Bazaar and Water Supply Pump set.
[13] Electrical connection i.e. (24131415104100) is shared between Slaughterhouse and Disposal Pump set

Figure 14: Front view of Main MC Building

Figure 15: Aerial view of Main MC Building

6.1.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Main MC Building is 2,253 kWh. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 39: 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	06131410478801	18,888	1,574	3,515[14]	14
2	06131410478500	1,365	113	280[15]	1
Total					**15**

Note: Based on the analysis of the historical billings it is identified that the total system requirement for this site is **15 kW**. However, it is highly recommended to replace the single-phase connection with three-phase connection before the installation of solar system.

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Building is 74,110 ft^2 whereas, the total area of rooftop available for the solar installation is 8,632 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.

[14] The peak of this electrical connection is in month September 2022.

[15] The peak of this electrical connection is in month August 2022.

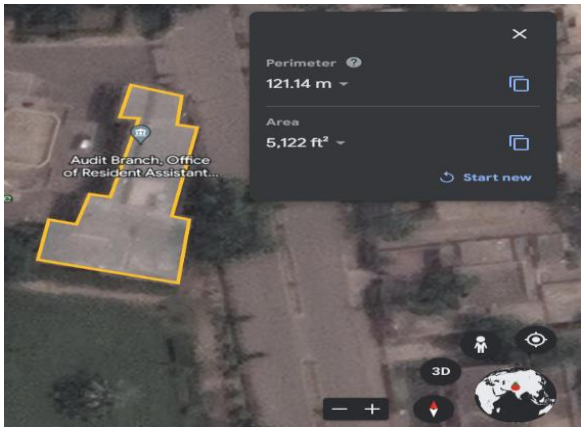

Figure 16: Top View of complete building

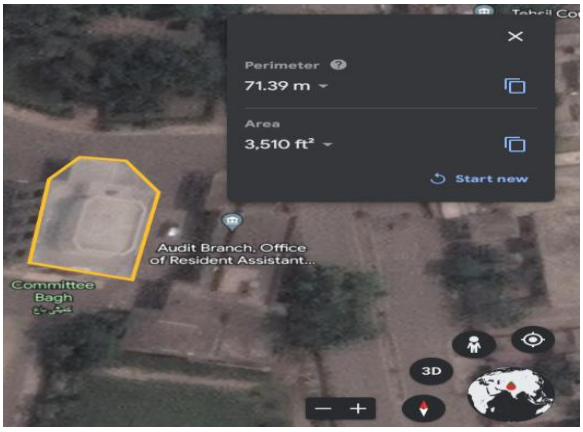

Figure 17: Top View of complete building

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

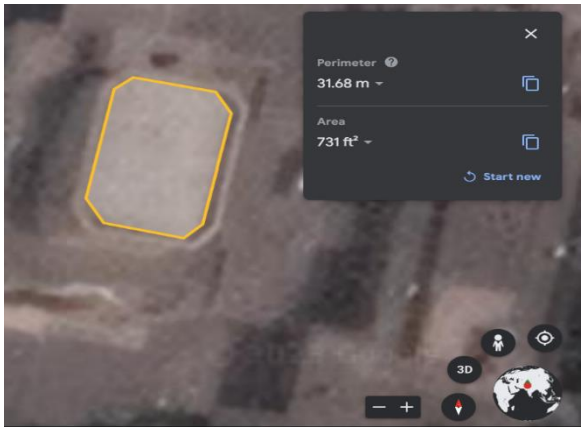

Figure 18: Location for Solar Installation – A

Figure 19: Location for Solar Installation – B

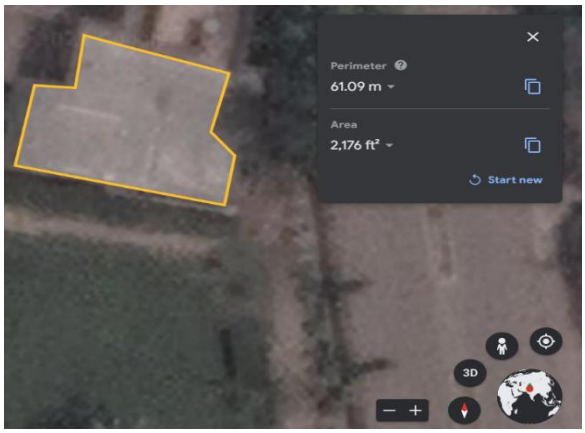

Figure 20: Location for Solar Installation – C

Table 40: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Total
Area availability (ft²)	731	869	2,176	3,776
Solar system capacity (kW)	7	9	22	38

6.2 Library & MC Hall

The project site i.e. Library & MC Hall is located near Khurianwala road, Jaranwala, Faisalabad, Punjab, Pakistan while the geographical co-ordinates of location are 31.338516°N (latitude) and 73.423365°E (longitude).

Figure 21: Front view of Library & MC Hall

Figure 22: Aerial view of Library MC Hall

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 this electrical connection is 10,637 kWh with the peak electricity consumption of 1,389 kWh in June 2022. The annual energy consumption for Library & MC Hall cannot be accurately determined as this meter is shared with street Lights, the Consultant has only carried out the assessment of installation capacity of solar system.

6.2.2 Roof Assessment

As per the Consultant's assessment, the total area of the Library & MC Hall is 12,270 ft^2 whereas, the total area of rooftop available for the solar installation is 7,133 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

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

Figure 24:Location for Solar Installation - A

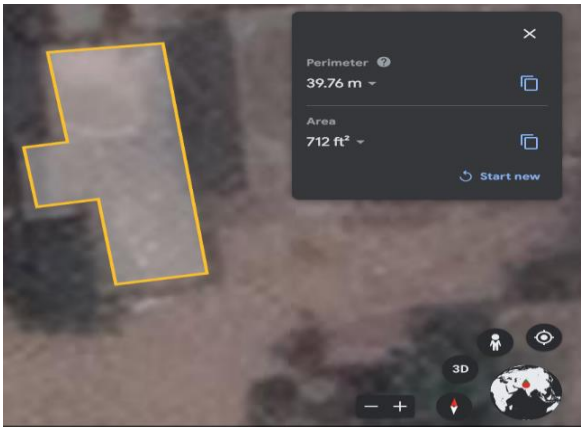

Figure 25:Location for Solar Installation - B

Figure 26:Location for Solar Installation - C

Table 41: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Total
Area availability (ft²)	1,743	712	1,426	3,881
Solar system capacity (kW)	17	7	14	38

6.3 Bus Stand

The project site i.e. Bus Stand Building is located near Faisalabad road Jaranwala, Faisalabad, Punjab, Pakistan, while the geographical co-ordinates of location are 31.330410°N (latitude) and 73.409189°E (longitude).

Figure 27: Front view of Bus Stand

Figure 28: Aerial view of Bus Stand

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 Bus Stand is 2,710 kWh with the peak electricity consumption of 961 kWh in July 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 42: Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	24131415103701	2,710	226	961	2

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

6.4 Fire Brigade

The project site i.e. Fire Brigade is located near Khurjanwala Road, Jaranwala, Faisalabad, Punjab Pakistan while the geographical co-ordinates of location are 31.33785°N (latitude) and 73.42343°E (longitude).

Figure 29:Front view of Fire Brigade

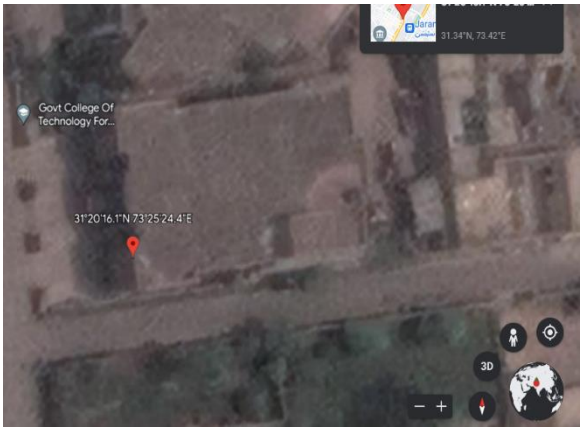

Figure 30:Aerial view of Fire Brigade

6.4.1 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 6,846 kWh with the peak electricity consumption of 1,299 kWh in February 2023. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 43:Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	10131410743501	6,846	570	1,299	5

Note: Based on the assessment of the historical billings it is identified that the system requirement for this site is **5kW** with a single-phase connection. It is highly recommended to replace this single-phase connection to three-phase connection before the installation of solar system as estimated by the Consultant.

6.4.1 Roof Assessment

As per the Consultant's assessment, the total area of the Fire Brigade is 9,160 ft^2 whereas, the total area of rooftop available for the solar installation is 5,211 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 31: Top View of complete building

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

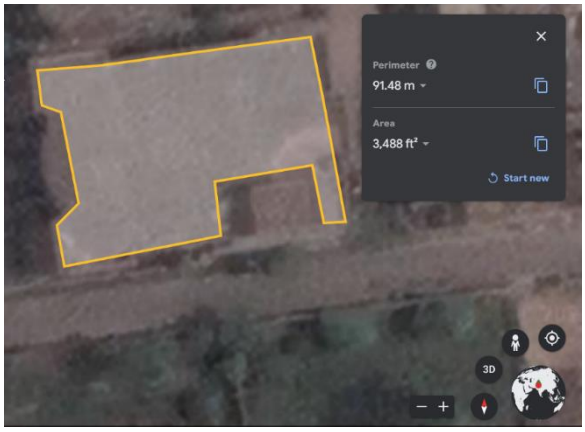

Figure 32: Location for Solar Installation

Table 44:System Size Calculation with Respect to Area

Parameters	Location
Area availability (ft²)	3,488
Solar system capacity (kW)	35

6.5 MC Mosque

The project site i.e. MC Mosque Building is located near Committee Bagh Jaranwala, Faisalabad, Punjab, Pakistan while the geographical co-ordinates of location are 31.33876°N (latitude) and 73.4224°E (longitude).

Figure 33: Front view of MC Mosque

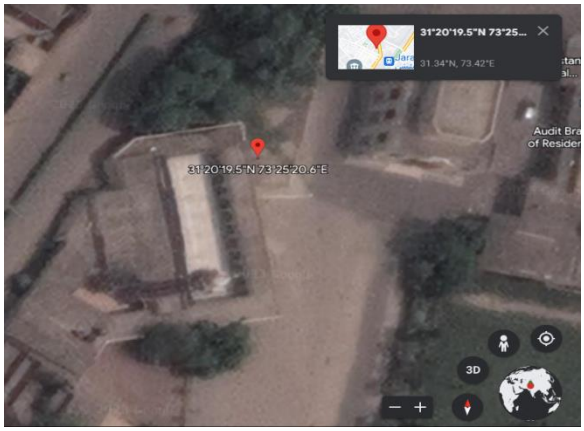

Figure 34: Aerial view of MC Mosque

6.5.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of MC Mosque Building is 6,561 kWh. With the peak electricity consumption of 786 kWh in September 2022.Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 45: 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	06131410477600	6,561	546	786	5

6.5.2 Roof assessment

As per the Consultant's assessment, the total area of the Main MC Mosque is 10,172 ft^2 whereas, the total area of rooftop available for the solar installation is 9,369 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 35: Top View of complete building

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

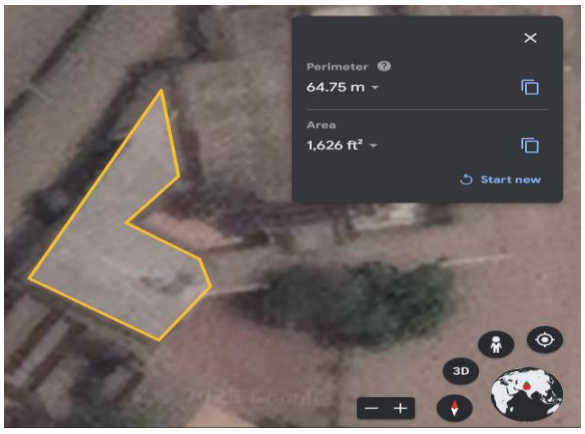

Figure 36: Location for Solar Installation - A

Figure 37: Location for Solar Installation - B

Figure 38: Location for Solar Installation – C

Table 46: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Total
Area availability (ft²)	1,626	1,271	1,315	4,212
Solar system capacity (kW)	16	13	13	42

6.6 Ramzan Bazar

The project site i.e. Ramzan Bazar is located near Khurianwala road, Jaranwala, Faisalabad, Punjab, Pakistan while the geographical co-ordinates of location are 31.33701°N (latitude) and 73.42356°E (longitude).

Figure 39: Front view of Ramzan Bazar

Figure 40:Top View of Ramzan Bazar

6.6.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Ramzan Bazar 11,753 kWh with the peak electricity consumption of 2,000 kWh in May 2022. The annual energy consumption for Ramzan Bazar cannot be accurately determined as this meter is shared with Water Supply Pump Set, the Consultant has only carried out the assessment of installation capacity of solar system.

6.6.2 Roof Assessment

As per the Consultant's assessment, the total area of the Ramzan Bazar is 15,004 ft^2 whereas, the total area of rooftop available for the solar installation is 7,083 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.

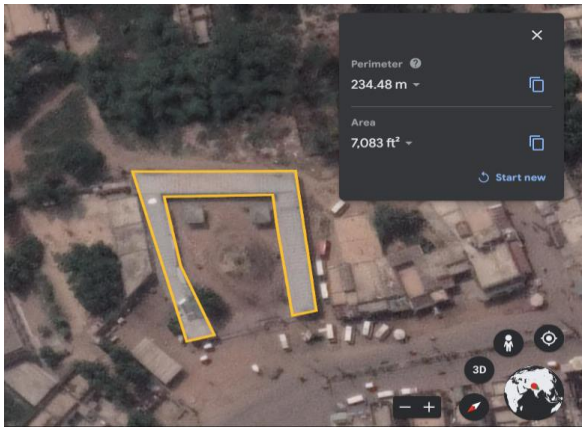

Figure 41: Top View of complete building

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

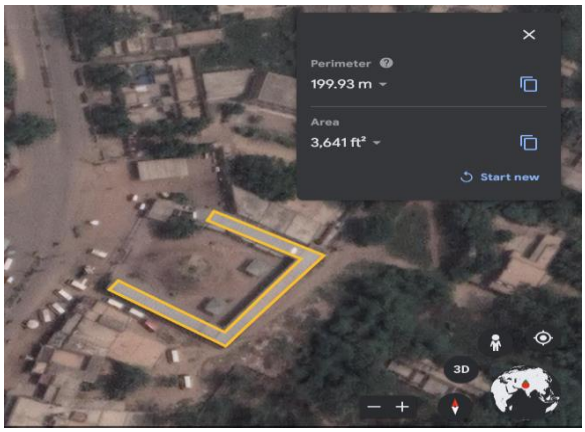

Figure 42: Location for Solar Installation

Table 47: System Size Calculation with Respect to Area

Parameters	Location
Area availability (ft²)	3,641
Solar system capacity (kW)	36

6.7 Slaughterhouse

The project site i.e. Slaughter House is located near Haji Shahid road, Jaranwala, Faisalabad, Punjab, Pakistan while the geographical co-ordinates of location are 31.32289°N (latitude) and 73.42472°E (longitude).

Figure 43:Front view of Slaughter House

Figure 44:Aerial view of Slaughter House

6.7.1 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 is 138,440 kWh with the peak electricity consumption of 41,120 kWh in July 2022. The annual energy consumption for Slaughterhouse cannot be accurately determined as this meter is shared with Disposal Pump set, the Consultant has only carried out the assessment of installation capacity of solar system.

6.7.2 Roof Assessment

As per the Consultant's assessment, the total area of the Slaughterhouse is 8,514 ft^2 whereas, the total area of rooftop available for the solar installation is 5,147 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 45: Top View of complete building

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

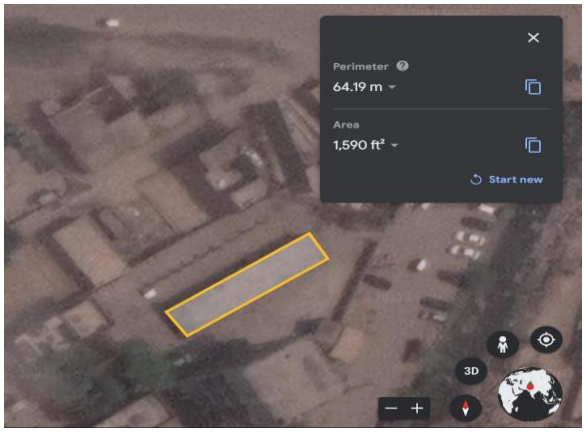

Figure 46: Location for Solar Installation

Table 48: System Size Calculation with Respect to Area

Parameters	Location
Area availability (ft^2)	1,590
Solar system capacity (kW)	16

6.8 Water Supply Branch

The project site i.e. Water Supply Branch is located near Khurianwala road, Jaranwala, Faisalabad, Punjab, Pakistan while the geographical co-ordinates of location are 31.33701°N (latitude) and 73.42356oE (longitude).

Figure 47: Front View of Water Supply Branch

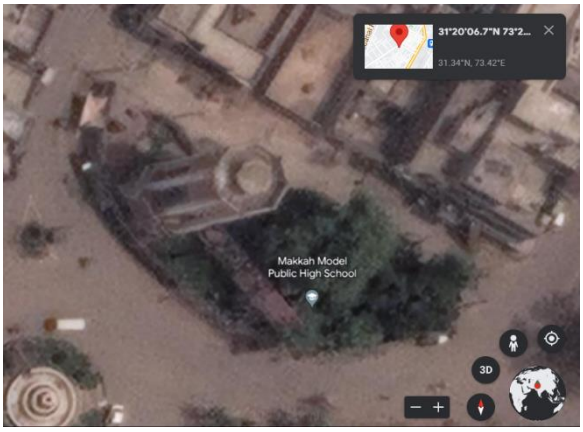

Figure 48:Aerial View of water supply Branch

6.8.1 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 Water Supply Office 790 kWh with the peak electricity consumption of 135 kWh in March 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 49: Solar System Requirement

Sr No	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	24131415102601	790	65	135	1

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

6.9 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.

6.9.1 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.

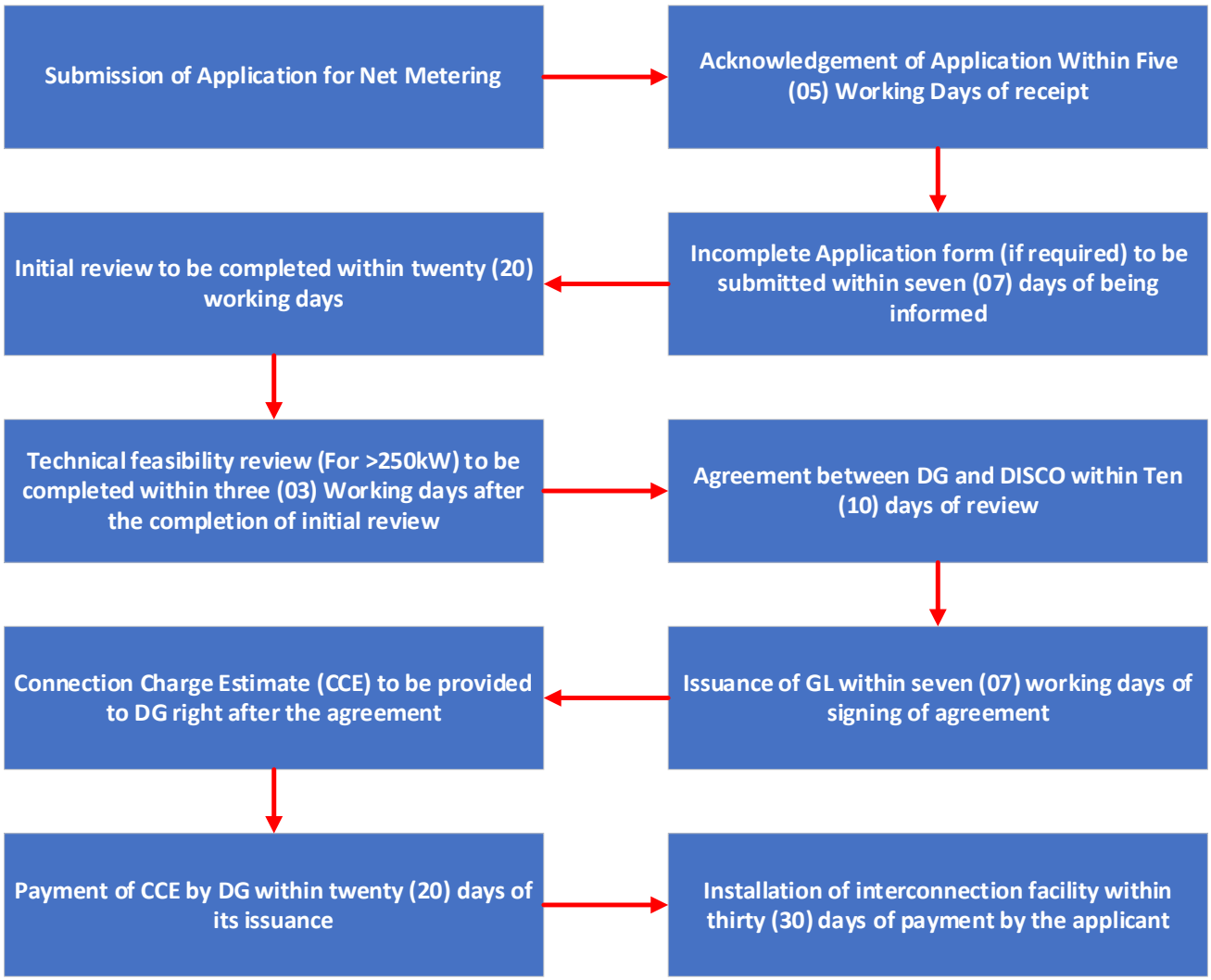

Figure 49: Pakistan Net Metering Application Process

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

7 Recommended Energy Efficiency Measures

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

7.1 Energy Efficiency Measures for Water Pumps & Wastewater Disposal System

7.1.1 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Alvi Park No. 2 - Unique ID: 51006193)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 28%.

Recommended Action

Replacement of Pump with new PECO 8MC 7-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 50: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	175
Design Motor Power of Existing Pump	kW	15
Measured Flow	m^3/h	89
Measured Head	m	14.5
Measured Motor Power	kW	14.60
Pump Efficiency	%	28%
Existing Operational Hours	h	12.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	7.8
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	21.0
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	57,816
Energy Required by Proposed Pump	kWh/y	54,320
Saving Potential	kWh/y	3,496

Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	561
Investment	US $	3,237
Simple Payback Period	months	69

7.1.2 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Canal Road No. 19 - Unique ID: 51006196)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 23%.

Recommended Action

Replacement of Pump with new PECO 8 HC 8-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 51: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	76
Design Head of Existing Pump	ft	100
Design Motor Power of Existing Pump	kW	19
Measured Flow	m^3/h	88
Measured Head	m	15.4
Measured Motor Power	kW	18.67
Pump Efficiency	%	23%
Existing Operational Hours	h	4.5
Proposed Pump Flow	m^3/h	76
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	5.2
Pump Operational Days	days	330
Efficiency	%	80%
Energy Required by Existing Pump	kWh/y	27,720
Energy Required by Proposed Pump	kWh/y	23,052
Saving Potential	kWh/y	4,668
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	750
Investment	US $	3,794
Simple Payback Period	months	61

7.1.3 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Canal Road No. 20A - Unique ID: 51006202)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 34%.

Recommended Action

Replacement of Pump with new PECO 12MC 2-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 52: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	175
Design Motor Power of Existing Pump	kW	15
Measured Flow	m^3/h	99
Measured Head	m	16.2
Measured Motor Power	kW	15.00
Pump Efficiency	%	34%
Existing Operational Hours	h	12.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	11.6
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	59,400
Energy Required by Proposed Pump	kWh/y	51,428
Saving Potential	kWh/y	7,972
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,280
Investment	US $	3,794
Simple Payback Period	months	36

7.1.4 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Canal Road No. 20B - Unique ID: 51006203)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 34%.

Recommended Action

Replacement of Pump with new PECO 8MC 7-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 53: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	175
Design Motor Power of Existing Pump	kW	15
Measured Flow	m^3/h	98
Measured Head	m	22.1
Measured Motor Power	kW	20.21
Pump Efficiency	%	34%
Existing Operational Hours	h	4.5
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	7.8
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	8.7
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	30,012
Energy Required by Proposed Pump	kWh/y	22,406
Saving Potential	kWh/y	7,606
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,222
Investment	US $	3,237
Simple Payback Period	months	32

7.1.5 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Sitayana Road No. 20C - Unique ID: 51106204)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 29%.

Recommended Action

Replacement of Pump with new PECO 8 HC 8-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 54: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	76
Design Head of Existing Pump	ft	200
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	77
Measured Head	m	23.8
Measured Motor Power	kW	20.60
Pump Efficiency	%	29%
Existing Operational Hours	h	3.8
Proposed Pump Flow	m^3/h	76
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	3.8
Pump Operational Days	days	330
Efficiency	%	80%
Energy Required by Existing Pump	kWh/y	25,493
Energy Required by Proposed Pump	kWh/y	16,757
Saving Potential	kWh/y	8,735
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,403
Investment	US $	3,794
Simple Payback Period	months	32

7.1.6 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Canal Pump No. 5 Lahore More - Unique ID: 51106205)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 21%.

Recommended Action

Replacement of Pump with new PECO 8 HC 8-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 55: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	76
Design Head of Existing Pump	ft	21
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	102
Measured Head	m	13.6
Measured Motor Power	kW	21.47
Pump Efficiency	%	21%
Existing Operational Hours	h	4.5
Proposed Pump Flow	m^3/h	76
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	6.0
Pump Operational Days	days	330
Efficiency	%	80%
Energy Required by Existing Pump	kWh/y	31,878
Energy Required by Proposed Pump	kWh/y	26,640
Saving Potential	kWh/y	5,238
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	841
Investment	US $	3,794
Simple Payback Period	months	54

7.1.7 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Canal Road No. 14 - Unique ID: 71106101)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 22%.

Recommended Action

Replacement of Pump with new PECO 8 HC 8-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 56: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	76
Design Head of Existing Pump	ft	175
Design Motor Power of Existing Pump	kW	19
Measured Flow	m^3/h	82
Measured Head	m	14.2
Measured Motor Power	kW	16.90
Pump Efficiency	%	22%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	76
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	5.4
Pump Operational Days	days	330
Efficiency	%	80%
Energy Required by Existing Pump	kWh/y	27,885
Energy Required by Proposed Pump	kWh/y	23,753
Saving Potential	kWh/y	4,132
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	664
Investment	US $	3,794
Simple Payback Period	months	69

7.1.8 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Jinnah Park Water Works - Unique ID: 71106103)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 29%.

Recommended Action

Replacement of Pump with new PECO 12MC 2-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 57: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	229
Design Head of Existing Pump	ft	140
Design Motor Power of Existing Pump	kW	45
Measured Flow	m^3/h	186
Measured Head	m	19.5
Measured Motor Power	kW	40.47
Pump Efficiency	%	29%
Existing Operational Hours	h	3.0
Proposed Pump Flow	m^3/h	204
Proposed Head	m	32
Power Consumption of Proposed Pump	kW	18.6
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	2.7
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	40,062
Energy Required by Proposed Pump	kWh/y	16,870
Saving Potential	kWh/y	23,192
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,725
Investment	US $	4,657
Simple Payback Period	months	15

7.1.9 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

R Replacement of Pumpset at (Jinnah Park Water Works - Unique ID: 71106103-1)

Study & Investigation

E Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 29%.

Recommended Action

Replacement of Pump with new PECO 12MC 2-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 58: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	229
Design Head of Existing Pump	ft	140
Design Motor Power of Existing Pump	kW	45
Measured Flow	m^3/h	187
Measured Head	m	19.5
Measured Motor Power	kW	41.00
Pump Efficiency	%	29%
Existing Operational Hours	h	3.0
Proposed Pump Flow	m^3/h	204
Proposed Head	m	32
Power Consumption of Proposed Pump	kW	18.6
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	2.8
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	40,590
Energy Required by Proposed Pump	kWh/y	16,971
Saving Potential	kWh/y	23,619
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,793
Investment	US $	4,657
Simple Payback Period	months	15

7.1.10 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 59: 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	Canal Road No. 12	21106207	2.5	3.0	50	150
2	Canal Road No. 17	51006198	2.5	3.0	50	150
3	Sitayana Road No. 20C	51106204	2.5	3.0	50	150
4	Canal Road No. 14	71106101	2.5	6.0	50	300
5	240 More Mauhallah Mustafabad	51206209-A	5.0	3.0	50	150
6	240 More Mauhallah Mustafabad	51206209-B	7.5	3.0	75	225
7	240 More Mauhallah Mustafabad	51206209-C	5.0	3.0	50	150
8	128-G.B	51206212-A	2.5	3.0	50	150
9	Alvi Road Housing Colony	51206217-B	2.5	3.0	50	150
10	Alvi Road Housing Colony	51206217-C	2.5	3.0	50	200
Total						**1775**

7.1.11 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 32 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 60: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	3,167,606
Annual Water consumption (post-implementation)	m^3/y	3,135,930
Annual Water saving per year	m^3/y	31,676
Estimate of Investment (including the cost of the server)	US$	32,000

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 1,235 streetlights are being operated by the municipality. Out of these, 778 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 50: 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 61: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	778
Number of non-functional streetlights (>20 feet)	#	50
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	728

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	39,866,058
Proposed number of photocell switches	#	33
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	33,000
Upfront investment cost	PKR	39,899,058
Upfront investment cost	US$	142,395
Annual Operating Electricity unit	kWh/yr	106,609
Annual Operating Cost	PKR/yr	4,797,414
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	519,785
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 1,235 streetlights operated by municipality out of which 457 are operational. 268 of the operational streetlights were LEDs so they are not recommended for replacement.

Recommended Action

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

Saving Assessment

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

Table 62: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	259
Number of functional streetlights (>20 feet)	#	0
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	259

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Upfront investment cost	PKR	13,224,799
Upfront investment cost	US$	47,198
Annual Operating Electricity unit	kWh/yr	34,033
Annual Electricity Consumption of Existing Lights	kWh/yr	94,301
Financial Savings	US$/yr	9,679
Payback	months	59

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 63: Replacement of inefficient equipment at office buildings

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
Main MC Building											
1	Tube light	6	40	240	599	LED Rod 20 Watts	20	120	300	2,900	17,400
2	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
3	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
4	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
5	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
6	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
7	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
8	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
9	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
10	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
11	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
12	Tube light	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
13	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
14	CFL	1	9	9	22	LED Bulb 8 Watts	8	8	20	330	330
15	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
16	ILB	2	100	200	499	LED Bulb 13 Watts	13	26	65	350	700
17	CFL	4	24	96	240	LED Bulb 13 Watts	13	52	130	350	1,400

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
18	Electric Rod	1	400	400	998	Flood LED 200 Watts	200	200	499	25,000	25,000
Library + Main Hall											
19	ILB	6	100	600	1,498	LED Bulb 13 Watts	13	78	195	350	2,100
20	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
21	CFL	3	12	36	90	LED Bulb 8 Watts	8	24	60	330	990
22	Tube light	7	40	280	699	LED Rod 20 Watts	20	140	349	2,900	20,300
23	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
24	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
25	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
26	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
27	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
28	Tube light	12	40	480	1,198	LED Rod 20 Watts	20	240	599	2,900	34,800
Fire Brigade											
29	Tube light	7	40	280	699	LED Rod 20 Watts	20	140	349	2,900	20,300
30	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
31	Tube light	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
32	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
33	Tube light	6	40	240	599	LED Rod 20 Watts	20	120	300	2,900	17,400
34	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
35	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
36	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
37	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
38	Tube light	6	40	240	599	LED Rod 20 Watts	20	120	300	2,900	17,400
39	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
40	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
Ramzan Bazar											
41	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
42	CFL	13	12	156	389	LED Bulb 8 Watts	8	104	260	330	4,290
Water Supply Branch											
43	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
44	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
45	CFL	1	9	9	22	LED Bulb 8 Watts	8	8	20	330	330
	Total										**138,000**

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 64: 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	12,765
Average Operational Hours for Building Cooling Equipment	Hours/day	5,681
Energy consumption of inefficient Equipment	kWh/yr	7,084
Energy consumption of Proposed Equipment	kWh/yr	45
Energy Savings	kWh/yr	1,138
Unit cost of electricity	PKR/kWh	1,014
Annual cost savings	USD	11
Upfront Investment (including change in fixtures)	USD	312
Payback Period	Months	8

8 Investment Estimate (including Material Specification/Quantities)

8.1 Potable Water Pump

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

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

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

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

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

Price of pumping unit as specified above

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

8.1.2 Investment Estimate (including Material Specification/Quantities) for PECO 12 MC /2 Stages, 30hp Motor

Pump Size		12 MC /2 Stages			
Capacity		203.9 m3/hr	Max. O.D bowl		11.5 Inches
Speed		1450 rpm	I.D tubewell	-	
Pump Input		30 HP	Length of suction pipe		
Prime Mover (SEM/DE)		30 HP			
			Length of bowl assembly		
			Length of column pipe		0
			Length of top pipe		1 Ft
			Total length of column		1 Ft

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

Pump assembly of	2	stages with flow type impellers			
Column assembly of	8	inshces I.D with flanged joins	each 10 ft length	0	Sets
			and one top set	1	feet length
			column shaft dia	38	mm
Discharge Head Inch	8				with prelubrication tank
Electric Motor vertical hollow shaft 30 HP/4 Pole					included
DWT 12 MC					included
Discharge head 8 " with top shaft					included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	557,692
Sales Tax @ 17%	Rs:	94,808
Total Cost of Pumpset	Rs:	1,305,000

8.1.3 Investment Estimate (including Material Specification/Quantities) for PECO 8 HC /8 Stages, 25hp Motor

Pump Size		8 HC /8 Stages			
Capacity		76.46 m3/hr	Max. O.D bowl		7.5 Inches
Speed		1450 rpm	I.D tubewell	-	
Pump Input		25 HP	Length of suction pipe		
Prime Mover (SEM/DE)		25 HP			
			Length of bowl assembly		
			Length of column pipe		
			Length of top pipe		0 Ft
			Total length of column		0 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	8	stages with flow type impellers			
Column assembly of	4	inshces I.D with flanged joins	each 10 ft length	0	Sets
			and one top set	0	feet length
			column shaft dia	0	mm
Electric Motor vertical hollow shaft 25 HP/4 Pole					included
DWT with Discharge Head					included
Mechanical installation within Pump House Only					included

Price of pumping unit as specified above

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

8.1.4 Investment Estimate (including Material Specification/Quantities) for PECO 8 MC /7 Stages, 15hp Motor

	Pump Size	12 MC /2 Stages			
Capacity		203.9 m3/hr	Max. O.D bowl		11.5 Inches
Speed		1450 rpm	I.D tubewell	-	
Pump Input		30 HP	Length of suction pipe		
Prime Mover (SEM/DE)		30 HP			
			Length of bowl assembly		
			Length of column pipe		0
			Length of top pipe		1 Ft
			Total length of column		1 Ft

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

Pump assembly of	2	stages with flow type impellers			
Column assembly of	8	inshces I.D with flanged joins	each 10 ft length	0	Sets
			and one top set	1	feet length
			column shaft dia	38	mm
Discharge Head Inch	8				with prelubrication tank
Electric Motor vertical hollow shaft 30 HP/4 Pole					included
DWT 12 MC					included
Discharge head 8 " with top shaft					included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	557,692
Sales Tax @ 17%	Rs:	94,808
Total Cost of Pumpset	Rs:	1,305,000

8.2 Investment Estimate (including Material Specification/Quantities) Streetlights

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

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 50W	50	7000 Lm	140 Lm/Watt	50	53,873	2,693,650
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	728	51,061	37,172,408
3	Accessories	Photocell switch				33	1,000	33,000
Lumpsum Price (PKR)								**39,899,058**
Lumpsum Price (USD)								**142,395**

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	259	51,061	13,224,799
Lumpsum Price (PKR)								**13,224,799**
Lumpsum Price (USD)								**47,198**

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	85	1,700	2,900	246,500
2	LED Bulb 8 Watts	8	21	168	330	6,930
3	LED Bulb 13 Watts	13	16	208	350	5,600
4	Flood LED 200 Watts	200	1	200	25,000	25,000
Lumpsum Price (PKR)						**284,030**
Lumpsum Price (USD)						**1,014**

9 Summary of Energy Efficiency Measures

MC Jaranwala's annual energy consumption is 1,339,462 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$ 25,055** with an estimated investment of **US$ 259,139**
- Reduce electricity consumption by approx. **156,011 kWh**
- Reduce GHG Emissions by **83 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of FESCO

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

Annexure 2: List of Energy Audit Equipment

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

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