Burewala Municipal Committee

Energy Audit Report

June 2023

History of the Document

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The Consultant is also grateful to entire Burewala Municipal Committee representatives for their support extended during the field study.

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ABBREVIATIONS

AC	Air Conditioner
ASD	Adjustable speed drive
BHP	Brake Horsepower
BOQ	Bill of Quantities
CEN	Committee for European Standardization
CFL	Compact Fluorescent Lamp
CO	Chief Officer
CTS	Complaint Tracking System
DCS	Distributed control system
DISCO	Distribution Company
EE	Energy Efficiency
ESMAP	Energy Sector Management Assistance Program
GHG	Green House Gases
GIS	Geographical Information System
GOPb	Government of Punjab
GST	General Sales Tax
HP	Horsepower
ICB	International competitive bidding
ID	Internal Diameter
IES	Illuminating Engineering Society
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicator
LED	Light Emitting Diode
MC	Municipal Committee
N/A	Not available
NG	Natural Gas
NRV	No Return Valve
O&M	Operation and Maintenance
OD	Outer Diameter
PCP	Punjab Cities Program
PF	Power Factor
PHED	Public Health Engineering Department
PKR	Pakistani Rupee
PMDFC	Punjab Municipal Development Fund Company
PMS	Performance Management System
Pumpset	Pump + Motor
QA	Quality Assurance
RPM	Revolutions per minute
SOP	Standard Operating Procedure
TMA	Tehsil Municipal Authority
TWEIP	Tubewell Efficiency Improvement Project
USAID	United States Agency for International Development
USD	US Dollar $
WBG	World Bank Group
WD	Wheel Drive

UNITS OF MEASUREMENTS

Description	UOM
Ampere	A
Calorific value	CV
Days	d
GCV	Gross Calorific Value
NCV	Net Calorific Value
Hours	h
Horsepower	HP
Hertz	Hz
Kilogram	Kg
Kilo Volt Amperes	kVA
Kilo Watt-hour	kWh
Liters	L
Cubic Meter	m^3
Meter	m
Pressure	Bar, PSI
Power Factor	PF
Parts per million	ppm
Revolutions Per Minute	rpm
Voltage	V
Year(s)	y
Pakistani Rupee	PKR
millimeter	mm

CONVERSION FACTORS

Parameters	Unit	Value	Source
Emission factor Petrol	tonne CO_2/GJ	0.0561	IPCC Default Value
Emission factor Diesel	tonne CO_2/GJ	0.0741	IPCC Default Value
Emission factor Natural Gas	tonne CO_2/GJ	0.0631	IPCC Default Value
Emission factor Grid	tonne CO_2/GJ	0.5823	Determined based on the power generation and fuel consumption data provided in Pakistan Energy Yearbook-2017-18

BASELINE PARAMETERS

Parameters	Unit	Value	Source
Costs			
• Petrol	PKR/liter	272.00	Shell Pakistan
• Diesel	PKR/liter	293.00	Shell Pakistan
Exchange Rate	PKR/US$	280.20	State Bank of Pakistan, Average rate for March 2023

1 Summary

1.1 Background

The Punjab Cities Program (PCP) is a World Bank-funded hybrid of Program for Results (PforR) and Investment Project Financing (IPF) operation. It is a USD 200 million 5 years (2018 -2023) program supporting 16 cities in Punjab. The main objective of the program is to strengthen the performance of participating Municipal Committees/Corporations (MCs), focusing on urban management and improvement of municipal infrastructure for satisfactory service delivery.

Under the PforR (Window-1) the Performance Based Grants (PBGs) are being provided to the MCs of the 16 selected cities for investments in municipal infrastructure and services.

The IPF (Window-2) is supporting provincial government agencies i.e. Local Government & Community Development Department (LG&CDD), Punjab Local Government Board (PLGB), Punjab Municipal Development Fund Company (PMDFC), and PFC Unit of Finance Department (FD).

1.2 Scope of work

As per the scope of work specified in the Terms of Reference of the project, the Consultant is required to:

a) develop a detailed work program for carrying out the works immediately after mobilizing
b) prepare an inventory of relevant assets owned/operated by the MC, including municipal buildings, vehicles, streetlights, and water-supply/wastewater disposal pumps
c) collect additional information on location (where applicable), performance and energy consumption analysis, estimation of expenditure incurred
d) provide detailed information for each asset, and an overall inventory and analytical report discussing key performance indicators
e) identify energy saving opportunities, and provide saving potential (in energy and monetary terms) for each opportunity, estimated investment costs and return on investments, engineering plans, and Bill of Quantities, as needed.

1.3 Process of the Energy Efficiency Assessment and Structure of the Report

During the information and data gathered during the on-site assessment, detailed analysis was carried out to determine the baseline energy consumption, energy efficiency of pumpsets, fuel consumption by vehicles and developed KPI's for pumpsets, streetlights, vehicles and buildings. Based on this analysis several energy efficiency measures have been identified and summary of potential savings for each measure (in energy and monetary terms) along with estimated investment costs and payback period is given in Section 6.

1.4 Burewala MC Background

Burewala is a city in the Vehari District of Punjab, Pakistan. The city of Burewala is the headquarters of Burewala Tehsil, an administrative subdivision of the district. It is located at 30.1592 N 72.6817 E and has a population of approximately 231,797. It is the 34th Biggest city of Pakistan by population.

Burewala is located at a distance of about 84 miles from Multan and is situated at the old historical Delhi Multan road. It is the last settlement of District Multan and is surrounded by Sahiwal District on three sides. The branch railway-line connecting Lahore with Lodhran passes through Burewala and as such Burewala is connected by rail with Pakpattan, Arifwala and vehari and later on to Lodhran on Multan Karachi line. By pass road is connected with Sahiwal via Chichawatni and Arifwala and have a link with Multan via Jahanian.

After the implementation of Punjab Local Government Ordinance 2001, it was given the status of MC in 2001.

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 Burewala MC has the following management.

Sr. No.	Name of Officer	Designation
1	Mr. Abdul Basit Siddiqui	Administrator
2	Mr. Imtiaz Ahmed Joiya	Chief Officer
3	Mr. Hafiz Muhammad Waseem	Municipal Officer (Infrastructure)
4	Mr. Ghulam Jilani	Municipal Officer (Regulation)
5	Mr. Muhammar Ammar Gurmani	Municipal Officer (Finance) Additional Charge
6	Mr. Mian Ijaz Iqbal	Municipal Officer (Planning) Additional Charge

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

1.4.1 Baseline Energy Consumption of Burewala

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	910,109
Electrical energy used by Wastewater Disposal[2]	kWh/year	591,986
Electrical energy used in Buildings[3]	kWh/year	88,649
Electrical energy used by Streetlights[4]	kWh/year	154,304
Diesel used by Vehicles	liter/year	110,664
Petrol used by Vehicles	liter/year	11,040

1.5 Key Performance Indicators

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

1.5.1 Potable Water & Wastewater Pumps

Table 2: KPIs for Potable Water & Wastewater pumps

Sr. No.	Description	Unit	KPI
1	Energy Density of Potable Water Production	(kWh/m^3)	0.17
2	Energy Density of Wastewater Disposal	(kWh/m^3)	0.03
3	Energy Density of Wastewater Treatment	(kWh/m^3) – if applicable	No wastewater treatment is carried out
4	Energy Cost on Potable Water Production	(PKR/m^3)	7.74
5	Energy Cost on Wastewater Disposal	(PKR/m^3)	1.16
6	Energy Cost on Wastewater Treatment	(PKR/m^3) – if applicable	No wastewater treatment is carried out

[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

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)	11,891
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	913
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	44768
		PKR/Lighting Equipment	42,684
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)	70,594
6	Average daily duration of operation	(Hour)	12.0
7	Average energy costs per kilometer of lit roads	(PKR/km)	535,100
8	Average energy costs per light pole/fixture	(PKR/ fixture)	41,087
9	Number and percentage of failed public lights		9%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	7.87
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.13
3	Average Energy Cost of Heating	(PKR/m^2)	6
4	Average Energy Cost of Cooling	(PKR/m^2)	154
5	Average Energy Cost of Lighting	(PKR/m^2)	80

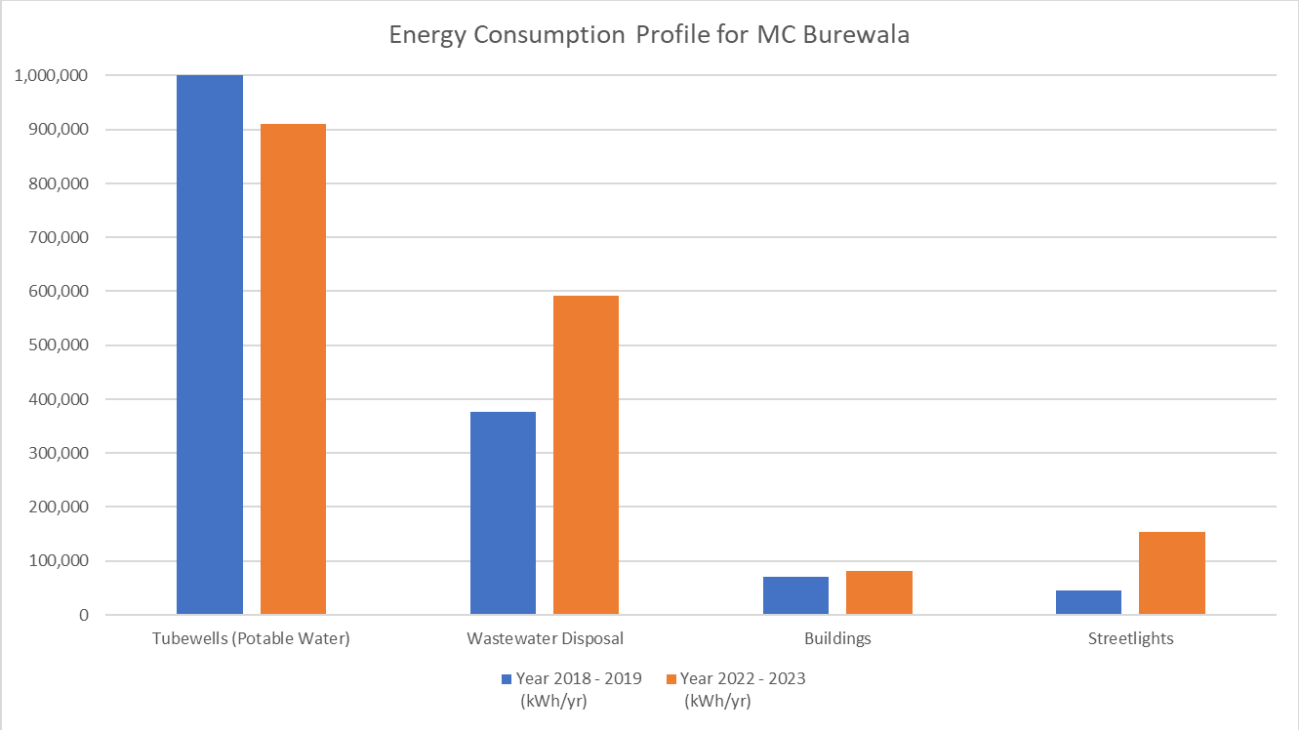
1.5.4 Vehicles

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	4.70
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	62.28

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 for MC Burewala
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Tubewells (Potable Water)
Wastewater Disposal
Buildings
Streetlights
Year 2018 - 2019 (kWh/yr)
Year 2022 - 2023 (kWh/yr)

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	34	31	1,267,300	910,109	357,191	0.23 kWh/m3	0.17 kWh/m3	Replacement of 5 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 6 pumps 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	6	376,102	591,986	-215,884	0.04 kWh/m3	0.03 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	4	7	69,926	82,087	-12,161	6.80 kWh/m2	7.98 kWh/m2	Municipal rest house, bus stand and Training school building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these building have not been considered in the overall energy consumption and KPI calculations. Electricity units (kWh) are increased due to increase in number of Air Conditioners (AC) and lighting load in MC Office Building.
4	Streetlights	56	191	44,813	154,304	-109,491	2,818 kWh/km	11,891 kWh/km	The number of operational lights in the MC has increased threefold. Consequently, the overall electricity consumption by streetlights in the MC has increased as well.

		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
									All of the operational lights in the MC are LEDs. It is observed that the KPI for streetlights has increased, this is due to the fact that while the number of lighting fixtures (and the associated electricity consumption) has increased, the overall area covered by streetlights has not.

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
Development of New Bore & Replacement of Pumpset at (TMA-TownHall - Unique ID: 31706529)	14,566	7,363	2,063,000	2,339	655,465	38	7
Replacement of Pumpset at (N-Block - Unique ID: 31806562)	12,396	3,608	1,011,002	1,991	557,821	22	6
Replacement of Pumpset at (Yaqubabad - Unique ID: 3100705)	10,040	3,608	1,011,002	1,612	451,805	27	5
Replacement of Pumpset at (Gulshan-e-Ghani - Unique ID: 31806570)	14,612	3,608	1,011,002	2,347	657,550	18	7
Replacement of Pumpset at (Mujahid Colony No. 1 - Unique ID: 31706548)	7,575	3,608	1,011,002	1,217	340,875	36	4
Replacement/Installation of Capacitors	Not Quantifiable	2,250	630,450	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	2,222	622,732	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	2,276	205	57,510	366	102,436	7	1
Total:	**61,466**	**26,473**	**7,417,700**	**9,871**	**2,765,952**		**31**

Table 7: Low Priority Measures

Low Priority Energy Efficiency Measure	Water Savings m^3/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Installation of Flow meters integrated with a centralized DCS system	62,120	40,000	11,208,000	0	0	0	Not Quantifiable
Total:	**62,120**	**40,000**	**11,208,000**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Burewala MC has forty-six (46) tubewells for groundwater, all of which are manually operated. Out of these, 31 pumpsets were found to be in working condition.

The MC has four (4) disposal station having seventeen (17) pumps. Out of these 4 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are three (3) dewatering sets in the MC, all of which 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 23 (twenty-three) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake audit of the following pumpsets as they have been abandoned by the MC

1. Ghallah Mandi (Unique ID: 31806561)
2. Khatija-tul-qubraa (Unique ID: 31806574)
3. Lat Bhattian (451-EB) (Unique ID: 31806583)
4. Iqbal No.1 (Unique ID: 30907281)
5. Habib Colony (Unique ID: 31706544)
6. Azeem Abad No.1 (Unique ID: 31806572)
7. Masoom Shah (Unique ID: 31806579)
8. Ghoshala (Unique ID: 31806559)
9. Ghulam Muhammad (Unique ID: 31806578)
10. E-Block (Unique ID: 31806567)
11. Mujahid Colony (Banqi) (Unique ID: 31806580)
12. Mujahid Colony Eid Gah (Unique ID: 31806581)
13. Dogar Market (Unique ID: 31806582)

(iv) Undertake audit of the following pumpset as it was under maintenance

1. Marzi pura/Iqbal Nagar No.2 (Unique ID: 31706537)

(v) Undertake audit of the following pumpset as there was no provision to install a flow meter

1. Ahata Shah Nawat (Unique ID: 31706541)
2. Muhammad Nagar (Unique ID: 80907282)

(vi) Undertake audit of the following pumpset as flow could not be detected due to excessive air and high turbulence in the delivery lines
   1. Ilyas Garden (Unique ID: 31107006)
   2. Habib Colony School (Unique ID: 31706545)

(vii) Undertake audit of the following pumpset the newly installed pumpset is not yet fully operational
   1. Anwar Town (Unique ID: 31807772)

(viii) Undertake assessment of the pumpset as there is no provision to install flow meter
   1. Ahata Shah Nawat (Unique ID: 31706541)
   2. Muhammad Nagar (Unique ID: 80907282)

(ix) Undertake assessment of the following disposal pumpset as the sites are under maintenance
   1. 451-EB (Unique ID: 31706531-B)
   2. 451-EB (Unique ID: 31706531-D)
   3. 451-EB (Unique ID: 31706531-E)
   4. 451-EB (Unique ID: 31706531-F)
   5. Marzipura Multan Road No.1 (Unique ID: 31716534-B)
   6. Marzipura Multan Road No.1 (Unique ID: 31716534-E)
   7. Disposal Works Lorry Adda (Unique ID: 31806568-C)

(x) Undertake assessment of the following disposal pumpset as the sites have been abandoned by the MC
   1. Marzipura Multan Road No.1 (Unique ID: 31716534-C)
   2. Marzipura Multan Road No.1 (Unique ID: 31716534-D)

(xi) Undertake assessment of the following disposal pumpset as there wasn't enough water in the well
   1. Disposal Works Lorry Adda (Unique ID: 31806568-B)

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

2.1 Inventory for water and wastewater pumping equipment

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

2.1.1 Tubewells

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

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	Year of Motor Manufacturing	Latitude	Longitude
1	31806566	H-Block	28-15331-0128900	Turbine	HMA	2018	Grundfos	2018	30.15944	72.68389
2	31806565	M-Block	28-15331-0021200	Turbine	PECO	1999	PECO	1999	30.16056	72.68472
3	31706551	Satellite Town No.1	28-15332-0071500	Turbine	KSB	2020	Siemens	2020	30.16083	72.69333
4	31706543	Bhatta Yousafabad	28-15334-1090902	Turbine	KSB	1990	Siemens	1980	30.14889	72.67556
5	31706529	TMA-TownHall	28-15331-0062700	Turbine	BECO	1971	BECO	1971	30.15961	72.68195
6	31806560	Water supply colony	28-15331-0491400	Turbine	KSB	2020	Siemens	2020	30.16079	72.67342
7	31806561	Ghallah Mandi	28-15331-0271700	Turbine	KSB	2020	Siemens	2020	30.15728	72.67988
8	31806562	N-Block	28-15332-0269301	Turbine	N/A	2009	Siemens	2009	30.15843	72.68679
9	31806563	P-Block 1	28-15332-0110400	Turbine	N/A	N/A	Siemens	N/A	30.15841	72.68985
10	31706552	Satellite No. 2	28-15332-0085406	Turbine	HMA	2017	Siemens	2017	30.16292	72.69579
11	31806564	W.W P-Block 2	28-15332-0213908	Turbine	HMA	N/A	Siemens	N/A	30.16039	72.68967
12	3100705	Yaqubabad	28-15334-0448000	Turbine	PECO	N/A	PECO	N/A	30.17111	72.68833
13	31706536	Farid Town	28-15334-0358402	Turbine	MECO	2009	Siemens	2009	30.15194	72.65444
14	31706539	Gulshan-e-Rehman	28-15334-0168590	Turbine	HMA	N/A	Siemens	N/A	30.15999	72.69983
15	31706541	Ahata Shah Nawat	28-15334-0560400	Turbine	Flow Pak	N/A	PECO	N/A	30.15806	72.66889
16	31706542	Housing Scheme Y-Block	28-15334-0549500	Turbine	MECO	2009	Siemens	2009	30.15806	72.66889
17	31806574	Khatija-tul-qubraa	28-15333-0307602	N/A	N/A	N/A	N/A	N/A	30.17469	72.68962
18	31806583	Lat Bhattian (451-EB)	28-15334-1073502	N/A	N/A	N/A	N/A	N/A	30.14938	72.65818
19	80907282	Muhammad Nagar	28-15334-042600	Turbine	PECO	N/A	PECO	N/A	30.15250	72.66417
20	30907281	Iqbal No.1	28-45334-0332100	N/A	N/A	N/A	N/A	N/A	30.15226	72.65749
21	31806570	Gulshan-e-Ghani	27-15334-0041802	Turbine	General Turbine	2004	BECO	2004	30.16500	72.68639
22	31706538	Yousaf Block	28-15334-1194400	Turbine	KSB	2020	Siemens	2020	30.15694	72.66194
23	31706544	Habib Colony	04-15331-0317702	N/A	PECO	1981	PECO	1981	30.15286	72.67605
24	31706545	Habib Colony School	28-15334-1090901	Turbine	PECO	N/A	PECO	N/A	30.14972	72.68000
25	31706550	Allabad water works	28-15332-1702102	Turbine	HMA	N/A	Siemens	N/A	30.16231	72.71495
26	31806571-1	I-Block (Park City)	28-15332-0002702	Turbine	HMA	N/A	Siemens	N/A	30.16389	72.69056
27	31806572	Azeem Abad No.1	28-15333-02174600	N/A	PECO	N/A	PECO	N/A	30.16707	72.69224
28	31806579	Masoom Shah	28-15334-0685907	N/A	N/A	N/A	N/A	N/A	30.14972	72.67000
29	3100703	Chak No. 437/EB	28-15334-0118501	Turbine	KSB	2020	Siemens	2020	30.16611	72.67639
30	3100704	Chak No.435	28-15334-0422802	Turbine	KSB	2020	Siemens	2020	30.17972	72.68972
31	31107007	Azeem Abad No.2	28-15333-0274800	Turbine	KSB	2008	Siemens	2008	30.16833	72.69222
32	31807771	Habib Colony 2	N/A	Turbine	KSB	2017	Siemens	2017	30.14972	72.68000
33	31806559	Ghoshala	28-15334-0150300	N/A	PECO	N/A	PECO	N/A	30.16405	72.67422
34	31806578	Ghulam Muhammad	28-15334-0685906	N/A	N/A	N/A	N/A	N/A	30.14972	30.14972
35	31807772	Anwar Town	28-15333-0544001	N/A	PECO	N/A	PECO	N/A	30.17380	72.69380
36	31706537	Marzi pura/Iqbal Nagar No.2	28-15334-0324704	N/A	BECO	N/A	BECO	N/A	30.15302	72.66176

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
37	31706546	447-EB	28-15332-0111900	Turbine	Flowpak	N/A	Siemens	N/A	30.12972	72.68972
38	31706547	445-EB	28-15334-0111800	Turbine	PECO	N/A	PECO	N/A	30.15583	72.70806
39	31706548	Mujahid Colony No. 1	28-15332-040900	Turbine	PECO	1989	PECO	1989	30.15971	72.69997
40	31706549	Mujahid Colony No. 2	28-15332-0110900	Turbine	KSB	2020	Siemens	2020	30.16063	72.70366
41	31806558	Azizabad	28-15334-0150300	Turbine	PECO	N/A	PECO	N/A	30.16382	72.67168
42	31806567	E-Block	28-15331-0010001	N/A	PECO	N/A	PECO	N/A	30.16072	72.68382
43	31806580	Mujahid Colony (Banqi)	N/A	N/A	N/A	N/A	N/A	N/A	30.15176	72.69979
44	31806581	Mujahid Colony Eid Gah	27-15332-1213206	N/A	N/A	N/A	N/A	N/A	30.15583	72.70806
45	31806582	Dogar Market	N/A	N/A	N/A	N/A	N/A	N/A	30.14936	72.65828
46	31107006	Ilyas Garden	N/A	Turbine	HMA	N/A	Siemens	N/A	30.17222	72.69194

2.1.2 Dewatering Sets

Table 9: Inventory Table of Dewatering Set

Sr. No.	Unique ID	Location	Quantity	Latitude	Longitude
1	31806569 A	Fire brigade office	1	30.164560	72.670984
2	31806569 B	Wapda works colony	2	30.158421	72.678094

2.1.3 Disposal Works

Table 10: Inventory Table of Disposal Works

Sr. No.	Unique ID	Location	Meter Reference No	Pump Type	Pump Brand	Pump Capacity (Cusec)	Motor Brand	Motor Capacity (hp)	Longitude	Latitude
1	31706531-A	451-EB	27-15334-0386902	Centrifugal Non-Clogging Pump	KSB	4	KSB	40	30.14239	72.63683
2	31706531-B			Centrifugal Non-Clogging Pump	KSB	5	KSB	60		
3	31706531-C			Centrifugal Non-Clogging Pump	KSB	5	KSB	60		
4	31706531-D			Centrifugal Non-Clogging Pump	KSB	4	KSB	40		
5	31706531-E			Centrifugal Non-Clogging Pump	KSB	5	KSB	60		
6	31706531-F			Centrifugal Non-Clogging Pump	KSB	5	KSB	60		
7	31716534-A	Marzipura Multan Road No.1	27-15334-0385700	Centrifugal Non-Clogging Pump	MECO	4	Siemens	75	30.14882	72.65105
8	31716534-B			Centrifugal Non-Clogging Pump	KSB	5	Siemens	80		
9	31716534-C			Centrifugal Non-Clogging Pump	KSB	5	Siemens	80		
10	31716534-D			Centrifugal Non-Clogging Pump	KSB	5	N/A	N/A	30.14855	72.65094
11	31716534-E			Centrifugal Non-Clogging Pump	KSB	2	N/A	N/A	30.14882	72.65105
12	31716534-F			Centrifugal Non-Clogging Pump	PECO	5	Siemens	N/A		
13	31806568-A	Disposal Works Lorry Adda	28-15334-0020800	Centrifugal Non-Clogging Pump	KSB	4	Siemens	60	30.16414	72.68293
14	31806568-B			Centrifugal Non-Clogging Pump	KSB	5	Siemens	N/A		
15	31806568-C			Centrifugal Non-Clogging Pump	KSB	5	Siemens	75		
16	31806575-A	Rahmatabad	28-15333-0397201	Centrifugal Non-Clogging Pump	N/A	N/A	Siemens	25	30.17602	72.68725

Sr. No.	Unique ID	Location	Meter Reference No	Pump Type	Pump Brand	Pump Capacity (Cusec)	Motor Brand	Motor Capacity (hp)	Longitude	Latitude
17	31806575-B			Centrifugal Non-Clogging Pump	KSB	2.5	PECO	25		

2.1.4 Filtration Units

Table 11: Inventory of Filtration Units

Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East
1	31806566-1	H-Block	Attached with (31806566) H Block Supply					30.95961	72.68401
2	31706551-1	Satellite Town No.1	Attached with (31706551) Satellite Town -1 Supply.					30.16087	72.69355
3	31806562-1	N-Block	Attached with (31806562) N Block Supply.					30.15843	72.68679
4	31806563-1	P-Block 1	Attached with (31806563) P- Block 1 Supply.					30.15841	72.68985
5	3097281-1	Iqbal Nagar No.2	Attached with (3097281) Iqbal Nagar Supply.					30.15226	72.65749
6	3100705-1	Yaqubabad	Attached with (3100705) Yaqoobabad Supply					30.17125	72.68847
7	31706542-1	Housing Scheme Y-Block	Attached with (31706542) Housing Scheme Supply					30.15886	72.67052
8	80907282-1	Muhammad Nagar	Attached with (30907282) Muhammad Nagar Supply					30.15262	72.66434
9	31807773	Lat Bhattian	Abandoned by MC					30.15900	72.70820
10	31706538-1	Yousaf Block	Attached with (31706538) Yousaf Block Marzipura Supply					30.15694	72.66176
11	31806567-1	E-Block	Attached with (31806567) E Block Supply					30.16072	72.68382
12	3100703-1	Chak No.437/EB	Attached with (3097281) Iqbal Nagar Supply					30.16626	72.67648
13	31807774	Habib Colony 2	Abandoned by MC					30.14972	72.68000
14	3100704-1	Chak 435	Attached with (3100704) Chak-435 Supply					30.17972	72.68972
15	31107007-1	Azeemabad No.1	Attached with (31107007) Azeemabad Supply					30.16829	72.69244
16	31706545-1	Habib-Colony School	Attached with (31706545) Habib Colony School Supply					30.14972	72.68000
17	31706546-1	447-EB	Attached with (31706546-447) EB Supply					30.12972	72.68972
18	31706547-1	445-EB	Attached with (31706547-445) EB Supply					72.70806	30.15583
19	31706548-1	Mujahid Colony No. 1	Attached with (31706548) Mujahid Colony No. 1 Supply					30.16000	72.68333
20	31806558-1	Azizabad	Attached with (31806558) Azeezabad Supply					30.16382	72.67168

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

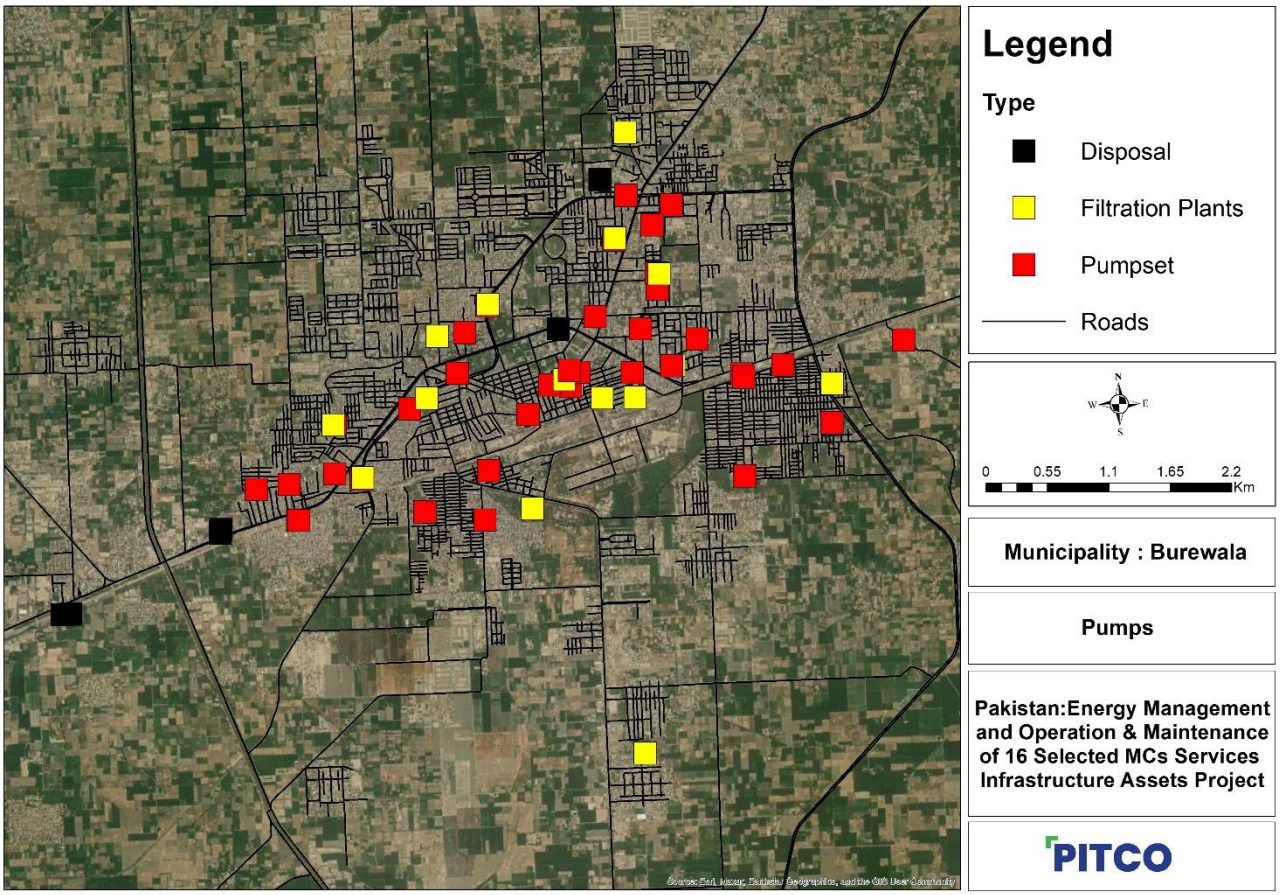


Figure 1: Map for Pumps and Disposal at MC Burewala

2.3 Baseline Energy Consumption Trend

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

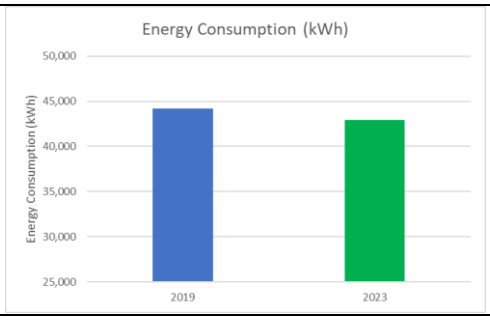
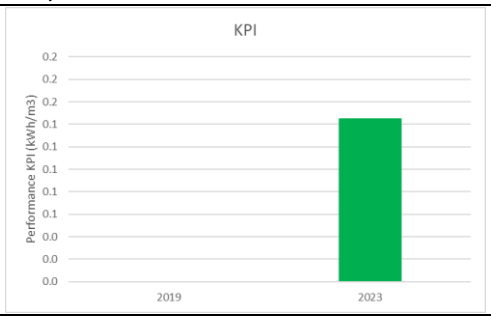
Table 12: Baseline Energy Consumption Trend

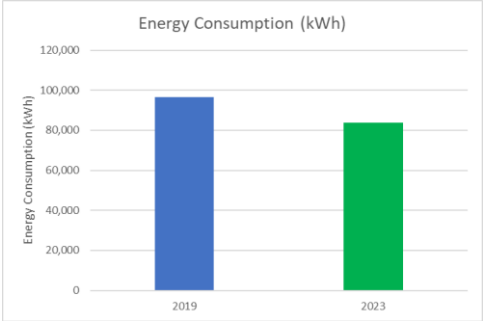
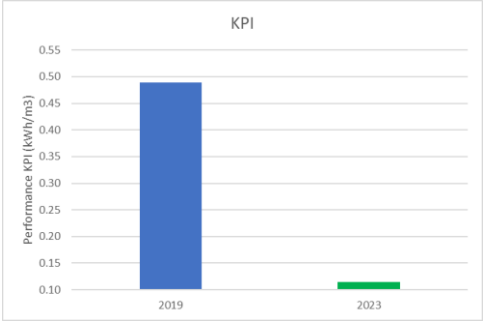
Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	910,109
Electrical energy used by Wastewater Disposal	kWh/y	591,986
Electrical energy used (Total)	kWh/y	1,502,095

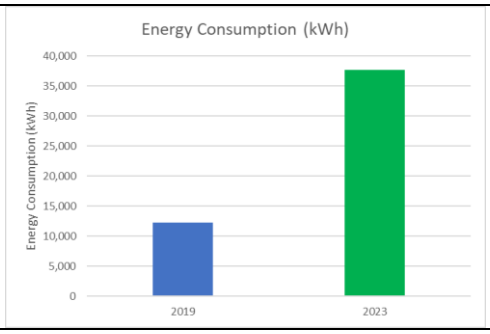
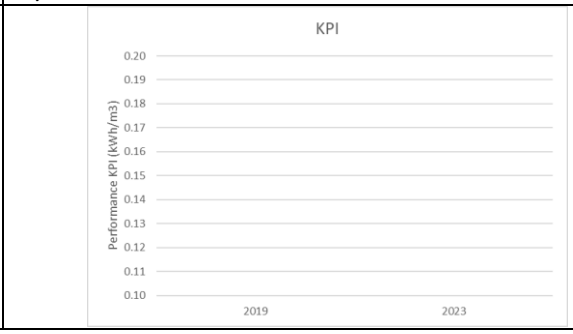
A comparison of current electricity consumption by the MC's water supply and disposal assets compared to results of the energy audit activity carried out in 2019, is presented in the following table:

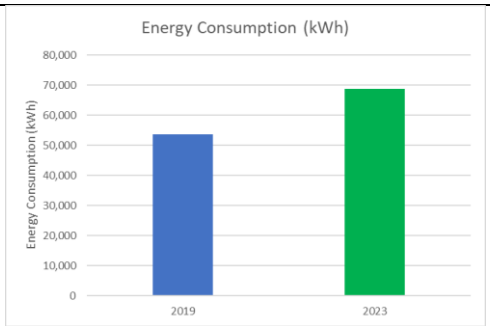
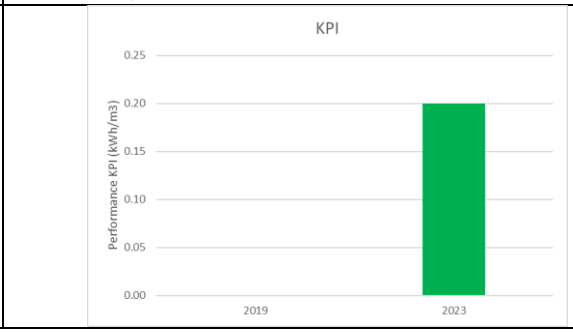
		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	34	31	1,267,300	910,109	357,191	0.23 kWh/m3	0.17 kWh/m3	Replacement of 5 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 6 pumps 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	6	376,102	591,986	-215,884	0.04 kWh/m3	0.03 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.

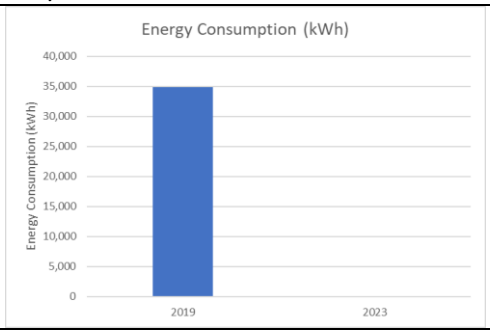
Replacement of 5 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken installation of 6 new pumpsets. A discussion on each newly installed asset is presented below:

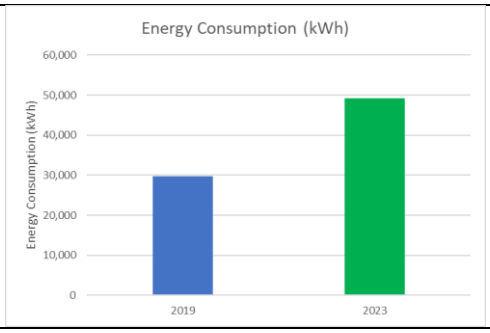
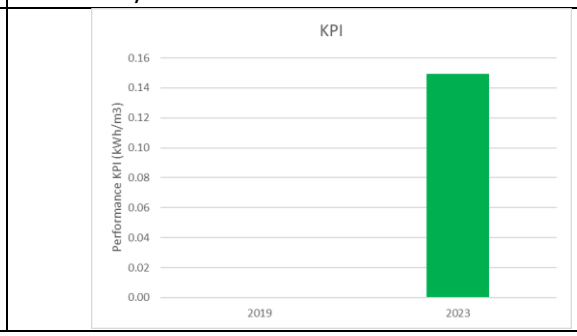
Satellite Town No.1 - Unique ID (31806566)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
44,186 kWh	42,922 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.15 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Annual energy consumption of this pumpset in 2019 was 44,186 kWh whereas, annual energy consumption of this pumpset of current year is 42,922 kWh with an annual energy savings of 1,264 kWh. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No calculations of the KPI has been calculated for the previous audit, as no pump flow assessment could be carried out at this site due to extremely rusty condition of the delivery pipe.	

Water supply colony - Unique ID (31806566)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
96,639 kWh	83,920 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.49 kWh/m3	0.11 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of new pumpset and bore was recommended due to the low efficiency. Annual energy consumption of this pumpset in 2019 was 96,639 kWh whereas, annual energy consumption of this pumpset of current year is 83,920 kWh with an annual energy savings of 12,719 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.	

Yousaf Block - Unique ID (31806566)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
12,244 kWh	37,723 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	N/A
	
Comments:	
A new pumpset has been installed at this site. Annual energy consumption of this pumpset in 2019 was 12,244 kWh whereas, annual energy consumption of this pumpset of current year is 37,723 kWh with an increase of 25,479 kWh in an annual energy consumption. No KPIs have been calculated for this site, as no flow could be detected due to the excessive air and high turbulence in the delivery lines in the recent audit whereas, no flow was detected due to was extremely rusty condition of the delivery pipe in the previous audit.	

Chak No. 437/EB - Unique ID (31806566)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
53,600 kWh	68,732 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.20 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 53,600 kWh whereas, annual energy consumption of this pumpset of current year is 68,732 kWh with an increase of 15,132 kWh in an annual energy consumption. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No calculations of the KPI has been calculated for the previous audit, as no pump flow assessment could be carried out at this site as there was no provision to install the ultrasonic water flowmeter.	

Chak No.435 - Unique ID (31806566)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
34,822 kWh	0 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.23 kWh/m3	0.00 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. As MC is not currently receiving bills on this newly installed pumpsets due to which the savings are not reflected in the KPIs and annual energy consumption kWh.	

Mujahid Colony No. 2 - Unique ID (31806566)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
29,795 kWh	49,263 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.15 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 29,795 kWh whereas, annual energy consumption of this pumpset of current year is 49,263 kWh with an increase of 19,468 kWh in an annual energy consumption. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No calculations of the KPI has been calculated for the previous audit, as no pump flow assessment could be carried out at this site due to extremely rusty condition of the delivery pipe.	

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.

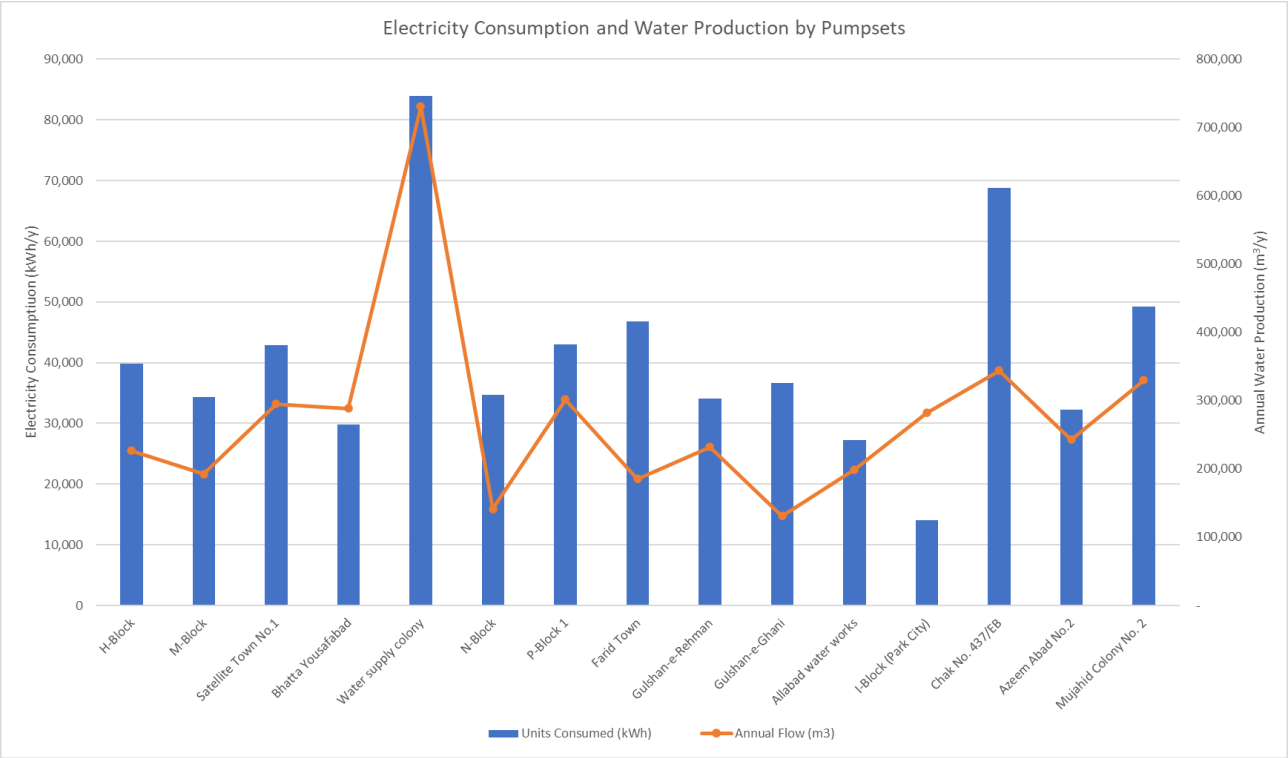
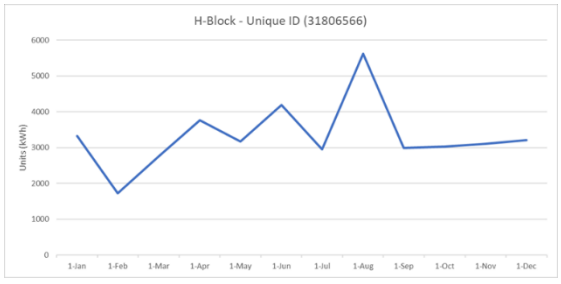


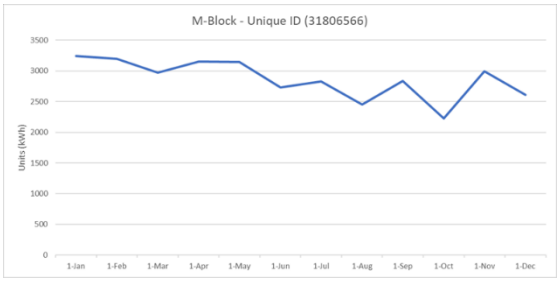
Figure 2: Electricity Consumption and Water Production by Pumpsets

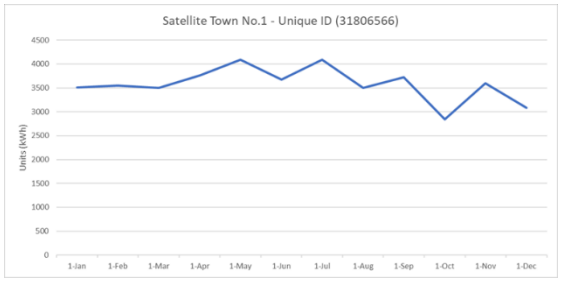
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

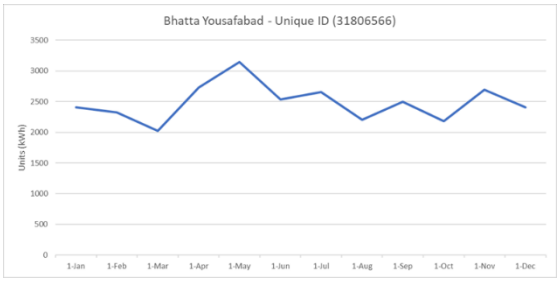
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

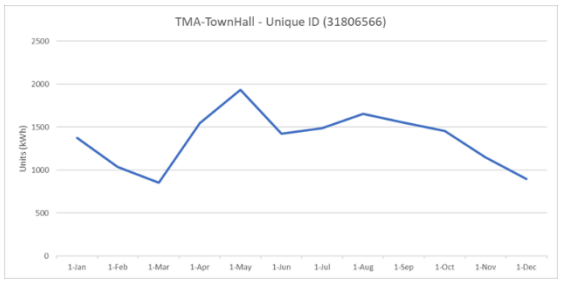
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

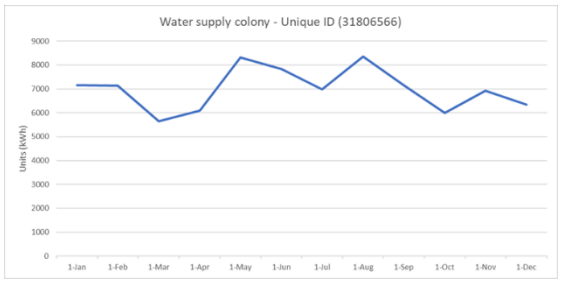









TMA-TownHall - Unique ID (31806566)
Units (kWh)
2500
2000
1500
1000
500
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Water supply colony - Unique ID (31806566)
Units (kWh)
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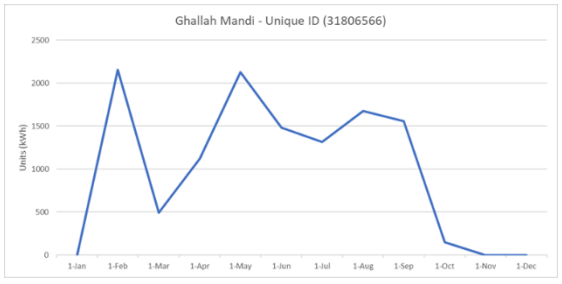
8000
7000
6000
5000
4000
3000
2000
1000
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


Ghallah Mandi - Unique ID (31806566)
Units (kWh)
2500
2000
1500
1000
500
0
1-Jan
1-Feb
1-Mar
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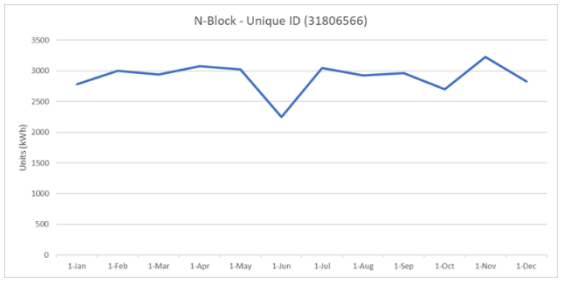
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


N-Block - Unique ID (31806566)
Units (kWh)
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3000
2500
2000
1500
1000
500
0
1-Jan
1-Feb
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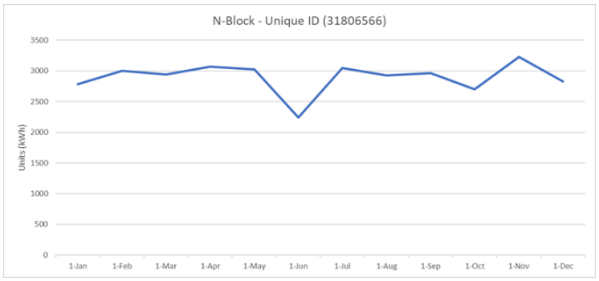
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


N-Block - Unique ID (31806566)
Units (kWh)
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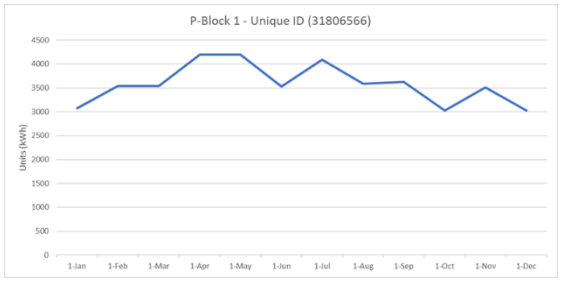
3000
2500
2000
1500
1000
500
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


P-Block 1 - Unique ID (31806566)
Units (kWh)
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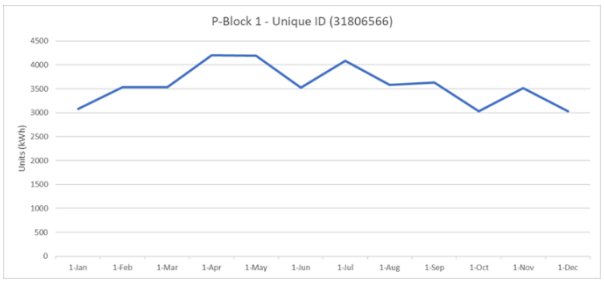
3500
3000
2500
2000
1500
1000
500
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec


P-Block 1 - Unique ID (31806566)
Units (kWh)
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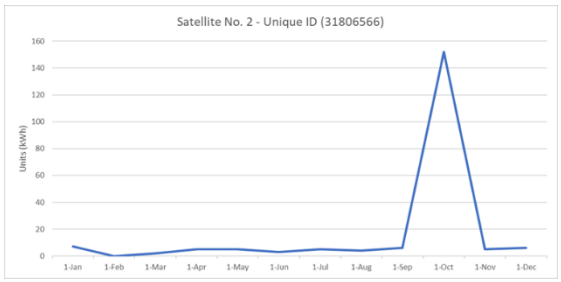
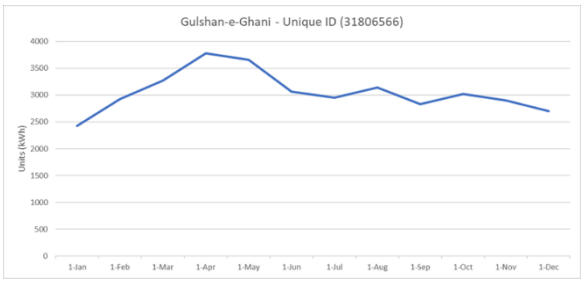
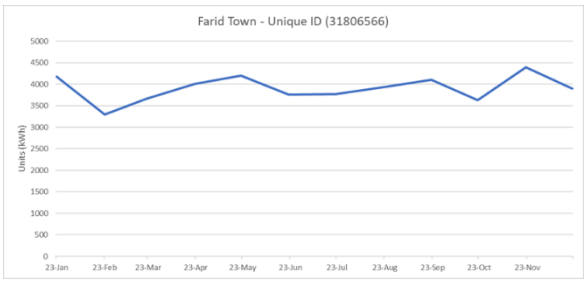
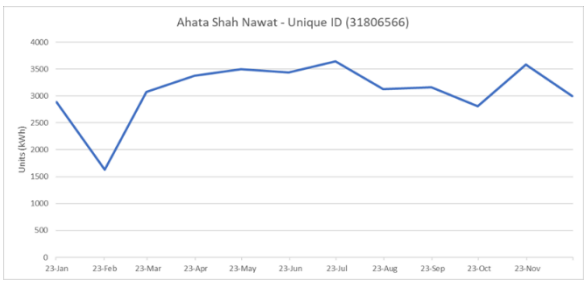
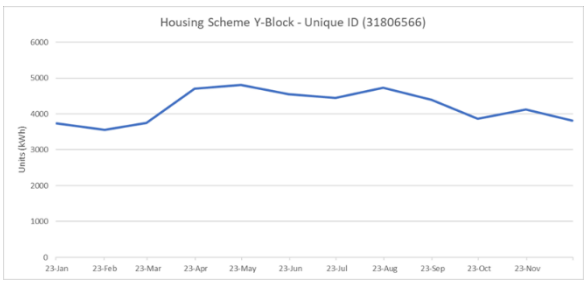
4000
3500
3000
2500
2000
1500
1000
500
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

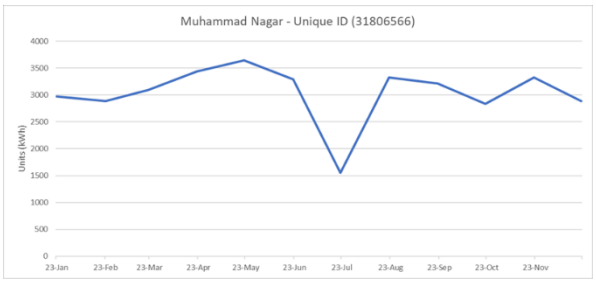

Satellite No. 2 - Unique ID (31806566)
Units (kWh)
160
140
120
100
80
60
40
20
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

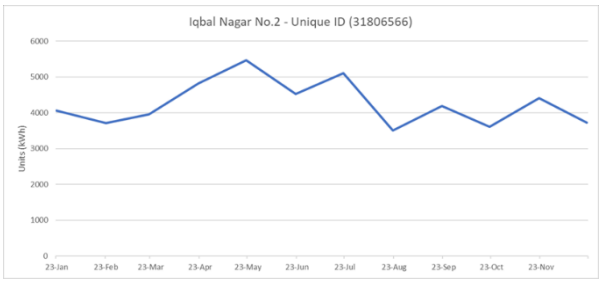

Gulshan-e-Ghani - Unique ID (31806566)
Units (kWh)
4000
3500
3000
2500
2000
1500
1000
500
0
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec

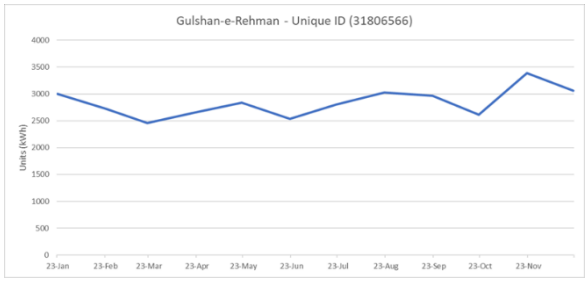

Farid Town - Unique ID (31806566)
Units (kWh)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

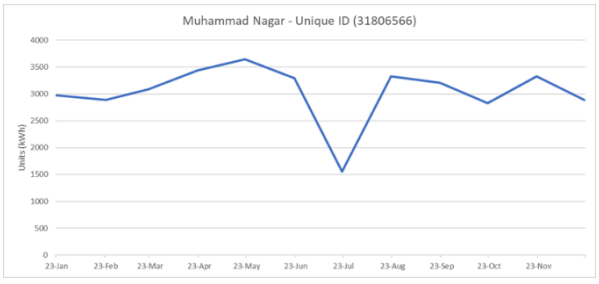

Ahata Shah Nawat - Unique ID (31806566)
Units (kWh)
4000
3500
3000
2500
2000
1500
1000
500
0
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

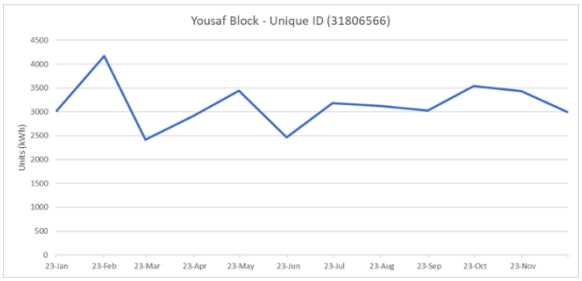

Housing Scheme Y-Block - Unique ID (31806566)
Units (kWh)
6000
5000
4000
3000
2000
1000
0
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

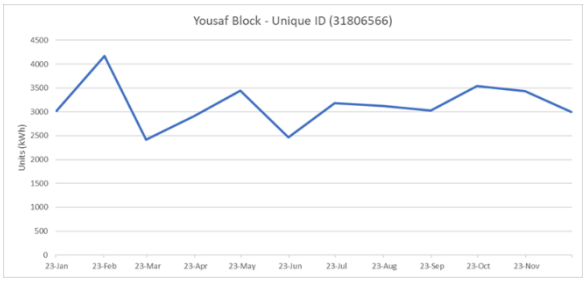

Muhammad Nagar - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

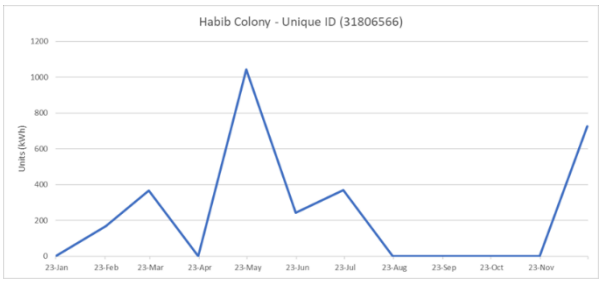

Iqbal Nagar No.2 - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

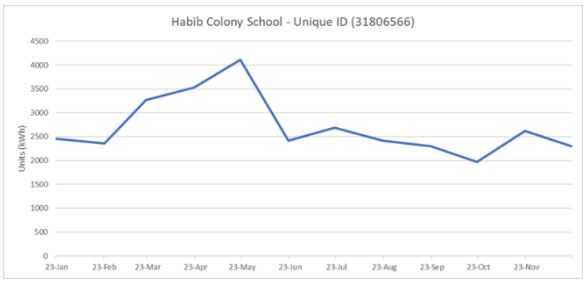

Gulshan-e-Rehman - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

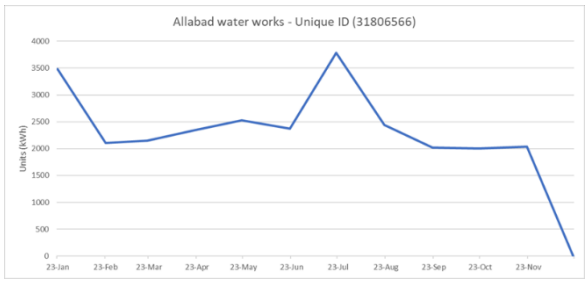

Muhammad Nagar - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

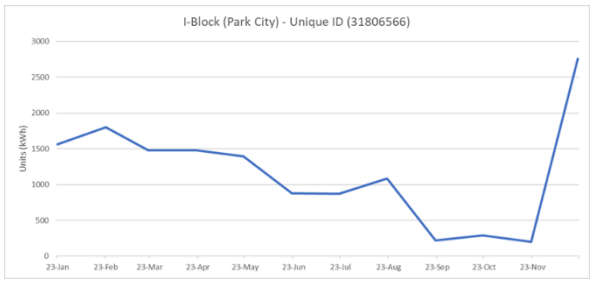

Yousaf Block - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

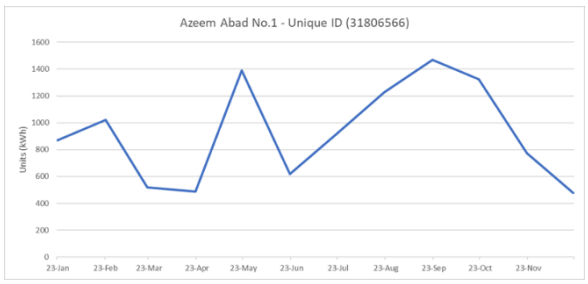

Yousaf Block - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov


Habib Colony - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov


Habib Colony School - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov


Allabad water works - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov


I-Block (Park City) - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov


Azeem Abad No.1 - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

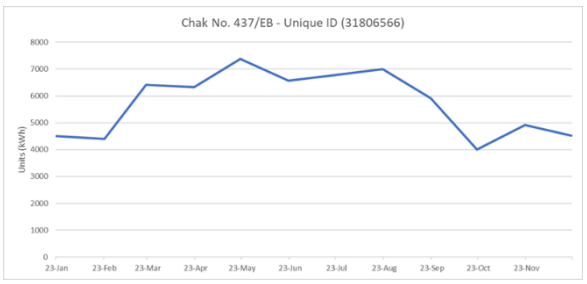

Chak No. 437/EB - Unique ID (31806566)
Units (kWh)
23-Jan
23-Feb
23-Mar
23-Apr
23-May
23-Jun
23-Jul
23-Aug
23-Sep
23-Oct
23-Nov

Figure 3: Energy Consumption Trend for Water Pumps

Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Burewala MC has forty-six (46) tubewells for groundwater, all of which are manually operated. Performance evaluation of pumpsets could be carried out at only 26 locations due to the reasons specified under section 2. Performance analysis was carried out for the operational tubewells, by simultaneous measurement of flow and electrical consumption. The list of audit equipment used by the Consultant is attached as Annexure 2. Since the Sluice valves at several pumping stations were either jammed or broken, it was not possible to determine system resistance and/or assess the pumpset performance at its duty point. Nevertheless, the purpose of the energy audit is to evaluate the energy consumption of MC's water supply network based on their actual/existing working condition. Therefore, any measurements made by altering the actual field operating mode/conditions will not be a true representation of the energy consumption of assets.

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

Figure 5: Sample pictures from field audit of pumpsets

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

Table 13: Matrix of Pumpset Assessment and Billing Data Availability

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
1	31806566	H-Block	Yes	Yes
2	31806565	M-Block	Yes	Yes
3	31706551	Satellite Town No.1	Yes	Yes
4	31706543	Bhatta Yousafabad	Yes	Yes
5	31706529	TMA-TownHall	Yes	Yes
6	31806560	Water supply colony	Yes	Yes
7	31806561	Ghallah Mandi	Yes	No
8	31806562	N-Block	Yes	Yes
9	31806563	P-Block 1	Yes	Yes
10	31706552	Satellite No. 2	Yes	Yes
11	31806564	W.WP-Block 2	Yes	Yes
12	3100705	Yaqubabad	Yes	Yes
13	31706536	Farid Town	Yes	Yes
14	31706539	Gulshan-e-Rehman	Yes	Yes

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
15	31706541	Ahata Shah Nawat	Yes	No
16	31706542	Housing Scheme Y-Block	Yes	Yes
17	31806574	Khatija-tul-qubraa	Yes	No
18	31806583	Lat Bhattian (451-EB)	Yes	No
19	80907282	Muhammad Nagar	Yes	No
20	30907281	Iqbal No.1	Yes	No
21	31806570	Gulshan-e-Ghani	Yes	Yes
22	31706538	Yousaf Block	Yes	No
23	31706544	Habib Colony	Yes	No
24	31706545	Habib Colony School	Yes	No
25	31706550	Allabad water works	Yes	Yes
26	31806571-1	I-Block (Park City)	Yes	Yes
27	31806572	Azeem Abad No.1	Yes	No
28	31806579	Masoom Shah	Yes	No
29	3100703	Chak No. 437/EB	Yes	Yes
30	3100704	Chak No.435	Yes	Yes
31	31107007	Azeem Abad No.2	Yes	Yes
32	31807771	Habib Colony 2	Yes	Yes
33	31806559	Ghoshala	Yes	No
34	31806578	Ghulam Muhammad	Yes	No
35	31807772	Anwar Town	Yes	No
36	31706537	Marzi pura/Iqbal Nagar No.2	Yes	No
37	31706546	447-EB	Yes	Yes
38	31706547	445-EB	Yes	Yes
39	31706548	Mujahid Colony No. 1	Yes	Yes
40	31706549	Mujahid Colony No. 2	Yes	Yes
41	31806558	Azizabad	Yes	Yes
42	31806567	E-Block	Yes	No
43	31806580	Mujahid Colony (Banqi)	Yes	No
44	31806581	Mujahid Colony Eid Gah	Yes	No
45	31806582	Dogar Market	Yes	No
46	31107006	Ilyas Garden	Yes	No

Table 14: Pumpset Primary Performance Parameters

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
			m^3/hr	m^3/hr	m	kW			
1	31806566	H-Block	101.9	98.1	35.99	18.37	62%	0.91	Efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was close to the cut-off value i.e., 52%.
2	31806565	M-Block	101.9	83.3	34.46	16.50	56%	0.85	Efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was close to the cut-off value i.e., 56%.
3	31706551	Satellite Town No.1	101.9	127.7	34.46	21.87	65%	0.79	New pumpset has been installed at the site. Efficiency of the pumpset is satisfactory. Previously, flow was not detected due to extremely rusty condition of the delivery pipe.
4	31706543	Bhatta Yousafabad	101.9	125.0	24.24	15.60	62%	0.87	Efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was close to the cut-off value i.e., 59%.
5	31706529	TMA-TownHall	76.5	2.1	52.51	9.20	4%	0.44	Water flow rate is very low possibly due to boring issue. Sluice/ gate valve is jammed. There is heavy leakage of water in gland packing. Previously, it was recommended to replace the pumpset due to low efficiency of 39%.
6	31806560	Water supply colony	101.9	138.4	30.90	22.70	60%	0.77	New pumpset has been installed at the site. Due to limited space, it was only possible to measure the normal operational values. No throttling could be performed due to high turbulence in the pipes. Previously, it was recommended to replace the pumpset due to low efficiency. i.e. 40%.
7	31806562	N-Block	101.9	85.7	26.38	20.30	36%	0.86	Efficiency of the pumpset is not satisfactory. i.e., below 55%. Sluice/ gate valve is jammed. Previously, it was recommended to replace the pumpset due to low efficiency. i.e. 45%.
8	31806563	P-Block 1	152.9	130.6	34.93	24.40	60%	0.94	Efficiency of the pumpset is satisfactory. Gate valve is jammed. Previously, efficiency of the pumpset was 56%.
9	31706552	Satellite No. 2	101.9	98.8	36.45	19.87	58%	0.84	Efficiency of the pumpset is satisfactory. No Sluice/Gate valve is installed.

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
									Previously, efficiency of the pumpset was 61%.
10	31806564	W.WP-Block 2	101.9	161.9	31.53	29.30	56%	0.84	Efficiency of the pumpset is satisfactory. No Sluice/Gate valve is installed. Previously, efficiency of the pumpset was 59%.
11	3100705	Yaqubabad	101.9	81.2	33.76	18.20	48%	0.89	Efficiency of the pumpset is not satisfactory. i.e., below 55%. Sluice/Gate valve is jammed. Previously, pump assessment was not evaluated as there was no provision to install the ultrasonic water flowmeter.
12	31706536	Farid Town	101.9	112.3	35.99	24.17	54%	0.96	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, efficiency of the pumpset was 60%.
13	31706539	Gulshan-e-Rehman	101.9	100.6	34.46	18.40	60%	0.86	Efficiency of the pumpset is satisfactory. No Sluice/Gate valve is installed. Previously, efficiency of the pumpset was 61%.
14	31706542	Housing Scheme Y-Block	101.9	115.5	35.99	24.53	54%	0.80	Efficiency of the pumpset is satisfactory. Sluice/Gate valve is jammed. Previously, efficiency of the pumpset was 57%.
15	31806570	Gulshan-e-Ghani	101.9	79.4	40.09	20.70	49%	0.88	Efficiency of the pumpset is not satisfactory. i.e., below 55%. Sluice/ gate valve is jammed. Previously, efficiency of the pumpset was 62%.
16	31706550	Allabad water works	101.9	120.7	25.91	18.20	55%	0.83	Efficiency of the pumpset is satisfactory. Throttling could not be performed as there was no provision to install the pressure gauge before the gate valve. Previously, efficiency of the pumpset was 66%.
17	31806571-1	I-Block (Park City)	101.9	122.2	32.85	20.20	64%	0.77	Efficiency of the pumpset is satisfactory. No Sluice/Gate valve is installed. Previously, efficiency of the pumpset was 61%.
18	3100703	Chak No. 437/EB	101.9	148.9	34.52	22.53	73%	0.84	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, pump assessment was not evaluated as there was no provision to install the ultrasonic water flowmeter.

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
19	3100704	Chak No.435	101.9	163.3	24.79	22.30	58%	0.75	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was 53%.
20	31107007	Azeem Abad No.2	101.9	105.1	41.68	21.23	66%	0.71	Efficiency of the pumpset is satisfactory. Sluice/Gate valve is jammed. Previously, efficiency of the pumpset was 63%.
21	31807771	Habib Colony 2	101.9	169.2	27.90	25.20	60%	0.79	Efficiency of the pumpset is satisfactory.
22	31706546	447-EB	101.9	124.1	27.90	21.00	53%	0.78	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Throttling could not be performed as there was no provision to install the pressure gauge before the gate valve. Previously, efficiency of the pumpset was found to be 42%.
23	31706547	445-EB	152.9	178.2	31.41	28.40	63%	0.91	Efficiency of the pumpset is satisfactory. Previously, flow was not measured as there was no provision to install the ultrasonic water flowmeter.
24	31706548	Mujahid Colony No. 1	101.9	64.4	28.01	14.20	41%	0.75	Efficiency of the pumpset is not satisfactory. i.e., 41% Previously, flow was not detected due to extremely rusty condition of the delivery pipe.
25	31706549	Mujahid Colony No. 2	101.9	142.8	34.46	23.20	68%	0.75	New pumpset has been installed at the site. Efficiency of the pumpset is satisfactory. Previously, flow was not detected due to extremely rusty condition of the delivery pipe.
26	31806558	Azizabad	101.9	138.1	33.06	26.60	55%	0.80	Efficiency of the pumpset is satisfactory. Sluice/gate valve is jammed. No NRV has been installed. Previously, efficiency of the pumpset was 57%.

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

Table 15: Pumpset Secondary Performance Parameters

Unique ID	Motor Vibration Hz	Temperature of Motor	Winter Operational Hours	Summer Operational Hours	Motor Rated kW	Motor Rated Efficiency	Transformer kVA	Elec. Connection	Line Leakage	Rated Head of Pump	Motor Rated Voltage V	Full Load PF	PF (Measured)	Load factor %	Observations
31806566	159.15	30	5	5	22	-	100	Safe	OK	150	380	-	0.91	82%	
31806565	11.37	31	5	5	22	-	200	Safe	OK	180	400	-	0.85	74%	
31706551	127.32	37	5	5	19	91	50	Safe	Not Ok	180	400	0.85	0.79	117%	Overloaded, Low PF
31706543	64.98	48	5	5	19	-	100	Safe	Ok	125	380	0.84	0.87	84%	
31706529	79.58	35	5	5	22	-	50	Safe	Not ok	200	-	-	0.44	41%	Low PF
31806560	106.10	44	20	22	37	-	50	Safe	Not Ok	180	400	0.85	0.77	61%	Low PF
31806562	106.10	42	5	5	22	-	-	Safe	Not Ok	-	380	0.88	0.86	91%	
31806563	106.10	38	5	5	-	-	50	Safe	Not Ok	-	-	-	0.94		
31706552	363.78	25	-	-	30	-	50	Safe	OK	175	400	0.88	0.84	67%	
31806564	106.10	46	5	5	30	-	50	Safe	Not Ok	200	400	0.88	0.84	98%	
3100705	136.42	59	5	5	22	-	50	Safe	OK	-	400	0.85	0.89	81%	
31706536	795.77	38	5	5	22	-	50	Safe	Not Ok	200	380	0.84	0.96	108%	Overloaded
31706539	379.52	32	5	5	22	-	50	Safe	Not Ok	150	400	0.87	0.86	82%	
31706542	1089.60	28	5	5	30	-	50	Safe	OK	175	380	0.84	0.80	82%	High Vibrations
31806570	159.15	30	5	5	140	-	50	Safe	OK	180	-	-	0.88	15%	
31706550	106.10	37	5	5	22	-	50	Safe	Not Ok	-	400	0.86	0.83	81%	
31806571-1	1432.39	31	5	5	30	-	50	Safe	-	175	400	0.87	0.77	68%	Low PF, High Vibrations
3100703	1591.55	41	5	5	30	91	100	Safe	Ok	180	400	0.85	0.84	76%	High Vibrations
3100704	119.37	38	5	5	30	91	50	Safe	Not Ok	180	400	0.85	0.75	75%	Low PF
31107007	636.62	44	5	5	30	-	25	Safe	Ok	150	380	0.84	0.71	71%	Low PF
31807771	106.10	51	5	5	30	91	50	Unsafe	Not Ok	175	400	0.85	0.79	84%	Low PF
31706546	106.10	44	5	5	30	-	50	Safe	Not Ok	-	-	-	0.78	70%	Low PF
31706547	106.10	62	5	5	50	-	50	Unsafe	Not Ok	-	-	-	0.91	57%	
31706548	119.37	38	5	5	25	-	100	Safe	Not Ok	-	-	-	0.75	57%	Low PF
31706549	119.37	-	5	5	25	91	50	Safe	Ok	180	400	0.85	0.75	93%	Low PF
31806558	53.05	51	5	5	50	-	100	Safe	Not Ok	-	-	-	0.80	53%	

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

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

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
1	31806566	H-Block	102	22.371	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	98.125	36.0	Flow at Existing Operating Conditions Flow nearest to duty point	18.37	62%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
2	31706551	Satellite Town No.1	102	18.65	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	127.749	34.5	Flow at Existing Operating Conditions	21.87	65%
2	105.87	45.0	Flow nearest to duty point	21.30	72%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
3	3100704	Chak No.435	102	29.828	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	163.27	24.8	Flow at Existing Operating Conditions	22.3	58%
2	123.24	35.3	Flow nearest to duty point	22.2	63%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
4	31807771	Habib Colony 2	102	29.828	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	169.24	27.9	Flow at Existing Operating Conditions	25.2	60%
2	147.75	34.9	Flow nearest to duty point	25	66%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
5	31706549	Mujahid Colony No. 2	102	25	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	142.77	34.5	Flow at Existing Operating Conditions	23.2	68%
2	123.96	40.1	Flow nearest to duty point	22.9	70%

2.4.3 Wastewater Disposal System

The MC has four disposal stations which have a total of seventeen (17) centrifugal pumps for suction of wastewater from collecting tanks to main sewage drain. All these pumps are manual and run as per requirement.

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

Table 17: Disposal Performance Parameters

Sr No	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	PITCO Comments
1	31706531-A	451-EB	509.7	682.5	7.62	36.80	45%	Efficiency of the pumpset is satisfactory. Previously, pumpset was under maintenance.
2	31706531-C	451-EB	407.8	300.0	7.62	16.00	46%	Efficiency of the pumpset is satisfactory. Previously, pumpset was under maintenance due the damaged delivery line.
3	31716534-A	Marzipura Multan Road No.1	407.8	642.2	4.27	18.40	48%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 42%.
4	31716534-F	Marzipura Multan Road No.1	509.7	689.2	6.71	37.30	40%	Efficiency of the pumpset is satisfactory. Previously, pumpset was under maintenance due to the non-functional motor.
5	31806568-A	Disposal Works Lorry Adda	509.7	344.0	16.76	47.60	39%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, pumpset was non-functional due the faulty MCU (Motor control unit).
6	31806575-A	Rahmatabad	254.9	188.0	5.49	7.90	42%	Efficiency of the pumpset is satisfactory. Previously, Pumpset was under maintenance due to the damaged delivery lines.

Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are three (3) dewatering sets in the MC all of which are functional. It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.

Figure 7: Dewatering Sets

Dewatering sets in the MC are primarily being employed to address chocked manholes and other issues relates to sewerage. It is envisaged that once all the improved proposed under the PCP sewerage component are implemented, the need for use of dewatering sets will be minimized, thereby greatly reducing the fuel consumption by these assets.

2.5 Proposed Resource Efficiency Measures- Water Pumps and Disposals

Based on the analysis, energy efficiency measures have been identified, including operational improvement and investment-oriented measures, and are discussed in detail in the table below.

Table 18: Water Pumps and Wastewater Disposal System: Recommendations for improvement

Sr No.	Unique ID	Location	Comments	Recommendation
			Pumps	
1	530537	Mohallah Sherro 2	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.
2	570541	Near Guru Kottha	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 a new pumpset but fails to deliver the rated flow at full-open condition. The pumpset should be checked by the OEM.
3	580543	Zia-e-Madina CNG	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.
4	590547	Qudratabad	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
5	590551	Nizamabad Phattak	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 a new pumpset but fails to deliver the rated flow at full-open condition. The pumpset should be checked by the OEM..
6	580542	Cheema Colony	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 10 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
7	5100553-A	Cheema Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
8	5100553-C	Cheema Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
9	530538-A	Railway Colony	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
10	530538-C	Railway Colony	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
11	530537	Mohallah Sherro 2	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.
12	570541	Near Guru Kottha	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 a new pumpset but fails to deliver the rated flow at full-open condition. The pumpset should be checked by the OEM.
13	580543	Zia-e-Madina CNG	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.
14	590547	Qudratabad	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
15	590551	Nizamabad Phattak	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 a new pumpset but fails to deliver the rated flow at full-open condition. The pumpset should be checked by the OEM..
16	580542	Cheema Colony	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 10 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
17	5100553-A	Cheema Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
18	5100553-C	Cheema Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
19	580542	Cheema Colony	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 10 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
20	5100553-A	Cheema Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
21	5100553-C	Cheema Colony	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
22	530538-A	Railway Colony	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.

Sr No.	Unique ID	Location	Comments	Recommendation
23	530538-C	Railway Colony	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
General Observations				
24	General	Smart Metering	No flow meters were installed at any of the tubewells.	Smart flow meters connected to a centralized DCS system needs to be installed to calculate the total water drawn by each pump and to monitor flow and water loss due to leakages. This can also help with water billing if the Government of Punjab intends to do so in future
25	General	Operating Time	Pumps should not be run during Peak electricity consumption hours.	Operational hours of pump should be scheduled keeping in mind the varying peak hours across the year to avoid peak charges. Peak hours for MEPCO during the entire year are given in Annexure 1.
26	General	Dewatering Sets	Dewatering sets were in satisfactory condition, but no O&M logs were available with the MC	It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.
27	General	Water Supply Network	Proper O&M of Air Release Valves	Air release valves installed on the network should be properly maintained.

3 Streetlights

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

3.1 Inventory

Surveyors conducted onsite surveys at Burewala MC and gathered detailed information about streetlights including their numbers, pole/fixture types and operation details. Details of the surveyed lights are provided in the following tables.

Table 19: Inventory Detail of Streetlights

	Streetlights	MC Operated	Privately Operated
Operational Street Lights	191	191	
Non-Operational Street Lights	12	12	
Faulty Meter / Line	6	6	
Total	**209**	**209**	**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 209 streetlights operated by MC, 47 lights are installed on PC, 58 lights are installed on steel structure, 47 lights are installed on tubular structure, and 17 lights are installed on pillars. The streetlights' structural classification is tabulated below.

Table 20: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Pillars	Grand Total
MC	47	58	47	17	169
Private					0

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

Table 21: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Gol Chowk	28	28-15331-0445700	0.681
2	Machli Bazar	12	011-5331-0062800	1.519
3	Vehari Bazar	47	28-15331-0438000	2.701
4	Water Works Colony	36	28-15331-0490300	1.051
5	Ladies and Children Park	16	07-15334-0671249	0.606
6	Habib Colony Road	13	28-15334-0672100	0.466
7	City Graveyard	10	28-15334-0083010	1.693
8	Fawarah Chowk	19	28-15332-0111600	0.624
9	Stadium Road	22	28-15332-0009202	0.731
10	Multan Road	6	28-15334-0041806	2.905

Out of the 209 surveyed lights in the MC, 191 lights were found to be operational. Details are given in the following table:

Table 22: Details of Operational Streetlights

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours[5]	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	120	182	-	12.0	95,659	-
LED	100	9	-	12.0	3,942	-
Total					**99,601**	**-**



Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

[5] Based on Interview with Client.

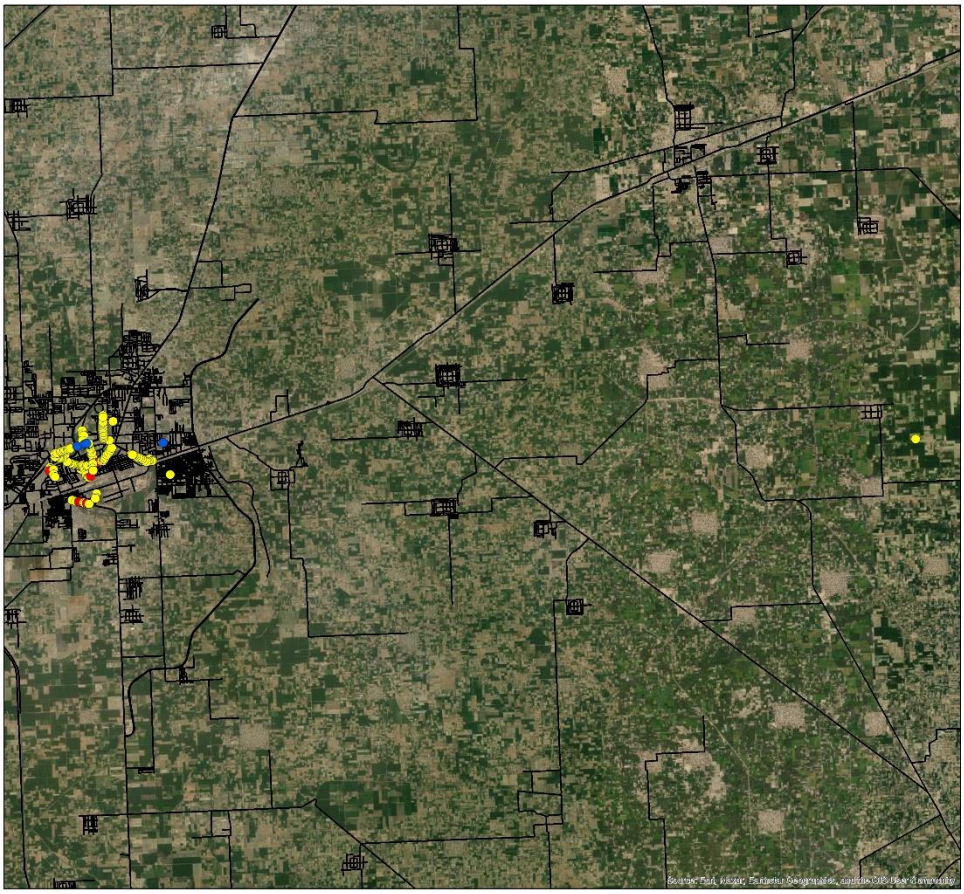


Figure 9: GIS Mapping of street lights in Burewala MC

3.3 Baseline Energy Consumption Trend

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

Table 23: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy consumed	kWh/y	**154,304**[6]
Total number of operational lights	No.	**191**

[6] Based on electricity bills, excludes bill for Machli Bazar

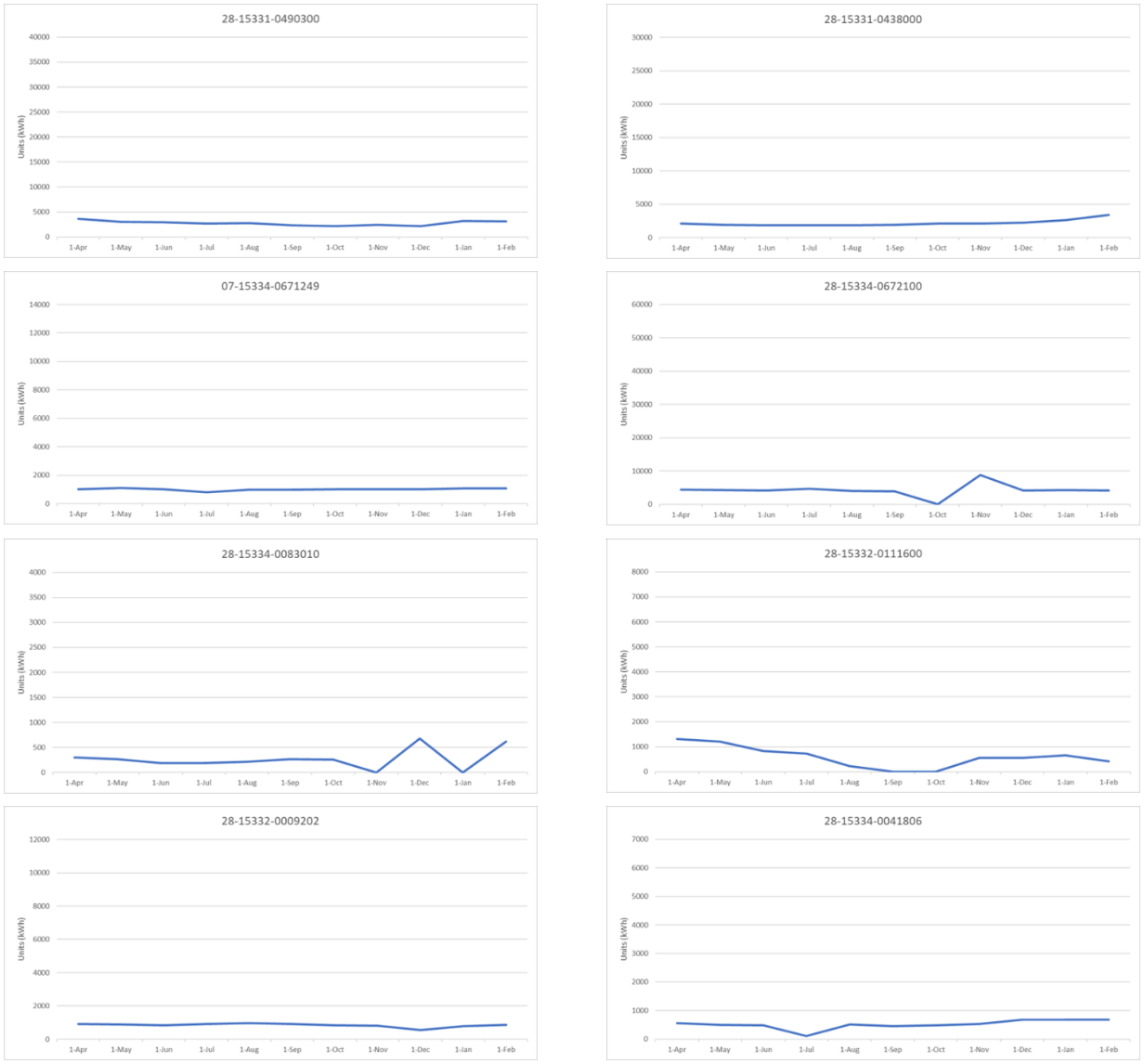


Figure 10: Energy Consumption trend of Streetlights

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	56	191	44,813	154,304	-109,491	2,818 kWh/km	11,891 kWh/km	The number of operational lights in the MC has increased threefold. Consequently, the overall electricity consumption by streetlights in the MC has increased as well. All of the operational lights in the MC are LEDs. It is observed that the KPI for streetlights has increased, this is due to the fact that while the number of lighting fixtures (and the associated electricity consumption) has increased, the overall area covered by streetlights has not.

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 Burewala.

3.5 Observations

- All Streetlights in Burewala MC are operated by MC.
- All operational streetlights are LEDs.
- Approximately 95% of the LED streetlights have a rating of 120 Watts.
- Burewala MC is not maintaining any record or database of streetlights.

3.6 Action plan for Energy Efficiency Measures – Streetlights

Based on the field observations and data analysis, the following energy efficiency measures have been identified:

Table 24: Streetlights - recommendations for improvement

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

Table 25: Vehicle Inventory Detail

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
1	Unregistered Vehicle 1	Truck	Hino	WU-720R-HKMRJ3	2012	4WD	Lifter Container	JM13235	JHMYFJ0HX02000005	4500
2	Unregistered Vehicle 2	Truck Sucker Machine	Hino	HINO-300	2008	4WD	Transport of Solid Waste, Sucker Machine	JM11795	JHFYF2011X06001694	4500
3	Unregistered Vehicle 3	Truck	Fuso	CHIL-01-H	2020	4WD	Transport of Solid Waste, Jetting Machine	4D34-R13870	MMC-04-CND1057	4500
4	Unregistered Vehicle 4	Tractor	Messy	MF-375	2015	4WD	Transport of Solid Waste, Trolley	N/A	K72222102/15	85 HP
5	Unregistered Vehicle 5	Tractor	Messy	MF-385	2020	4WD	Transport of Solid Waste, Front Loader	504532-F	G-84889-03/20	85 HP
6	Unregistered Vehicle 6	Tractor	Messy	MF-240	2011	2WD	Transport of Solid Waste, Trolley	N/A	4404/17/11	50 HP
7	Unregistered Vehicle 7	Tractor	Messy	MF-240	1980	2WD	Lifter Container	N/A	MFL/205/5	50 HP
8	Unregistered Vehicle 8	Tractor	Messy	MF-240	2020	2WD	Transport of Solid Waste, Trolley	739879-F	A-44027/17/20	50 HP
9	Unregistered Vehicle 9	Tractor	Messy	MF-240	2020	2WD	Transport of Solid Waste, Trolley	739877-F	A-44027/01/20	50 HP
10	Unregistered Vehicle 10	Tractor	Messy	MF-375	2020	4WD	Transport of Solid Waste, Front Blade	523864-F	K-73246/12/20	75 HP
11	VRD-1851	Truck	Mazda	N/A	1990	2WD	Firefighting, For watching green balts	N/A	N/A	3500
12	Unregistered Vehicle 11	Mini Truck Tipper	Suzuki	N/A	2022	2WD	Transport of Solid Waste	388108	PK492770	1000
13	Unregistered Vehicle 12	Rickshaw	Hi Speed	SRI62FMJ-L	2010	2WD	Transport of Solid Waste, Rickshaw for waste	SR162FMJL8J	LZSHCKZS5K8013520	150
14	Unregistered Vehicle 13	Tractor	Messy	MF-135	1986	2WD	Transport of Solid Waste Trolley	N/A	PAK-14871	35 HP
15	Unregistered Vehicle 14	Tractor	Messy	MF-240	2011	2WD	Grass Cutter	N/A	41404/18/11	50 HP
16	Unregistered Vehicle 15	Rickshaw	Hi Speed	SR150	2020	2WD	Transport of Solid Waste	SR162FMJLBJ	C00110, LZSHCKZS4K8013525	150 CC
17	Unregistered Vehicle 16	Truck	Bedford	N/A	1968	4WD	Firefighting	M025266	2714912	107 HP
18	Unregistered Vehicle 17	Mini Truck Tipper	Hino	HINO-300	2012	4WD	Encroachment / Loading & Unloading	JM13202	JHFAF04H42000273	4500
19	VRC-3371	Car	Suzuki	khyber	N/A	2WD	Transport of Staff	274451	403703	1000
20	VRK-371	Tractor	Fiat	FIAT NH 640	2006	4WD	Transport of Solid Waste, Front Loader	N/A	00499506L8	85 Hp
21	Unregistered Vehicle 18	Tractor	Massey	MF-385	2015	4WD	Transport of Solid Waste, Front Loader	N/A	84531/04/15	85 Hp
22	VRK-372	Tractor Front blade	Fiat	FIAT NH 640	2006	4WD	Transport of Solid Waste, Front Blade	SAN4-39T1307-190587	N/A	85 Hp
23	Unregistered Vehicle 19	Tractor	Massey	MF-240	2011	4WD	Transport of Solid Waste Trolley	N/A	41404/13/11	50 HP
24	Unregistered Vehicle 20	Tractor trolley	Massey	MF-240	2015	4WD	Transport of Solid Waste Trolley	CE99001V698924A	42801/47/15	50 HP
25	Unregistered Vehicle 21	Rickshaw	Hi Speed	SR150	2020	2WD	Transport of Solid Waste	SR162FMJL8J900759	LZSHCKZS7K80135	150
26	Unregistered Vehicle 22	Rickshaw	Hi Speed	SR150	2020	2WD	Transport of Solid Waste	SRI62FMJL8J900871	LZSHCKZSOK813523	150

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
27	Unregistered Vehicle 23	Rickshaw	Hi Speed	SR200	2020	2WD	Transport of Solid Waste	SRI62FMJL8JC00577	LZSHCKZS8K8013527	200
28	Unregistered Vehicle 24	Rickshaw	Hi Speed	SR150	2020	2WD	Transport of Solid Waste	SRI62FMJL8JC00627	LZSHCKZS8013530	150
29	Unregistered Vehicle 25	Tractor Front loader	Massey	MF-385	2020	4WD	Transport of Solid Waste	504529-F	G-84891-4120	85 HP
30	Unregistered Vehicle 26	Tractor Front loader	Massey	MF-385	2020	4WD	Transport of Solid Waste	504524-F	G-84889-02120	85 HP
31	Unregistered Vehicle 27	Tractor Front blade	Massey	MF-375	2020	2WD	Transport of Solid Waste, Front Blade	523444-F	K-73212-07/20	75 HP
32	Unregistered Vehicle 28	Tractor Front blade	Massey	MF-375	2020	2WD	Transport of Solid Waste, Front Blade	523852-F	K-73245-02/20	75 HP
33	Unregistered Vehicle 29	Tractor Mechanical Sweeper	Massey	MF-240	2020	2WD	Transport of Solid Waste, Mechanical Sweeper	739840-F	A-44027-22/20	50 HP
34	Unregistered Vehicle 30	Tractor trolley	Massey	MF-240	2020	2WD	Transport of Solid Waste Trolley	739821-F	A-44027-21/20	50 HP
35	Unregistered Vehicle 31	Tractor trolley	Massey	MF-240	2020	2WD	Transport of Solid Waste Trolley	739815-F	A-44027-20/20	50 HP
36	Unregistered Vehicle 32	Tractor	Massey	MF-240	2020	2WD	Transport of Solid Waste	739896-F	A-44027-01/20	50 HP
37	Unregistered Vehicle 33	Truck	Bedford	N/A	1980	4WD	Water Browser	16E75	2714912	107 HP
38	VRG-37	Car	Suzuki	Cultus	2006	2WD	Transport of Staff, Office Work	811964	954981	1000
39	VRK-37	Jeep	Potohar	Potohar SJ-410	2006	4WD	Transport of Staff, Office Work	705486	335546	1000
40	Unregistered Vehicle 34	Mini Tipper	Suzuki	Suzuki Ravi	2022	2WD	Transport of Solid Waste	388107	492759	796
41	Unregistered Vehicle 35	Mini Tipper	Suzuki	Suzuki Ravi	2022	2WD	Transport of Solid Waste	388111	492766	1000

4.2 Baseline Fuel Consumption Trend

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

Table 26: On-field fuel Consumption analysis of MC vehicles

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)				
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption
1	Unregistered Vehicle 1	9:30 AM	10:15 AM	0.93	1.24 Liters/hr	8:15 AM	9:30 AM		4.5	3.6 Liters/hr
2	Unregistered Vehicle 2	9:55 AM	10:50 AM	1.04	1.13 Liters/hr	8:40 AM	9:55 AM		4.07	3.26 Liters/hr
3	Unregistered Vehicle 3	9:55 AM	10:55 AM	2.29	2.29 Liters/hr	8:40 AM	9:55 AM		6	4.8 Liters/hr
4	Unregistered Vehicle 4	10:45 AM	11:45 AM	1.38	1.38 Liters/hr	8:55 AM	10:45 AM		4.51	2.46 Liters/hr
5	Unregistered Vehicle 5	10:05 AM	11:05 AM	1.31	1.31 Liters/hr	8:50 AM	10:05 AM		4.26	3.41 Liters/hr
6	Unregistered Vehicle 6	10:17 AM	11:17 AM	1.2	1.2 Liters/hr	8:55 AM	10:17 AM		4.79	3.5 Liters/hr
7	Unregistered Vehicle 7	10:12 AM	11:12 AM	1.42	1.42 Liters/hr	9:00 AM	10:12 AM		3.68	3.07 Liters/hr
8	Unregistered Vehicle 8	10:30 AM	11:30 AM	1.51	1.51 Liters/hr	9:00 AM	10:30 AM		4	2.67 Liters/hr
9	Unregistered Vehicle 9	10:35 AM	11:35 AM	1.19	1.19 Liters/hr	9:03 AM	10:35 AM		4.58	2.99 Liters/hr
10	Unregistered Vehicle 10	10:10 AM	11:10 AM	1.85	1.85 Liters/hr	9:05 AM	10:10 AM		8.89	8.21 Liters/hr
11	VRD-1851	10:25 AM	11:25 AM	0.76	0.76 Liters/hr	9:20 AM	10:25 AM		4.99	4.61 Liters/hr
12	Unregistered Vehicle 11	10:30 AM	11:30 AM	0.76	0.76 Liters/hr	9:25 AM	10:30 AM	7	1.97	0.28 Liters/km
13	Unregistered Vehicle 12	10:40 AM	11:40 AM	0.5	0.5 Liters/hr	9:30 AM	10:40 AM		2.21	1.89 Liters/hr
14	Unregistered Vehicle 13	12:00 PM	1:00 PM	1.86	1.86 Liters/hr	11:00 AM	12:00 PM		4.61	4.61 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
15	Unregistered Vehicle 14	12:12 PM	1:12 PM	0.87	0.87 Liters/hr	11:05 AM	12:10 PM		3.86	3.56 Liters/hr
16	Unregistered Vehicle 15	12:22 PM	1:22 PM	0.3	0.3 Liters/hr	11:10 AM	12:20 PM		1	0.86 Liters/hr
17	Unregistered Vehicle 16	12:15 PM	1:15 PM	2	2 Liters/hr	11:15 AM	12:15 PM		10	10 Liters/hr
18	Unregistered Vehicle 17	12:30 PM	1:30 PM	2.12	2.12 Liters/hr	11:20 AM	12:30 PM		3.01	2.58 Liters/hr
19	VRC-3371	12:35 PM	1:35 PM	2.42	2.42 Liters/hr	11:25 AM	12:32 PM		3.66	3.28 Liters/hr

Table 27: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	Unregistered Vehicle 2	2.30
2	Unregistered Vehicle 3	6
3	Unregistered Vehicle 4	6
4	Unregistered Vehicle 5	6
5	Unregistered Vehicle 7	3
6	Unregistered Vehicle 9	3
7	Unregistered Vehicle 10	6
8	Unregistered Vehicle 13	4
9	Unregistered Vehicle 15	9.27
10	Unregistered Vehicle 18	6
11	Unregistered Vehicle 19	4
12	Unregistered Vehicle 20	3
13	Unregistered Vehicle 21	3
14	Unregistered Vehicle 22	9.27
15	Unregistered Vehicle 23	9.27
16	Unregistered Vehicle 24	9.23
17	Unregistered Vehicle 25	6
18	Unregistered Vehicle 26	6
19	Unregistered Vehicle 27	6
20	Unregistered Vehicle 28	6
21	Unregistered Vehicle 29	3
22	Unregistered Vehicle 30	3
23	Unregistered Vehicle 31	3
24	Unregistered Vehicle 32	3

The logbooks of remaining vehicles are not available in MC.

The MC made 19 of its vehicles available to the Consultant for carrying out on-field testing. The average fuel consumption of the vehicles in idle condition was found to be 1.37 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 3.85 liters/hour.

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

Table 28: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	110,664
Annual Cost of Fuel (Diesel)	PKR/y	32,424,552
Annual Consumption of Fuel (Petrol)	Liter/y	11,040
Annual Cost of Fuel (Petrol)	PKR/y	3,002,880

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 Burewala 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 Burewala 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 seven MC owned buildings in the MC. Detailed assessment of these is given in the following section

5.1 GIS Map

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

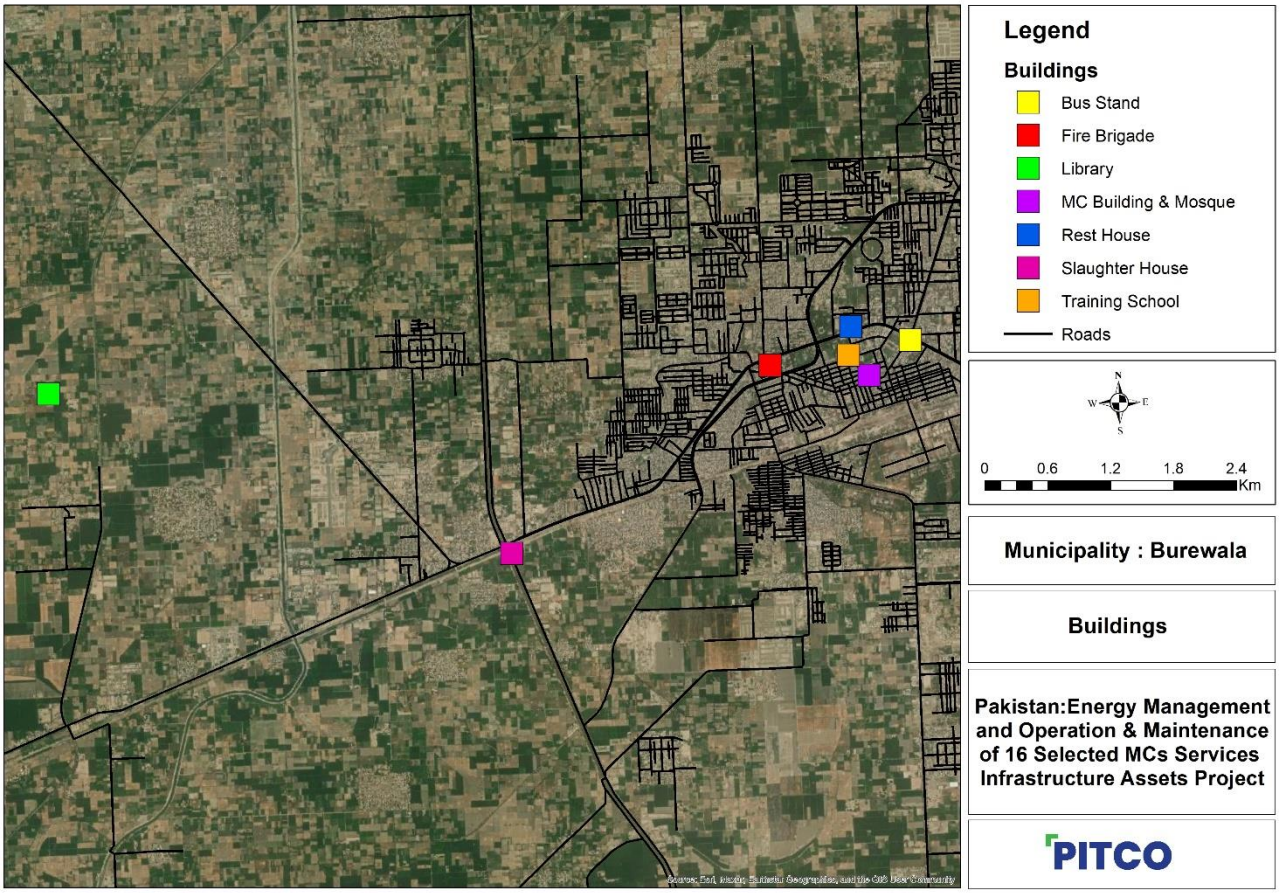


Figure 12: Map for Buildings

5.2 Building Details

Details of the MC buildings are given below.

Table 29: Buildings' Details

Sr. No.	Address	GPS	Unique ID	Ownership	Age of Building	Condition of Building	Total Area (m2)	Insulation of Building	Number of Floors
1	Library	N:30.16058 E:72.60109	81007297	MC	N/A	Satisfactory	607	No Proper Insulation	1
2	Bus Stand	N:30.162825 E:72.68633	81007296	MC	N/A	Satisfactory	20.4	No Proper Insulation	1
3	Fire Brigade	N:30.16107 E:72.67239	81007294	MC	N/A	Satisfactory	3,541	No Proper Insulation	1
4	Slaughter House	N:30.14564 E:72.64631	81007295	MC	N/A	Satisfactory	755	No Proper Insulation	1
5	MC Building & Mosque	N:30.15992 E:72.68216	81007298	MC	N/A	Satisfactory	5893	No Proper Insulation	2
6	Rest House	N:30.164155 E:72.680499	81007299	MC	33	Satisfactory	250.1	No Proper Insulation	1
7	Training School	N:30.1617 E:72.680146	81007300	MC	N/A	Satisfactory	202	No Proper Insulation	1

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

Table 30: Number of Heating Units in MC Buildings

Sr. No.	Name of Room	Type of Heating Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Energy consumption (kWh/year)
MC Building & Mosque								
1	**Outside of Mosque**	Electric Geyser	1	2000	4	4	104	832
2	**Kachi Abadi**	Electric Heater	1	1000	4	4	104	416
Rest House								
1	**Outside**	Electric Heater	1	-	-	-	-	Non-Functional
	Total							**1,248**

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

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Library								
1	**Main Hall**	Ceiling Fan	3	80	6	8	208	300
2	**Library office**	Ceiling Fan	2	80	6	8	208	200
3	**Library office**	Exhaust Fan	1	30	-	-	-	Non-Functional
4	**Ladies room**	Ceiling Fan	3	80	4	8	208	200
5	**Ladies room**	Air Cooler	1	125	4	8	208	104
6	**Outside**	Ceiling Fan	1	80	6	8	208	100
Bus Stand								
1	**Ticket office**	Ceiling Fan	1	80	24	8	208	399
Fire Brigade								
1	**Office**	Ceiling Fan	1	80	12	8	208	200
2	**Rest Room**	Ceiling Fan	1	80	5	8	208	83
3	**Open Area**	Ceiling Fan	1	80	8	8	208	133
Slaughter House								
1	**Doctor room**	Pedestal Fan	1	125	12	8	208	312
2	**Doctor Room Gallery**	Ceiling Fan	1	80	12	8	208	200
3	**Slaughter House Residence Room 1**	Ceiling Fan	1	80	16	8	208	266
4	**Slaughter House Residence Room 2**	Pedestal Fan	1	125	6	8	208	156
5	**Open Area**	Air Cooler	1	125	10	8	208	260
MC Building & Mosque								
1	**Outside of the Mosque**	Ceiling Fan	4	80	10	8	208	666
2	**Outside of the Mosque**	Bracket Fan	2	50	10	8	208	208
3	**Main Hall mosque**	Ceiling Fan	8	80	10	8	208	1,331
4	**Main Hall mosque**	Split Ac	1	2850	4	4	104	1,186
5	**Main Hall mosque**	Ceiling Fan	1	80	10	8	208	166
6	**Main Hall mosque**	Inverter	1	1700	10	4	104	1,768
7	**Mosque washroom**	Exhaust Fan	1	30	-	-	-	Non-Functional
8	**Administrative office gallery**	Ceiling Fan	3	80	8	8	208	399
9	**Administrative P.A office**	Ceiling Fan	1	80	8	8	208	133
10	**Administrative P.A office**	Split Ac	1	1740	8	4	104	1,448
11	**Administrative office**	Bracket Fan	6	50	4	8	208	250
12	**Administrative office**	Inverter	3	1452	4	4	104	1,812
13	**AC Chamber**	Bracket Fan	4	50	4	8	208	166
14	**AC Chamber**	Split Ac	1	1650	4	4	104	686
16	**AC Chamber**	Exhaust Fan	1	30	4	12	312	37
17	**Kitchen**	Ceiling Fan	1	80	4	8	208	67
18	**Kitchen**	Exhaust Fan	1	30	4	12	312	37
19	**Tax branch hall**	Ceiling Fan	5	80	4	8	208	333

[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)
20	**Tax branch hall**	Exhaust Fan	1	30	1	12	312	9
21	**Electric room**	Ceiling Fan	1	80	8	8	208	133
22	**Complaint office**	Ceiling Fan	1	80	8	8	208	133
23	**Sanitation office**	Ceiling Fan	2	80	8	8	208	266
24	**Water Supply office**	Ceiling Fan	1	80	8	8	208	133
25	**Regulation branch**	Ceiling Fan	1	80	8	8	208	133
26	**LP tax office**	Ceiling Fan	1	80	8	8	208	133
27	**Kachi Abadi**	Ceiling Fan	2	80	8	8	208	266
28	**Sanitation Gallery**	Air Cooler	1	125	-	-	-	Non-Functional
29	**Infrastructure office**	Ceiling Fan	2	80	8	8	208	266
30	**Infrastructure office**	Inverter	1	1452	8	8	208	2,416
31	**Infrastructure branch**	Ceiling Fan	2	80	8	8	208	266
32	**Sub-Engineer office**	Ceiling Fan	1	80	8	8	208	133
33	**Computer + Operator**	Ceiling Fan	1	80	8	8	208	133
34	**Computer + Operator**	Exhaust Fan	1	30	8	12	312	75
35	**Sub-Engineer office 2**	Ceiling Fan	1	80	5	8	208	83
36	**Sub-Engineer office 2**	Split Ac	1	1650	4	8	208	1,373
37	**Sub-Engineer office 2**	Exhaust Fan	1	30	3	12	312	28
38	**Office Gallery**	Air Cooler	1	125	6	8	208	156
39	**Account Office**	Ceiling Fan	2	80	8	8	208	266
40	**Account Office**	Bracket Fan	1	50	8	8	208	83
41	**Account Office**	Exhaust Fan	2	30	4	12	312	75
42	**MOF Office**	Ceiling Fan	1	80	4	8	208	67
43	**MOF Office**	Split Ac	1	1740	4	8	208	1,448
44	**Planning branch**	Ceiling Fan	3	80	8	8	208	399
45	**Planning branch**	Split Ac	1	1740	4	8	208	1,448
46	**Planning branch**	Bracket Fan	1	50	8	8	208	83
47	**Gallery MOF**	Ceiling Fan	1	80	8	8	208	133
48	**Chief Office**	Ceiling Fan	1	80	8	8	208	133
49	**Chief Office**	Inverter	1	1452	8	8	208	2,416
50	**Chief Office**	Bracket Fan	1	50	8	8	208	83
51	**Chief Office**	Exhaust Fan	1	30	4	12	312	37
52	**Meeting Hall**	Bracket Fan	12	50	2	8	208	250
53	**Meeting Hall**	Window Ac	2	0	-	-	-	Non-Functional
54	**Meeting Hall**	Exhaust Fan	4	30	2	8	208	50
55	**Meeting Hall**	Pedestal Fan	1	125	2	8	208	52
56	**Regulation office**	Ceiling Fan	1	80	8	8	208	133
57	**Regulation office**	Inverter	1	1452	8	8	208	2,416
58	**Regulation office**	Window Ac	1	0	-	-	-	Non-Functional
59	**Account Clerk office**	Ceiling Fan	1	80	8	8	208	133
59	**Air Cooler**	Air Cooler	1	125	8	8	208	208
60	**Gallery office**	Ceiling Fan	2	80	8	8	208	266

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)
61	**Engineer Room**	Ceiling Fan	1	80	4	8	208	67
62	**Engineer Room**	Inverter	1	1452	4	8	208	1,208
63	**Record branch**	Ceiling Fan	1	80	8	8	208	133
64	**Record Store**	Ceiling Fan	1	80	4	8	208	67
65	**Audit Branch**	Ceiling Fan	1	80	8	8	208	133
66	**Audit Branch**	Split Ac	1	0	-	-	-	Non-Functional
67	**Regulation Clerk office**	Ceiling Fan	1	80	8	8	208	133
68	**Regulation branch office**	Ceiling Fan	2	80	8	8	208	266
69	**Regulation branch office**	Bracket Fan	1	50	8	8	208	83
70	**Regulation branch office**	Pedestal Fan	1	125	6	8	208	156
71	**Store**	Ceiling Fan	1	80	4	8	208	67
72	**Computer Operator Registration branch**	Ceiling Fan	1	80	8	8	208	133
73	**Gallery**	Ceiling Fan	2	80	8	8	208	266
74	**Store Room 2**	Ceiling Fan	1	80	-	-	-	Non-Functional
75	**Store Room 2**	Air Cooler	3	125	-	-	-	Non-Functional
76	**Outside**	Air Cooler	1	125	-	-	-	Non-Functional
			Rest House					
1	**Room 1**	Ceiling Fan	1	80	8	8	208	133
2	**Room 1**	Window AC	1	0	-	-	-	Non-Functional
3	**Room 2**	Ceiling Fan	1	80	8	8	208	133
4	**Room 2**	Window AC	1	0	-	-	-	Non-Functional
			Training School					
1	**Room 1**	Ceiling Fan	2	80	8	8	208	266
2	**Staff office**	Ceiling Fan	1	80	1	8	208	17
3	**class room**	Ceiling Fan	2	80	8	8	208	266
4	**class room**	Pedestal Fan	1	125	2	6	156	39
	Total Annual kWh							**33,489**

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

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Electricity consumption (kWh/year)
Library							
1	**Main Hall**	Tube light	1	40	-	-	Non-Functional
2	**Main Hall**	CFL	2	40	8	312	200
3	**Main Hall**	LED	2	18	8	312	90
4	**Library office**	Tube light	3	40	6	312	225
5	**Library office**	CFL	3	40	6	312	225
6	**Library office**	LED	2	12	8	312	60
7	**Library office**	CFL	1	12	6	312	22
8	**Ladies room**	Tube light	1	40	6	312	75
9	**Ladies room**	CFL	3	12	6	312	67
10	**Ladies room**	LED	2	18	8	312	90
11	**Ladies room**	LED	1	12	8	312	30
12	**Outside room**	Tube light	1	40	-	-	Non-Functional
13	**Outside room**	CFL	1	24	-	-	Non-Functional
14	**Outside room**	LED	1	18	8	312	45
Bus Stand							
1	**Ticket office**	CFL	1	12	24	312	90
2	**Ticket office**	LED	1	18	24	312	135
Fire Brigade							
1	**Office**	LED	1	30	12	312	112
2	**Rest room**	LED	1	12	12	312	45
3	**Outside**	LED	4	120	12	312	1,797
Slaughter House							
1	**Doctor Room**	LED	1	12	8	312	30
2	**Doctor Room Gallery**	LED	2	12	8	312	60
3	**Main hall**	CFL	1	24	-	-	Non-Functional
4	**Main hall**	LED	3	12	8	312	90
5	**Open hall**	LED	3	12	8	312	90
6	**Slaughter House Residence Room 1**	LED	2	12	12	312	90
7	**Slaughter House Residence Room 2**	LED	1	12	12	312	45
8	**Kitchen**	LED	1	12	12	312	45
9	**Open Area**	LED	1	12	12	312	45
MC Building & Mosque							
1	**Outside of Mosque**	Tube Light	1	40	-	-	-

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

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Electricity consumption (kWh/year)
2	**Outside of Mosque**	CFL	1	24	12	312	90
3	**Outside of Mosque**	LED	2	40	12	312	300
4	**Outside of Mosque**	CFL	1	24	12	312	90
5	**Outside of Mosque**	LED	3	20	12	312	225
6	**Main Hall office**	Tube Light	1	40	-	-	Non-Functional
7	**Main Hall office**	LED	4	40	10	312	499
8	**Main Hall office**	LED	4	20	10	312	250
9	**Main Hall office**	LED	3	12	10	312	112
10	**Mosque Washroom**	LED	6	12	8	312	180
11	**Administrative office gallery**	Tube Light	1	40	-	-	Non-Functional
12	**Administrative office gallery**	LED	5	12	8	312	150
13	**Administrative office gallery**	LED	2	40	8	312	200
14	**Administrative office gallery**	LED	1	30	8	312	75
15	**Administrative office gallery**	LED	16	12	4	312	240
16	**Administrative office gallery**	LED	3	50	4	312	187
17	**AC Chamber**	CFL	1	40	4	312	50
18	**AC Chamber**	LED	1	30	8	312	75
19	**AC Chamber**	CFL	1	40	4	312	50
20	**AC Chamber**	LED	1	12	2	312	7
21	**AC Chamber**	LED	4	40	-	-	Non-Functional
22	**Kitchen**	LED	1	12	4	312	15
23	**Tax Branch Hall**	CFL	4	40	3	312	150
24	**Tax Branch Hall**	LED	1	12	4	312	15
25	**Computer room tax branch**	CFL	1	40	8	312	100
26	**Electric room**	LED	1	40	8	312	100
27	**Complaint office**	LED	4	12	8	312	120
28	**Sanitation office**	CFL	1	40	8	312	100
29	**Sanitation office**	LED	1	12	8	312	30
30	**Water Supply office**	Tube Light	1	40	-	-	Non-Functional
31	**Water Supply office**	CFL	1	25	8	312	62
32	**Water Supply office**	LED	1	20	8	312	50
33	**Regulation branch 1**	Tube Light	2	40	8	312	200
34	**Regulation branch 1**	CFL	1	40	-	-	Non-Functional
35	**IP Tax branch**	LED	3	18	8	312	135
36	**Kachi Abadi**	CFL	1	24	8	312	60
37	**Kachi Abadi**	LED	1	12	8	312	30
38	**Sanitation store room**	LED	1	12	2	312	7
39	**Sanitation gallery**	CFL	1	24	10	312	75
40	**Sanitation gallery**	LED	1	18	10	312	56
41	**Sanitation gallery**	LED	2	120	10	312	749
42	**Infrastructure office**	CFL	1	25	8	312	62
43	**Infrastructure office**	LED	1	12	8	312	30

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Electricity consumption (kWh/year)
44	Infrastructure office	LED	2	40	8	312	200
45	Washroom office	LED	2	12	2	312	15
46	Infrastructure branch	LED	2	12	8	312	60
47	Infrastructure branch	LED	1	18	8	312	45
48	Sub-engineer office	CFL	1	40	8	312	100
49	Computer operator	CFL	1	40	8	312	100
50	Computer operator	LED	2	12	8	312	60
51	Sub-engineer office 2	CFL	1	40	4	312	50
52	Sub-engineer office 2	LED	2	12	4	312	30
53	Sub-engineer office 2	LED	2	40	4	312	100
54	office gallery	LED	1	18	12	312	67
55	Account office	Tube Light	3	40	8	312	300
56	Account office	CFL	1	24	4	312	30
57	Account office	LED	1	12	8	312	30
58	Account office	LED	1	18	8	312	45
59	Account office	LED	1	40	8	312	100
60	MOF office	LED	5	12	8	312	150
61	MOF office	LED	1	18	8	312	45
62	Planning Branch	Tube Light	1	40	-	-	Non-Functional
63	Planning Branch	LED	9	20	8	312	449
64	Planning Branch	LED	1	30	8	312	75
65	Planning Branch	LED	7	7	-	-	Non-Functional
66	Planning Branch	LED	2	12	4	312	30
67	Gallery MOF	LED	1	12	8	312	30
68	Chief office	Tube Light	1	40	-	-	Non-Functional
69	Chief office	LED	4	30	8	312	300
70	Chief office	LED	6	12	8	312	180
71	Meeting Hall	Tube Light	56	40	-	-	Non-Functional
72	Meeting Hall	CFL	1	24	-	-	Non-Functional
73	Meeting Hall	LED	4	7	8	312	70
74	Meeting Hall	Rod	2	100	2	312	125
75	Regulation office	CFL	1	40	8	312	100
76	Regulation office	LED	1	12	8	312	30
77	Finance Clerk office	CFL	1	40	8	312	100
78	Finance Clerk office	CFL	2	24	8	312	120
79	Kitchen 2	LED	1	12	4	312	15
80	Gallery office	Incandescent light bulb	1	100	8	312	250
81	Gallery office	TubeLight Panel	1	72	-	-	Non-Functional
82	Gallery office	LED	1	12	8	312	30
83	Computer room	LED	2	12	8	312	60
84	Computer room	LED	2	30	8	312	150
85	Record branch	CFL	1	30	8	312	75

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[9]	Operating days per year	Annual Electricity consumption (kWh/year)
86	**Record store**	CFL	3	12	4	312	45
87	**Audit branch**	CFL	3	12	8	312	90
88	**Audit branch**	LED	2	12	8	312	60
89	**Audit branch**	CFL	2	40	8	312	200
90	**Audit branch officer**	LED	4	40	8	312	399
91	**Regulation clerk office**	Tube Light	1	40	8	312	100
92	**Regulation clerk office**	CFL	1	40	8	312	100
93	**Registration branch**	Tube Light	3	40	-	-	Non-Functional
94	**Registration branch**	LED	1	30	8	312	75
95	**Registration branch**	LED	1	12	8	312	30
96	**Store**	Tube Light	2	40	-	-	Non-Functional
97	**Store**	LED	1	12	4	312	15
98	**Computer operator registration branch**	Tube Light	1	40	8	312	100
99	**Computer operator registration branch**	LED	1	18	8	312	45
100	**Computer operator registration branch**	LED	1	12	8	312	30
101	**MC office outside**	LED	6	120	12	312	2,696
102	**Store**	LED	3	72	-	-	Non-Functional
103	**Store**	LED	1	12	-	-	Non-Functional
104	**Outside**	CFL	1	24	-	-	Non-Functional
105	**Outside**	LED	1	120	12	312	449
				Rest House			
1	**Outside of the building**	Tube Light	1	40	-	-	Non-Functional
2	**Outside of the building**	CFL	1	24	12	312	90
3	**Outside of the building**	LED	2	12	12	312	90
4	**Room 1**	LED	1	12	12	312	45
5	**Room 2**	LED	1	12	12	312	45
6	**Washroom**	CFL	1	24	4	312	30
				Training School			
1	**Room 1**	LED	3	30	8	312	225
2	**Room 1**	LED	1	12	4	312	15
3	**Staff room**	Tube Light	1	40	-	-	Non-Functional
4	**Staff room**	LED	1	12	1	312	4
5	**Class room**	Tube Light	2	40	-	-	Non-Functional
6	**Class room**	LED	1	30	8	312	75
7	**Outside**	LED	2	12	-	-	Non-Functional
	Total Annual kWh						**17,487**

5.3 Baseline Energy Consumption Trend

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

Table 33: Energy consumption in Office Buildings

SI No.	Description	Unit	Value[10]
1	Annual Electricity Consumption	kWh	86,649
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[10] Based on Utility Bills

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Buildings	4	7	69,926	82,087	-12,161	6.80 kWh/m2	7.98 kWh/m2	Municipal resthouse, bus stand and Training school building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these building have not been considered in the overall energy consumption and KPI calculations. Electricity units (kWh) are increased due to increase in number of Air Conditioners (AC) and lighting load in MC Office Building.

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

Table 34: Cooling Equipment Comparison

Building Name	Initial Audit (2019) Type of Cooling Equipment	Count	Proposed Replacements	Recent Audit (2023) Count
MC Building and Mosque	Ceiling Fan	62	0	63
MC Building and Mosque	Exhaust Fan	3	0	13
MC Building and Mosque	Bracket Fan	5	0	28
MC Building and Mosque	Air Cooler	14	0	7
MC Building and Mosque	Split AC	11	0	7
MC Building and Mosque	Inverter	-	-	8
MC Building and Mosque	Window AC	4	4	3
MC Building and Mosque	Pedestal Fan	-	-	2
Library	Ceiling Fan	9	0	9
Library	Air Cooler	-	-	1
Library	Exhaust Fan	-	-	1
Slaughter House	Ceiling Fan	1	0	2
Slaughter House	Pedestal Fan	-	-	2
Slaughter House	Air Cooler	-	-	1
Fire Brigade	Ceiling Fan	4	0	3

Table 35: Lighting Equipment Comparison

Building Name	Initial Audit (2019) Type of Cooling Equipment	Count	Proposed Replacements	Recent Audit (2023) Count
MC Building and Mosque	Tube light	37	37	74
MC Building and Mosque	CFL	58	58	35
MC Building and Mosque	LED	44	0	159
MC Building and Mosque	Incandescent light bulb	1	1	1
MC Building and Mosque	ROD	-	-	2
MC Building and Mosque	Tube light Panel	-	-	1
Library	Tube light	5	5	6
Library	CFL	10	10	10
Library	LED	-	-	8
Slaughter House	Incandescent light bulb	4	4	0
Slaughter House	LED	-	-	14
Slaughter House	CFL	-	-	1
Fire Brigade	Tube light	5	5	0
Fire Brigade	CFL	8	8	0
Fire Brigade	LED	2	0	6

Table 36: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh	Comment
MC Building and Mosque	48,781	58,396	Municipal rest house, bus stand and Training school building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these building have not been considered in the overall energy consumption and KPI calculations. Electricity units (kWh) are increased due to increase in number of Air Conditioners (AC) and lighting load in MC Office Building.
Library	5,037	4,998	
Slaughter House	7,838	9,944	
Fire Brigade	8,270	8,749	
Overall	**69,926**	**82,087**	

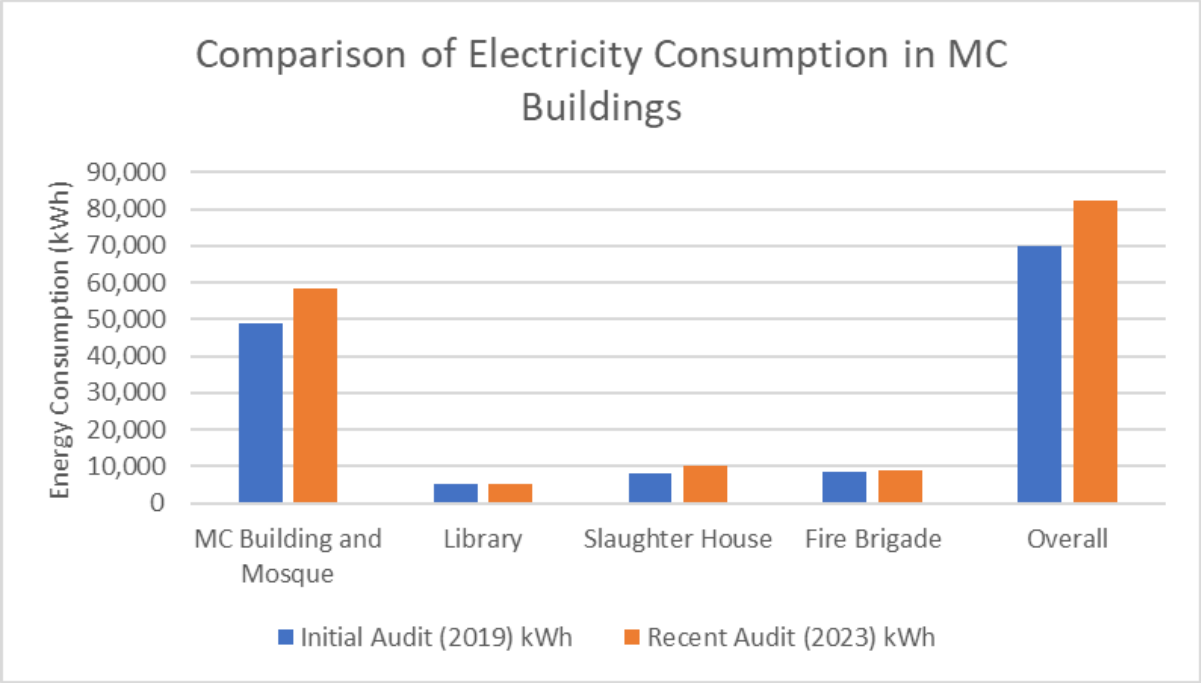


Figure 13:Comparison of Electricity Consumption in MC Buildings

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 Burewala

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

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

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

Table 37: Metering details at MC Burewala

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Library	81007297	05153310412101	1	A-3a (66)
2	Bus Stand	81007296	01153310010700	1	A-3a (66)
3	Fire Brigade	81007294	05153310492200	1	A-3a (66)
4	Slaughter House	81007295	28153341085203	12	A-3a (66)
5	MC Building & Mosque	81007298	01153310063000	1.7	A-3a (66)
			01153310061200	4	A-3a (66)
6	Rest House	81007299	01153310097000	4	A-3a (66)
7	Training School	81007300	01153310100400	1	A-3a (66)

6.1 Main MC Building & Mosque

The project site i.e. Main Office Building & Mosque is located near Street 5 E Block, Burewala, Punjab, Pakistan while the geographical co-ordinates of location are 30.16004°N (latitude) and 72.68160°E (longitude).

Figure 14: Front view of MC Office Building

Figure 15: Aerial view of MC Office Building

6.1.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of MC Office Building is 58,396 kWh. With the peak electricity consumption of 7,342 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 38: 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	01153310063000	26,076	2,173	4,516[11]	19
2	01153310061200	32,320	2,694	4,898[12]	24
Total					**43**

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Building & Mosque is 63,431 ft^2 whereas, the total area of rooftop available for the solar installation is 18,691 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

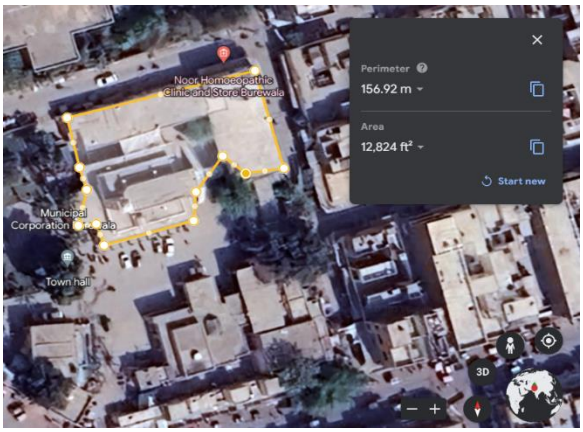


Figure 16: Top View of complete building

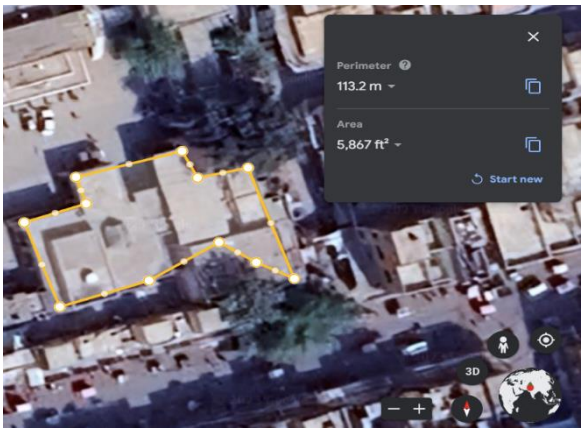


Figure 17:Top View of complete building

[11] This is the peak energy consumption of month of August 2022.

[12] This is the peak energy consumption of month of May 2022.

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.

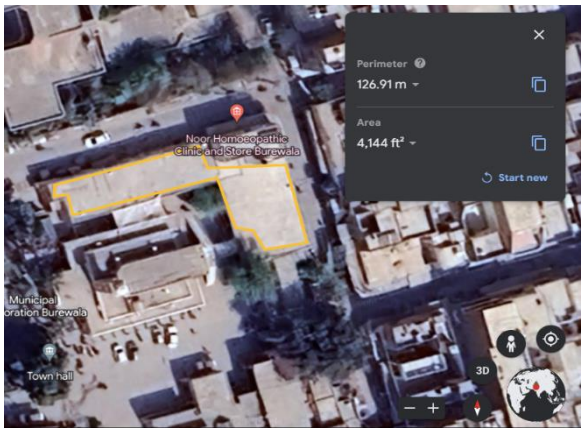


Figure 18:Location for Solar Installation - A

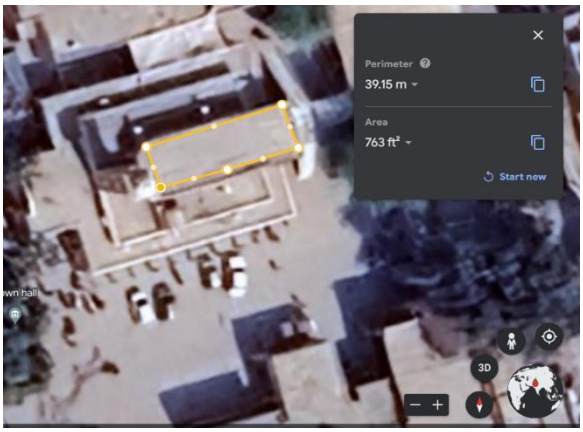


Figure 19:Location for Solar Installation – B

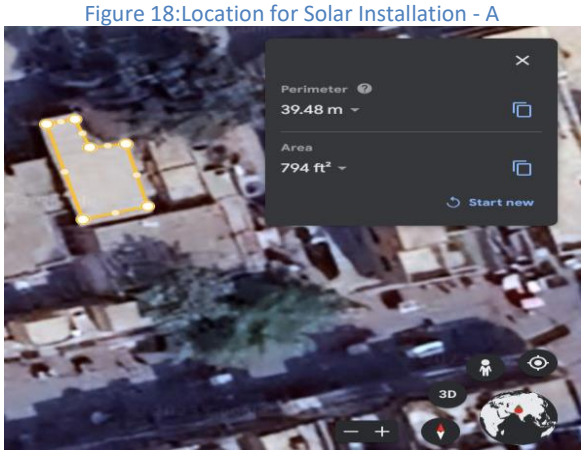


Figure 20:Location for Solar Installation-C

Figure 21:Location for Solar Installation-D

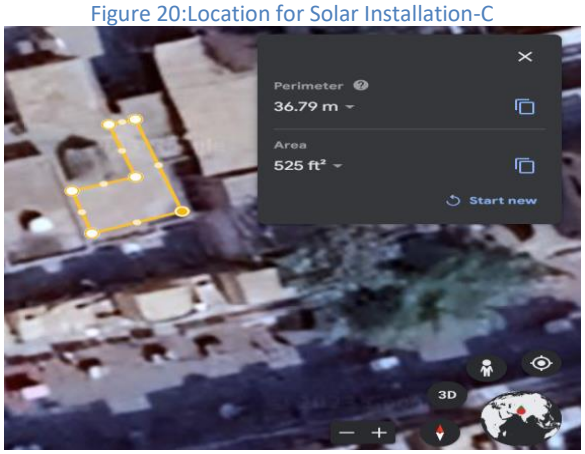


Figure 22:Location for Solar Installation-E

Figure 23:Location for Solar Installation-F

Table 39: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Location – D	Location – E	Location – F	Total
Area availability (ft²)	4,144	763	794	436	525	318	6,982
Solar system capacity (kW)	41	8	8	4	5	3	69

Based on the analysis of the historical billings it is identified that the total system requirement for this site is 43 kW.

6.2 Rest House

The project site i.e. Rest House is located near Main Multan Road, Burewala, Punjab, Pakistan while the geographical co-ordinates of location are 30.16414°N (latitude) and 72.68071°E (longitude).

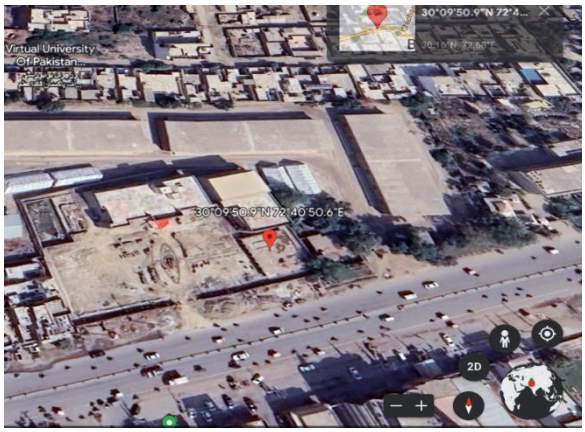


Figure 11: Aerial view of Rest House

6.2.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Rest House 2,084 kWh with the peak electricity consumption of 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 40 Solar System Requirement

Sr No.	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	01153310097000	2,084	173	299	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.

6.3 Bus Stand

The project site i.e. General Bus Stand Building is located near, Lahore Road, Block P, Housing Scheme, Burewala, Punjab, Pakistan while the geographical co-ordinates of location are 30.162825 °N (latitude) and 72.68633°E (longitude).

Figure 24:Front view of Bus Stand

Figure 25: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 2,775 kWh with the peak electricity consumption of 826 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 5: 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	01153310010700	2,775	231	826	2

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

6.4 Library

The project site i.e. Library is located near Press Club, College Road, Burewala, Punjab, Pakistan while the geographical co-ordinates of location are 30.1605°N (latitude) and 72.6808°E (longitude).

Figure 26: Front view of Library

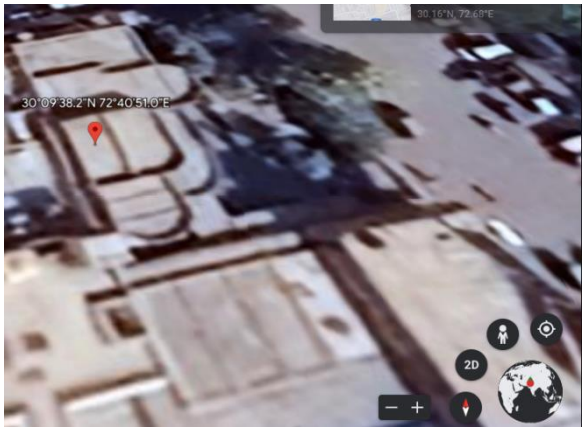


Figure 27:Aerial view of Library

6.4.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption of Library is 4,998 kWh with the peak electricity consumption of 624 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 6: 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	05153310412101	4,998	416	624	4

Note: Based on the analysis of the historical electricity billing data, it is identified that the solar system requirement for this site is only **4 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.

6.5 Slaughterhouse

The project site i.e. Slaughter House is located near Link Road, Burewala, Punjab, Pakistan while the geographical co-ordinates of location are 30.14589°N (latitude) and 72.64628°E (longitude).

Figure 28:Front view of Slaughter House

Figure 29: Aerial view of Slaughter House

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 Slaughterhouse 9,944 kWh with the peak electricity consumption of 1,141 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 7: 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	28153341085203	9,944	828	1,141	7

6.5.2 Roof Assessment

As per the Consultant's assessment, the total area of the Slaughterhouse is 8,130 ft^2 whereas, the total area of rooftop available for the solar installation is 3,734 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.

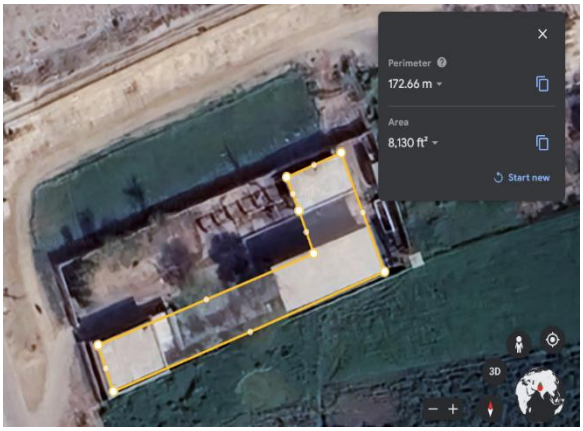


Figure 30:View of complete building

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.

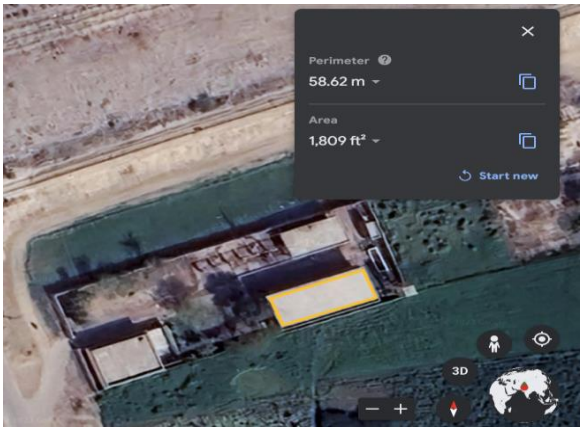


Figure 31:Location for Solar Installation – A

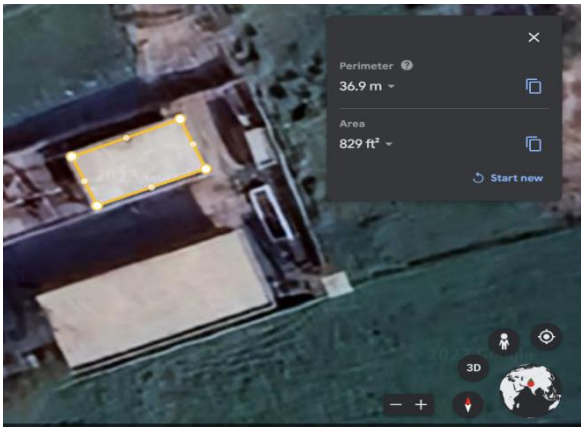


Figure 32:Figure 20:Location for Solar Installation – B

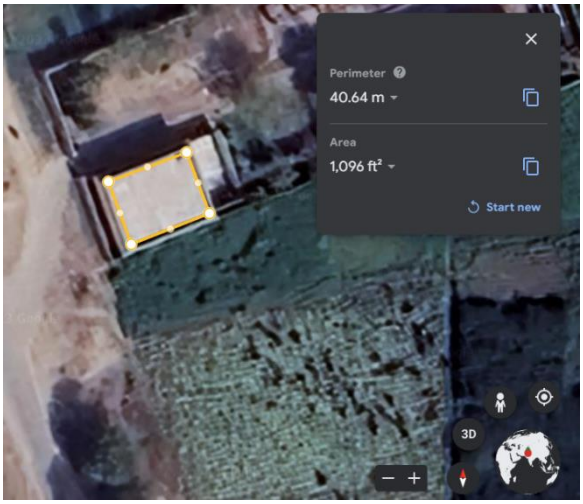


Figure 33:Location for Solar Installation – C

Table 8: System Size Calculation with Respect to Area

Parameters	Location A	Location B	Location C	Total
Area availability (ft^2)	1,809	829	1,096	3,734
Solar system capacity (kW)	19	8	11	38

6.6 Fire Brigade

The project site i.e. Fire Brigade is located Vehari Bazar, Burewala, Vehari, Punjab, Pakistan while the geographical co-ordinates of location are 30.16107 °N (latitude) and 72.67239°E (longitude).

Figure 23:Front view of Fire Brigade

Figure 24:Aerial view of Fire Brigade

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 Fire Brigade 8,749 kWh with the peak electricity consumption of 1,099 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 9: 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	05153310492200	8749	729	1,099	6

6.6.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main Fire Brigade is 38,115 ft^2 whereas, the total area of rooftop available for the solar installation is 755 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.

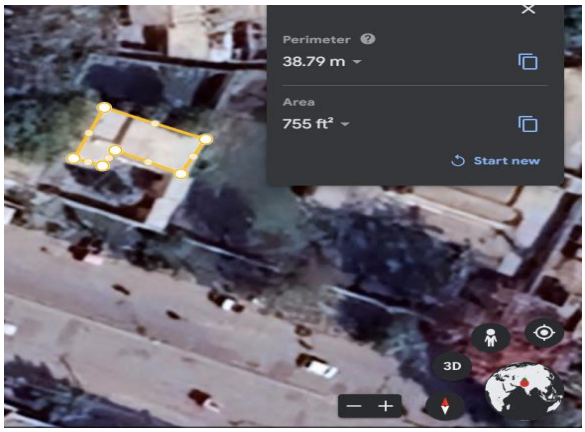


Figure 34: View of complete building

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.

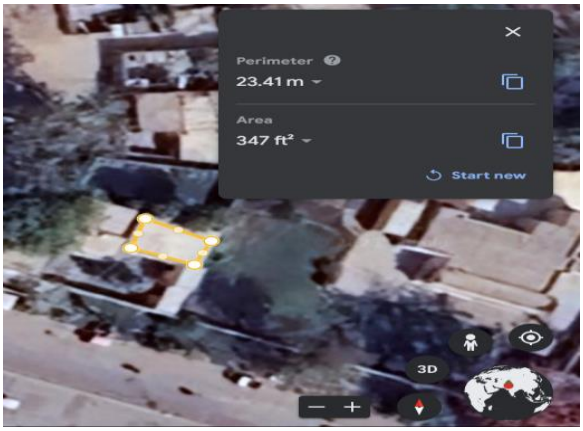


Figure 35:Location for Solar Installation – A

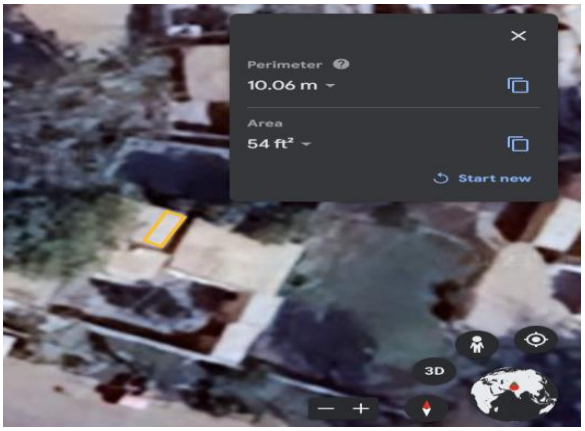


Figure 36:Location for Solar Installation – B

Table 10: System Size Calculation with Respect to Area

Parameters	Location A	Location B	Total
Area availability (ft^2)	347	54	401
Solar system capacity (kW)	3	1	4

Note: As per the Consultant's assessment, the total available space for the installation of solar assessment is less than the required space so it is recommended to install the ground mounted solar system.

6.7 Training School

The project site i.e., Training School Building is located near Govt. Girls Primary School, Street 1 E Block, Burewala, Punjab, Pakistan while the geographical co-ordinates of location are 30.1617°N (latitude) and 72.680146°E (longitude).

Figure 37:Front view of Training School

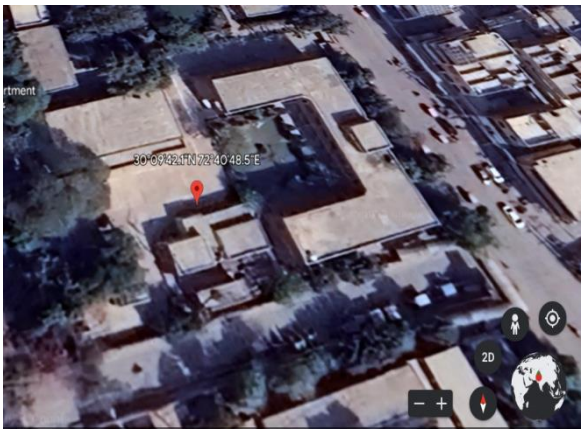


Figure 38:Top View of complete building

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 Water Supply Office 1,703 kWh with the peak electricity consumption of 533 kWh in October 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 11: 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	01153310100400	1703	141	533	1

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

6.8 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.

6.8.1 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.

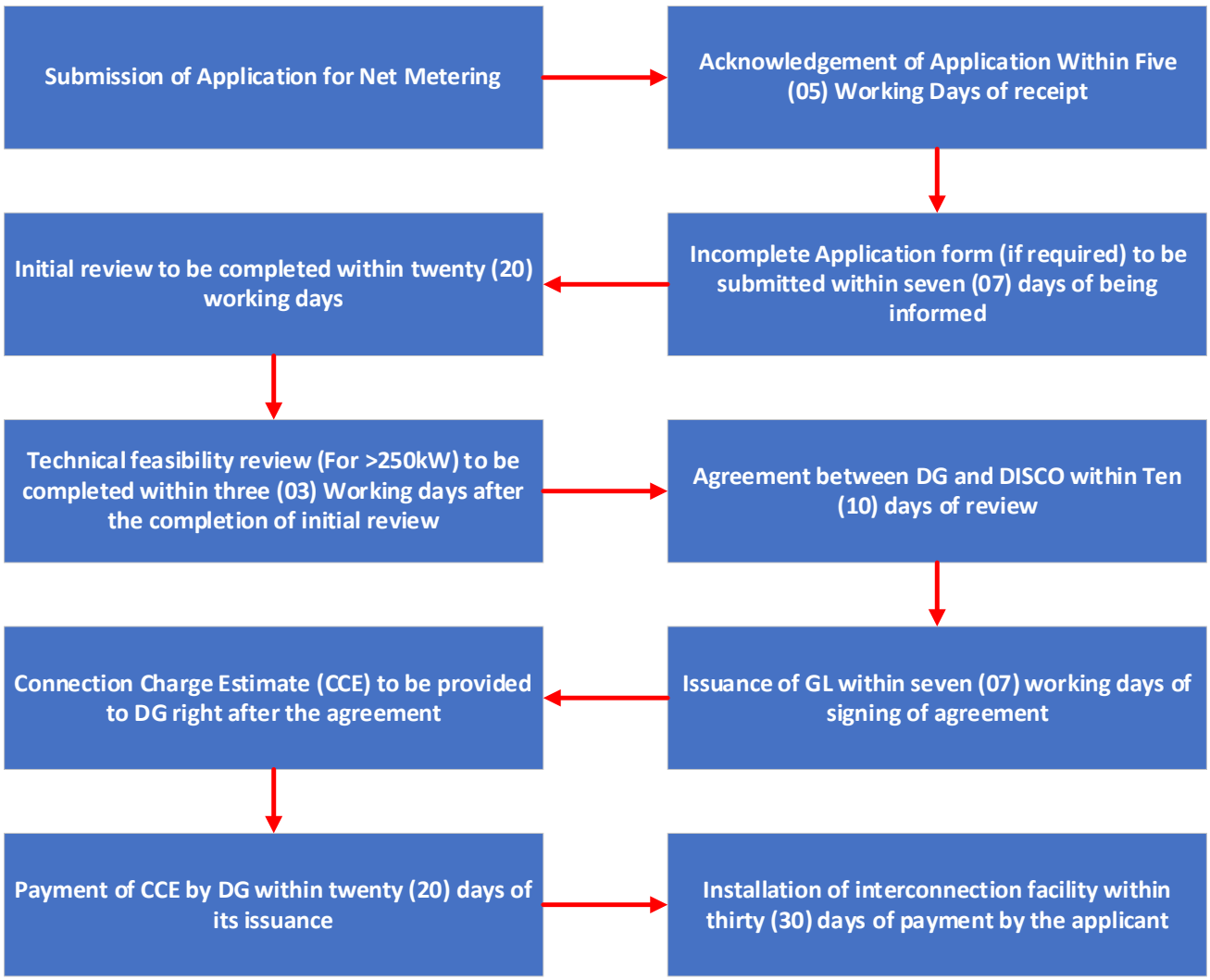


Figure 39:Pakistan Net Metering Application Process

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

Development of New Bore & Replacement of Pumpset at (TMA-TownHall - Unique ID: 31706529)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 4%.

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 41: 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	2
Measured Head	m	52.5
Measured Motor Power	kW	9.20
Pump Efficiency	%	4%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	76
Proposed Head	m	46
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	0.1
Pump Operational Days	days	330
Efficiency	%	80%
Energy Required by Existing Pump	kWh/y	15,180
Energy Required by Proposed Pump	kWh/y	614
Saving Potential	kWh/y	14,566
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,339
Investment	US $	7,363
Simple Payback Period	months	38

7.1.2 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (N-Block - Unique ID: 31806562)

Study & Investigation

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

Recommended Action

Replacement of Pump with new PECO 10MC 5-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 42: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	86
Measured Head	m	26.4
Measured Motor Power	kW	20.30
Pump Efficiency	%	36%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	100
Proposed Head	m	27
Power Consumption of Proposed Pump	kW	14.9
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	4.3
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	33,495
Energy Required by Proposed Pump	kWh/y	21,099
Saving Potential	kWh/y	12,396
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,991
Investment	US $	3,608
Simple Payback Period	months	22

7.1.3 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Yaqubabad - Unique ID: 3100705)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 48%.

Recommended Action

Replacement of Pump with new PECO 10MC 5-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 43: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	81
Measured Head	m	33.8
Measured Motor Power	kW	18.20
Pump Efficiency	%	48%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	100
Proposed Head	m	27
Power Consumption of Proposed Pump	kW	14.9
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	4.1
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	30,030
Energy Required by Proposed Pump	kWh/y	19,990
Saving Potential	kWh/y	10,040
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,612
Investment	US $	3,608
Simple Payback Period	months	27

7.1.4 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Gulshan-e-Ghani - Unique ID: 31806570)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 49%.

Recommended Action

Replacement of Pump with new PECO 10MC 5-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 44: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	180
Design Motor Power of Existing Pump	kW	140
Measured Flow	m^3/h	79
Measured Head	m	40.1
Measured Motor Power	kW	20.70
Pump Efficiency	%	49%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	100
Proposed Head	m	27
Power Consumption of Proposed Pump	kW	14.9
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	4.0
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	34,155
Energy Required by Proposed Pump	kWh/y	19,543
Saving Potential	kWh/y	14,612
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,347
Investment	US $	3,608
Simple Payback Period	months	18

7.1.5 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Mujahid Colony No. 1 - Unique ID: 31706548)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 41%.

Recommended Action

Replacement of Pump with new PECO 10MC 5-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 45: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	25
Measured Flow	m^3/h	64
Measured Head	m	28.0
Measured Motor Power	kW	14.20
Pump Efficiency	%	41%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	100
Proposed Head	m	27
Power Consumption of Proposed Pump	kW	14.9
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	3.2
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	23,430
Energy Required by Proposed Pump	kWh/y	15,855
Saving Potential	kWh/y	7,575
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,217
Investment	US $	3,608
Simple Payback Period	months	36

7.1.6 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 46: 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	Satellite Town No.1	31706551	2.5	3.0	50	150
2	TMA-TownHall	31706529	5.0	3.0	50	150
3	Water supply colony	31806560	2.5	3.0	50	150
4	Housing Scheme Y-Block	31706542	2.5	3.0	50	150
5	Habib Colony School	31706545	5.0	3.0	50	150
6	I-Block (Park City)	31806571-1	2.5	3.0	50	150
7	Chak No.435	3100704	2.5	3.0	50	150
8	Azeem Abad No.2	31107007	2.5	3.0	50	150
9	Habib Colony 2	31807771	2.5	3.0	50	150
10	447-EB	31706546	2.5	3.0	50	150
11	Mujahid Colony No. 1	31706548	2.5	3.0	50	150
12	Mujahid Colony No. 2	31706549	2.5	3.0	50	150
13	451-EB	31706531-A	5.0	3.0	50	150
14	451-EB	31706531-C	2.5	3.0	50	150
15	Marzipura Multan Road No.1	31716534-A	2.5	3.0	50	150
Total						**2,250**

7.1.7 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 sixty-three (63) 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 47: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	5,547,155
Annual Water consumption (post-implementation)	m^3/y	5,491,683
Annual Water saving per year	m^3/y	55,472
Estimate of Investment (including the cost of the server)	US$	40,000

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 209 streetlights are being operated by the municipality. Out of these, 191 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 40: 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 48: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	12
Number of non-functional streetlights (>20 feet)	#	0
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	12

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	612,732
Proposed number of photocell switches	#	10
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	10,000
Upfront investment cost	PKR	622,732
Upfront investment cost	US$	2,222
Annual Operating Electricity unit	kWh/yr	1,577
Annual Operating Cost	PKR/yr	70,956
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	125,913
Monthly diesel cost for operating fork lifter for two days	PKR/month	20,000
Monthly cost of renting Fork Lifter for two days	PKR/month	80,000
Miscellaneous Cost	PKR/month	20,000
Monthly maintenance cost	PKR/month	120,000

7.3 Energy Efficiency Measures for Buildings

7.3.1 High Priority Energy Efficiency Measure: Replacement of inefficient equipment in the buildings

Project

Replacement of inefficient equipment with new efficient equipment.

Study & Investigation

Following equipment are found to be inefficient and should be replaced with their more efficient counterparts.

Table 49: Replacement of inefficient equipment at office buildings

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment (Watt)	Overall Wattage of Proposed Equipment (Watt)	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters (PKR)
MC Building & Mosque											
1	Incandescent light bulb	1	100	100	250	LED Bulb 13 Watts	12	12	30	350	350
2	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
3	Tube Light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
4	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
5	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
6	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
7	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
8	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
9	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
10	CFL	4	40	160	399	LED Bulb 20 Watts	20	80	200	830	3,320
11	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
12	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
13	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
14	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
15	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
16	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
17	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
18	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
19	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
20	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment (Watt)	Overall Wattage of Proposed Equipment (Watt)	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters (PKR)
21	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
22	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
23	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700
24	CFL	1	30	30	75	LED Bulb 13 Watts	13	13	32	350	350
25	CFL	3	12	36	90	LED Bulb 8 Watts	8	24	60	330	990
26	CFL	3	12	36	90	LED Bulb 8 Watts	8	24	60	330	990
27	CFL	2	40	80	200	LED Bulb 20 Watts	20	40	100	830	1,660
28	CFL	1	40	40	100	LED Bulb 20 Watts	20	20	50	830	830
29	Incandescent light bulb	1	100	100	250	LED Bulb 13 Watts	12	12	30	350	350
30	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
31	Tube Light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
32	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
33	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
34	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
35	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
Bus Stand											
1	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
Library											
1	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
2	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
3	CFL	2	40	80	200	LED Bulb 20 Watts	20	40	100	830	1,660
4	CFL	3	40	120	300	LED Bulb 20 Watts	20	60	150	830	2,490
5	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
6	CFL	3	12	36	90	LED Bulb 8 Watts	8	24	60	330	990
Rest House											
1	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
2	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 50: Saving & cost benefit analysis

Parameters	Unit	Value
Average Operational Days for Building lighting Equipment	days/year	312
Average Operational Hours for Building lighting Equipment	Hours/day	8
Energy consumption of inefficient Equipment	kWh/yr	4,513
Energy consumption of Proposed Equipment	kWh/yr	2,236
Energy Savings	kWh/yr	2,276
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	366
Upfront Investment (including change in fixtures)	USD	205
Payback Period	Months	7

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 /5 Stages, 25hp Motor

Pump Size		10 MC /5 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	inshces 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:	864,104
Sales Tax @ 17%	Rs:	146,898
Total Cost of Pumpset	Rs:	1,011,002

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

Pump Size		8 MC /7 Stages			
Capacity		51 m3/hr	Max. O.D bowl		7.5 Inches
Speed		1450 rpm	I.D tubewell	-	
Pump Input		15 HP	Length of suction pipe		
Prime Mover (SEM/DE)		15 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	7	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	1	feet length
				column shaft dia	25	mm
Discharge head inch	4					with prelubrication tank
Electric Motor vertical hollow shaft 15 HP/4 Pole						included
DWT 8M C						included
Discharge head 4 " with top shaft						included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	775,214
Sales Tax @ 17%	Rs:	131,786
Total Cost of Pumpset	Rs:	907,000

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
Mechanica; 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

8.2 Investment Estimate (including Material Specification/Quantities) Streetlights

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

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	12	51,061	612,732
2	Accessories	Photocell switch				10	1,000	10,000
Lumpsum Price (PKR)								**622,732**
Lumpsum Price (USD)								**2,222**

8.3 Investment Estimate (including Material Specification/Quantities) Buildings

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

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

Sr. No	Proposed Equipment	Wattage of Proposed Equipment	Equipment Count	Overall Wattage of Proposed Equipment	Individual Cost of Proposed Equipment (PKR)	Cost of Proposed Equipment
1	LED Bulb 13 Watts	12	1	12	350	350
2	LED Rod 20 Watts	20	11	220	2900	31900
3	LED Bulb 20 Watts	20	21	420	830	17430
4	LED Bulb 8 Watts	8	11	88	330	3630
5	LED Bulb 13 Watts	13	12	156	350	4200
Lumpsum Price (PKR)						**57,510**
Lumpsum Price (USD)						**205**

9 Summary of Energy Efficiency Measures

MC Burewala's annual energy consumption is 3,017,585 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$ 9,871** with an estimated investment of **US$ 66,473**
- Reduce electricity consumption by approx. **61,466 kWh.**
- Reduce GHG Emissions by **31 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of MEPCO

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

Annexure 2: List of Energy Audit Equipment

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

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