Okara Municipal Committee

Energy Audit Report

June 2023

History of the Document

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The Consultant is also grateful to entire Okara 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 Okara MC Background

Tehsil Okara is one of the third tehsils of district Okara. It spreads over an area of 1,241 square kilometres with a population of 862,364 (as per DCR 1998).

Okara Tehsil is about 127 kilometres to the south-west of Lahore, on the National Highway, and on the main Lahore-Karachi Railway Line. Okara is bounded by district Faisalabad and Sheikhupura on the north-west where river Ravi forms the natural boundary. On the north-east lies the district of Kasur. On the south is the district of Bahawalnagar and south-west is Pakpattan district and the boundary of Sahiwal district on the west. On the south runs the river Satluj with some area of Tehsil Depalpur across the river along with Indo-Pak border.

Okara was raised to the level of Municipal Committee in 1937. After the implementation of Punjab Local Government Ordinance 2001, it was given the status of MC.

The Administration consists of Administrator, Chief Officer and 3 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 Okara MC has the following management.

Sr. No.	Name of Officer	Designation
1	Mr. Malik Ahmad Faraz	Administrator
2	Mr. Umer Naseem	Chief Officer
3	Mr. Tallat Mehmood*	Municipal Officer (Infrastructure)
4	Mr. Muhammad Mehboob	Municipal Officer (Finance)
5	Mr. Sheraz Ali	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Okara

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	586,166
Electrical energy used by Wastewater Disposal[2]	kWh/year	927,327
Electrical energy used in Buildings[3]	kWh/year	61,713
Electrical energy used by Streetlights[4]	kWh/year	144,964
Diesel used by Vehicles	liter/year	19,320
Petrol used by Vehicles	liter/year	7,416

1.5 Key Performance Indicators

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

1.5.1 Potable Water & Wastewater Pumps

Table 2: KPIs for Potable Water & Wastewater pumps

Sr. No.	Description	Unit	KPI
1	Energy Density of Potable Water Production	(kWh/m3)	0.20
2	Energy Density of Wastewater Disposal	(kWh/m3)	0.19
3	Energy Density of Wastewater Treatment	(kWh/m3)	No wastewater treatment is carried out
4	Energy Cost for Potable Water Production	(PKR/m3)	9.14
5	Energy Cost for Wastewater Disposal	(PKR/m3)	8.34
6	Energy Cost for Wastewater Treatment	(PKR/m3)	No wastewater treatment is carried out

1.5.2 Streetlights

Table 3: KPIs for Streetlights

Sr. No.	Description	Unit	KPI
1	Average electricity consumed per kilometer of lit roads	(kWh/km)	1,133
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	43

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

Sr. No.	Description	Unit	KPI
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	46,153
		PKR/Lighting Equipment	36,829
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)	483,067
6	Average daily duration of operation	(Hour)	12.0
7	Average energy costs per kilometer of lit roads	(PKR/km)	50,970
8	Average energy costs per light pole/fixture	(PKR/ fixture)	2,402
9	Number and percentage of failed public lights		57%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	4.12
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.01
3	Average Energy Cost of Heating	(PKR/m^2)	0
4	Average Energy Cost of Cooling	(PKR/m^2)	74
5	Average Energy Cost of Lighting	(PKR/m^2)	53

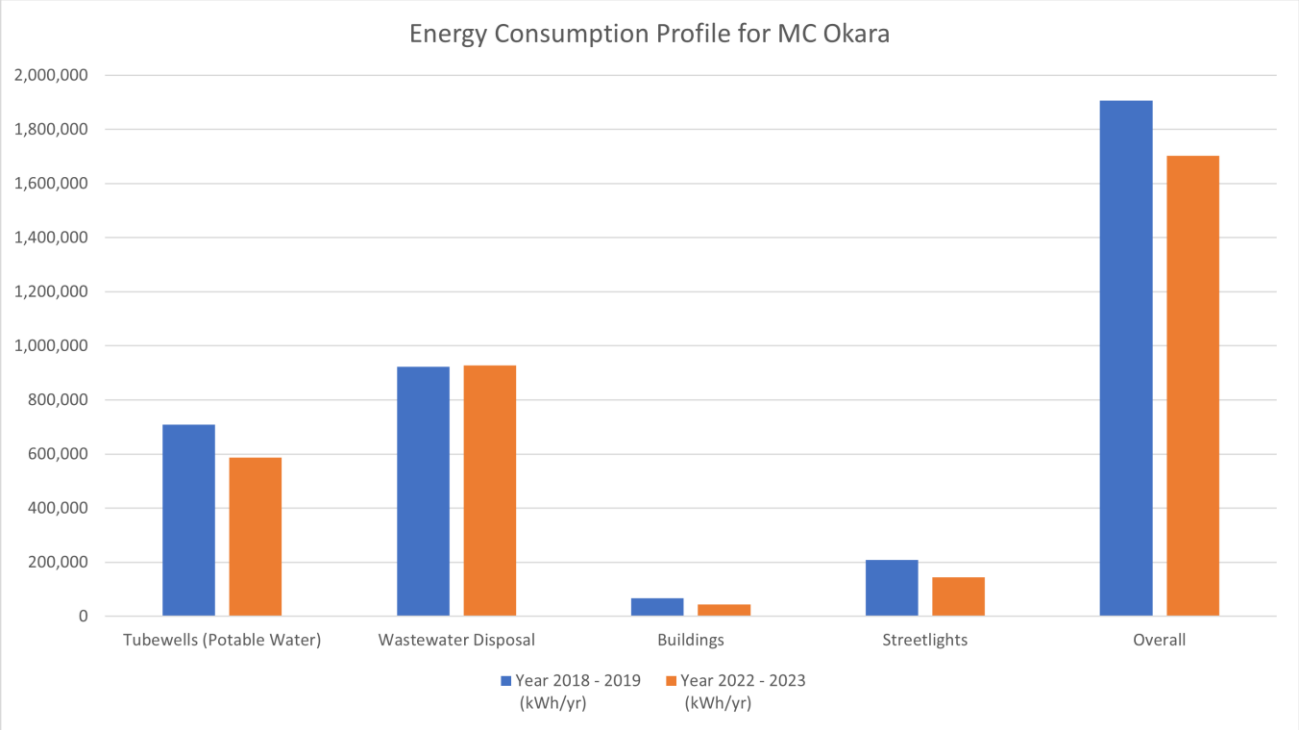
1.5.4 Vehicles

Table 5: KPIs for Vehicles

Sr. No	Description	Unit	KPI
1	Fuel consumption for staff transport vehicles	km/Liter	Cannot be Determined
2	Fuel consumption for solid/liquid waste transport	km/Liter	5.33
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	55

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 Okara
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Tubewells (Potable Water)
Wastewater Disposal
Buildings
Streetlights
Overall
Year 2018 - 2019 (kWh/yr)
Year 2022 - 2023 (kWh/yr)

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	13	17	708,723	586,166	122,557	0.39 kWh/m3	0.20 kWh/m3	Replacement of 5 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 4 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	8	10	922,235	927,327	-5,092	0.06 kWh/m3	0.07 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. The overall energy consumption per cubic meter of wastewater disposed has increased.
3	Buildings	6	8	66,356	44,211	22,145	3.67 kWh/m2	3.18 kWh/m2	Municipal resthouse and bus stand were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of municipal rest house building and bus stand have not been considered in the overall energy consumption and KPI calculations.
4	Streetlights	897	1,307	208,775	144,964	63,811	2,836 kWh/km	1,133 kWh/km	Based on the previous assessment, there were only 897 operational lights with an average consumption of 232kWh/light/annum, whereas,

		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
									currently there are 1307 operational lights with average energy consumption of 110.9kWh/light/annum.
	Overall	924	1,342	1,906,089	1,702,668	203,421			Considering a net cost of PKR 45/kWh for the MC, the financial savings for the MC stand at PKR 9,153,945 per annum

1.7 Energy Efficiency Recommendations Matrix

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

1.7.1 Energy Efficiency Recommendations Matrix

Table 6: High Priority Measures

High Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Replacement of Pumpset at (Pump No. 18 LBDC - Unique ID: 81306133)	16,962	3,794	1,063,000	2,724	763,311	17	9
Replacement of Pumpset at (Pump No. 15 LBDC - Unique ID: 81306134)	22,719	3,794	1,063,000	3,649	1,022,357	12	11
Replacement of Pumpset at (Pump No. 8 LBDC - Unique ID: 81306142)	13,697	3,237	907,000	2,200	616,361	18	7
Replacement of Pumpset at (Pump No. 5 LBDC - Unique ID: 81306145)	18,772	3,794	1,063,000	3,015	844,757	15	9
Replacement of Pumpset at (Pump No. 4 LBDC - Unique ID: 81306146)	26,935	3,794	1,063,000	4,326	1,212,091	11	14
Replacement of Pumpset at (Pump No. 1 LBDC - Unique ID: 81306149)	14,907	3,794	1,063,000	2,394	670,819	19	7
Replacement of Pumpset at (Pump No. 22 Rajbaha 42 - Unique ID: 81406158)	5,816	3,237	907,000	934	261,698	42	3
Replacement of Pumpset at (Akber Tank Water Works - Unique ID: 81306131-1)	4,321	4,657	1,305,000	694	194,440	81	2
Replacement/Installation of Capacitors	Not Quantifiable	1,800	504,360	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	315,635	88,440,825	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	43,317	2,447	685,720	6,957	1,949,257	4	22
Total:	**167,446**	**349,982**	**98,064,905**	**26,892**	**7,535,092**		**84**

Table 7: Medium Priority Measures

Medium Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Replacement of existing MC operated non efficient streetlights with LEDs	110,328	48,734	13,655,338	17,719	4,964,752	33	64
Total:	**110,328**	**48,734**	**13,655,338**	**17,719**	**4,964,752**	**33**	**64**

Table 8: Low Priority Measures

Low Priority Energy Efficiency Measure	Water Savings m^3/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Installation of Flow meters integrated with a centralized DCS system	29,716	29,500	8,265,900	0	0	0	Not Quantifiable
Total:	**29,716**	**29,500**	**8,265,900**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Okara MC has thirty-five (35) tubewells for groundwater, all of which are manually operated. Out of these, 17 pumpsets were found to be in working condition.

The MC has two (2) disposal station having twelve (12) pumps. Out of these, 10 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are nineteen (19) dewatering sets in the MC, out of which 15 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 fifteen (15) operational sites since the Sluice valves were either jammed or broken.

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

1. Pump No. 16 LBDC (Unique ID: 81306135)
2. Pump No. 13 LBDC (Unique ID: 81306137)
3. Pump No. 10 LBDC (Unique ID: 81306140)
4. Pump No. 7 LBDC (Unique ID: 81306143)
5. Pump No. 3 LBDC (Unique ID: 81306147)
6. Pump No. 14 (Unique ID: 81306253)
7. Pump No. 21 (Unique ID: 81406157)
8. Pump No. 23 Rajbaha 42 (Unique ID: 81406159)
9. Pump No. 20 District complex (Unique ID: 81406163)
10. Pump No. 19 (Unique ID: 81406164)
11. Pump No. 17 LBDC (Unique ID: 81406172)
12. Tehsil Road Sold W.W (Unique ID: 81306124-2)
13. Tehsil Road Sold W.W (Unique ID: 81306124-3)
14. Tehsil Road Sold W.W (Unique ID: 81306124-4)
15. Akber Tank Water Works (Unique ID: 81306131-2)
16. Akber Tank Water Works (Unique ID: 81306131-3)
17. Akber Tank Water Works (Unique ID: 81306131-4)
18. W.W Chamra Mandi (Unique ID: 81406160-1)

(iv) Undertake assessment of the following pumpsets as no flow could be detected possibly owning to rusty condition of the inner surface of the pipe

1. Pump No. 12 LBDC (Unique ID: 81306138)
2. Pump No. 9 LBDC (Unique ID: 81306141)
3. W.W Chamra Mandi (Unique ID: 81406160)
4. Tehsil Road Sold W.W (Unique ID: 81306124-1)

(v) Undertake assessment of the following pumpsets reliable power readings could not be measured due to phase imbalance in all three phases

1. Pump No. 6 LBDC (Unique ID: 81306144)

(vi) Undertake assessment of the following disposal pumpsets due to faulty motors

1. 2/4L Disposal (Unique ID: 81306136-E)
2. 1/4 L Disposal (Unique ID: 81306150-A)

(vii) Undertake assessment of the following disposal pumpsets as no flow could be detected due to low water level in the well

1. 1/4 L Disposal (Unique ID: 81306150-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 9: Inventory of Tubewells/Water Pumps (Potable Water)

Sr. No.	Unique ID	Location	Meter Reference No	Pump Type	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	Year of Motor Manufacturing	Latitude	Longitude
1	81306135	Pump No. 16 LBDC	45-11431-0357200	Turbine	Peco	2005	Siemens	2005	30.824339	73.429025
2	81306137	Pump No. 13 LBDC	45-11412-0491400	Turbine	KSB	2020	Siemens	2020	30.8298	73.444278
3	81306124-5	Tehsil Road Old w.w	24-11431-2205501	Turbine	KSB	2020	Siemens	2020	30.811592	73.444058
4	81306142	Pump No. 8 LBDC	45-11412-0491900	Turbine	Peco	N/A	Peco	N/A	30.831308	73.452502
5	81306144	Pump No. 6 LBDC	46-11412-0492402	Turbine	HMA	2005	Siemens	2005	30.831487	73.454888
6	81306145	Pump No. 5 LBDC	45-11412-0492100	Turbine	Peco	N/A	Peco	N/A	30.831536	73.455643
7	81306146	Pump No. 4 LBDC	46-11412-0492401	Turbine	HMA	2005	Siemens	2005	30.83168	73.45635
8	81306147	Pump No. 3 LBDC	45-11412-0492200	Turbine	Peco	1987	Peco	1987	30.831606	73.457252
9	81306148	Pump No. 2 LBDC	45-11412-0492300	Turbine	Beco	1998	Peco	1998	30.831712	73.458348
10	81306149	Pump No. 1 LBDC	45-11412-0492400	Turbine	Peco	1987	Peco	1987	30.8316	73.460055
11	81406172	Pump No. 17 LBDC	45-11431-0357500	Turbine	KSB	N/A	Siemens	N/A	30.823363	73.427163
12	81306253	Pump No. 14	45-11431-0357402	Turbine	N/A	N/A	N/A	N/A	30.82943	73.442628
13	81306124-1	Tehsil Road Sold W.W	24-11431-2205501	Turbine	Peco	1988	Peco	1988	30.811592	73.444058
14	81306124-2	Tehsil Road Sold W.W	24-11431-2205501	Centrifugal	KSB	1987	N/A	1987	30.811592	73.444058
15	81306124-3	Tehsil Road Sold W.W	24-11431-2205501	Centrifugal	KSB	1987	N/A	1987	30.811592	73.444058
16	81306124-4	Tehsil Road Sold W.W	24-11431-2205501	Centrifugal	KSB	1987	N/A	1987	30.811592	73.444058
17	81306131-1	Akber Tank Water Works	44-11431-2205800	Turbine	Peco	1988	Peco	1988	30.311843	73.437628
18	81306131-2	Akber Tank Water Works	No-Meter	Centrifugal	Peco	1978	Peco	1978	30.811843	73.437628
19	81306131-4	Akber Tank Water Works	No-Meter	Centrifugal	KSB	1978	Brus	1978	30.811843	73.437628
20	81306133	Pump No. 18 LBDC	45-11431-0357100	Turbine	Peco	1997	Peco	1997	30.82135	73.423895
21	81306131-3	Akber Tank Water Works	No-Meter	Centrifugal	KSB	1978	Brus	1978	30.811843	73.437628
22	81306134	Pump No. 15 LBDC	45-11431-0357401	Turbine	HMA GrundFos	2005	GrundFos	2005	30.825091	73.43054
23	81306138	Pump No. 12 LBDC	45-11412-0491500	Turbine	Meco	2006	Siemens	2006	30.827039	73.446565
24	81306139	Pump No. 11 LBDC	45-11412-0491700	Turbine	Peco	1997	Peco	1997	30.830921	73.449372
25	81306140	Pump No. 10 LBDC	45-11412-0491800	Turbine	Meco	2005	Siemens	2005	30.831075	73.450813
26	81306141	Pump No. 9 LBDC	45-11412-0491900	Turbine	Meco	2006	Siemens	2006	30.831298	73.451777
27	81406157	Pump No. 21	45-11434-0346301	Turbine	Peco	1996	Peco	1996	30.793894	73.425203
28	81406158	Pump No. 22 Rajbaha 42	45-11434-0346301	Turbine	Peco	2001	Peco	2001	30.78848	73.4339
29	81406159	Pump No. 23 Rajbaha 42	No-Meter	N/A	N/A	N/A	N/A	N/A	30.787946	73.433872
30	81406160	w.w Chamra Mandi	45-11434-0356500	Centrifugal	KSB	1987	Siemens	1987	30.801344	73.443258
31	81406160-1	w.w Chamra Mandi	45-11434-0356500	Centrifugal	KSB	1987	Siemens	1987	30.801344	73.443258
32	81406163	Pump No. 20 District complex	45-11431-0356300	Turbine	Peco	2000	Peco	1987	30.799861	73.42815
33	81406164	Pump No. 19	45-11431-0356700	Turbine	KSB	2020	Siemens	2020	30.802362	73.429372
34	81306131-5	Akber Tank Water Works	44-11431-2205800	Turbine	KSB	2020	Siemens	2020	30.811843	73.437628
35	81306143	Pump No. 7 LBDC	45-11412-0492000	Turbine	Peco	1987	N/A	1987	30.831499	73.454043

2.1.2 Disposal Works

Table 10: Inventory Table of Disposal Works

Sr. No.	Unique ID	Location	Meter Reference No	Pump Type	Pump Manufacturer	Pump Capacity (Cusec)	Motor Manufacturer	Motor Capacity (Hp)	Latitude	Longitude
1	81306136-A	2/4L	24-11412-2201001, 24-11412-2200901	Centrifugal	KSB	7	Siemens	75	30.828836	73.44343
2	81306136-B	2/4L		Centrifugal	KSB	7	Siemens	75	30.828836	73.44343
3	81306136-C	2/4L		Centrifugal	KSB	7	Siemens	75	30.828836	73.44343
4	81306136-D	2/4L	24-11412-2200902	Centrifugal	KSB	7	Siemens	75	30.828836	73.44343
5	81306136-E	2/4L		Centrifugal	KSB	7	Siemens	75	30.828836	73.44343
6	81306136-F	2/4L		Centrifugal	KSB	7	Siemens	75	30.828836	73.44343
7	81306136-G	2/4L	24-11412-2201001, 24-11412-2200901	Centrifugal	KSB	5	Siemens	75	30.828836	73.44343
8	81306150-A	1/4L	24-11412-2201202	Centrifugal	KSB	4	Siemens	50	30.82858	73.468714
9	81306150-B	1/4L		Centrifugal	KSB	5	KSB	50	30.82858	73.468714
10	81306150-C	1/4L		Centrifugal	KSB	5	KSB	50	30.82858	73.468714
11	81306150-D	1/4L		Centrifugal	KSB	5	KSB	50	30.82858	73.468714
12	81306150-E	1/4L		Centrifugal	KSB	5	KSB	50	30.82858	73.468714

2.1.3 Dewatering Sets

Table 11: Inventory of Dewatering Sets

Sr. No.	Unique ID	Location	Quantity	Latitude	Longitude
1	52206263 A	Govt. Colony	1	30.814588	73.461172
2	52206263 B	Street Number 7, Okara,	2	30.812209	73.466268
3	52206263 C	Mc Building	8	30.809700	73.448017
4	52206263 D	Rest House	4	30.81113	73.444483
5	52206263 E	Safdar Park	1	30.81283	73.44731
6	52206263 F	Near Press Club	1	30.81180	73.44606
7	52206263 G	Multan Okara Road	1	30.799199	73.430993
8	52206263 H	Shah Din Road	1	30.807962	73.430309

2.1.4 Filtration Units

Table 12: Inventory of Filtration Units

Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East
1	81406161	Chamra Mandi	Connected with Chamra Mandi Pump (81406160) & Pump No # 6 LBDC (81306144)					30.801216	73.443706
2	81306125	Tehsil Road	Connected with Tehsil Road and Old Water Works (81306124)					30.811097	73.444548
3	81306126	Mehboob Alam Chowk	Connected with Tehsil Road and Old Water Works (81306124)					30.809176	73.440753
4	81306129	PHQ Hospital	Connected with Tehsil Road and Old Water Works (81306124)					30.810702	73.443006
5	81306132	Sabri Chowk	Connected with Pump No # 15 (81306134) & Akbar Tank Water Works (81306131)					30.8136	73.432219
6	81306151	Khan Colony	Connected with Pump No # 6 (81306144)					30.82332	73.454537
7	81306152	New Campus School	Submersible	1	N/A	N/A	Grundfos	30.816789	73.451797
8	81406156	Qadar Colony	Submersible	1	Insaaf	N/A	Insaaf	30.807474	73.435893
9	81406162	5/4L	Submersible	1	N/A	N/A	N/A	30.79156	73.440695
10	81406165	Kot Ameer Ali Shah	Submersible	1	Golden Pumps	2020	N/A	30.800805	73.446287
11	81406167	Ghaziabad	Connected with Pump No # 8 LBDC (81306142)					30.807128	73.456635
12	81406166	Samad Pura (Railway Road)	Connected with Pump No # 7 LBDC (81306143) & Pump No 1 – 6,8,9					30.807638	73.44957
13	81406168	Siddique Nagar Street No. 3	Centrifugal	1	Grundfos	N/A	Al karam Motor	30.797741	73.45306
14	81406169	People Colony Street No. 3	Centrifugal	1	S.W	N/A	Golden Motors	30.800197	73.452986
15	81406170	Girls Colony Madina Town	Centrifugal	1	S.W	N/A	Golden Motors	30.795175	73.451469
16	81406171	Sea Line Colony	Centrifugal	1	S.W	N/A	Golden Motors	30.795434	73.439486
17	81406173	MC office	Submersible	1	Taifu	N/A		30.809134	73.447589
18	81406174	Sabri Colony Street No. 11	Submersible	1	Golden Pumps	N/A	Golden Motors	30.816385	73.435912
19	81407771	Municipal Stadium	Connected with Tehsil Road & Old water Works (81306124)					30.81383	73.443138
20	81407772	Junior Model School		1	N/A	N/A	N/A	30.814831	73.44994
21	81407773	Makkah Madina Town Phase 1	Submersible	1	N/A	N/A	N/A	30.800007	73.468148
22	81407774	Chak 53/2L Tube well	Centrifugal	1	N/A	N/A	N/A	30.79333	73.464846
23	81407775	Bajwa Colony New Railway Station	Connected with Pump No 1-9 LBDC					30.807643	73.449575

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

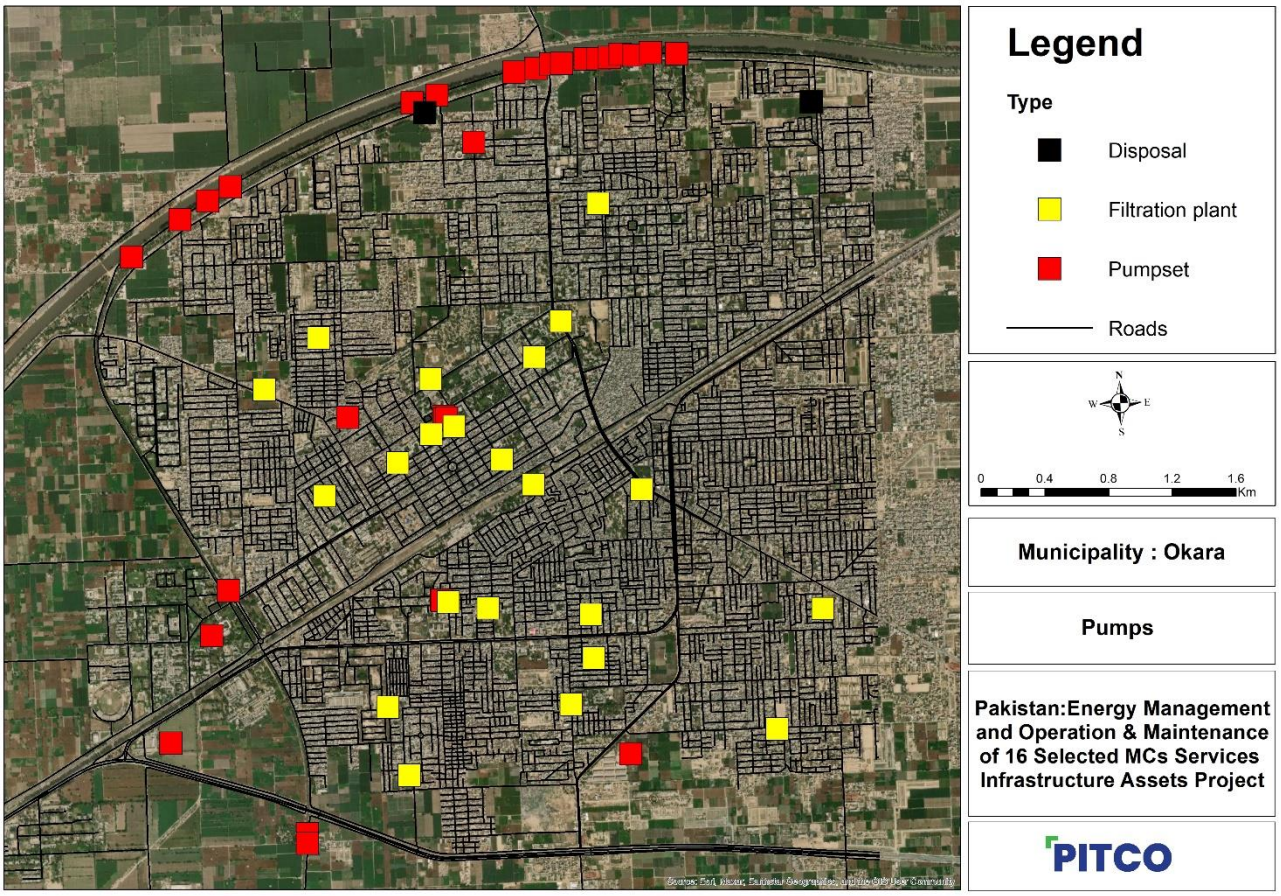


Figure 1: Map for Pumps and Disposal at MC Okara

2.3 Baseline Energy Consumption Trend

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

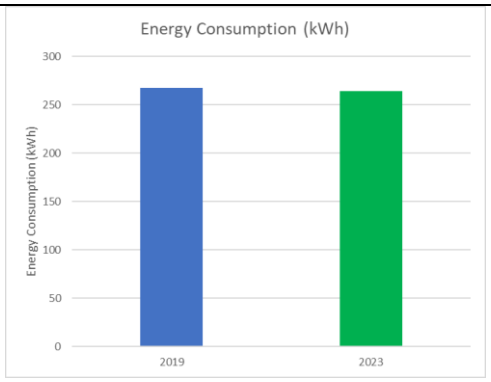
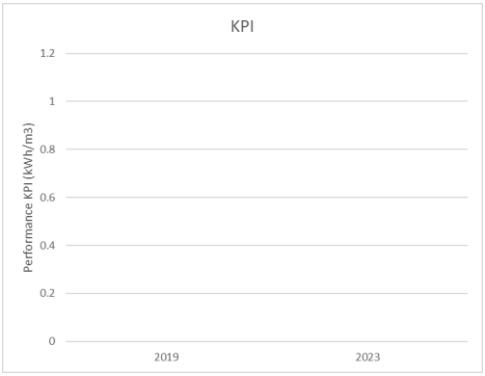
Table 13: Baseline Energy Consumption Trend

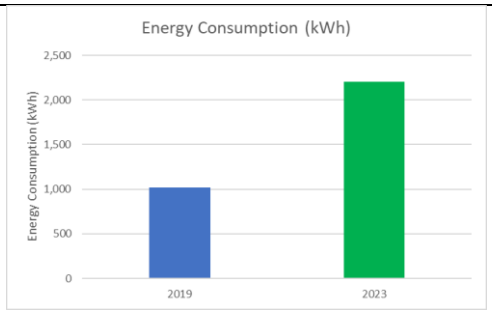
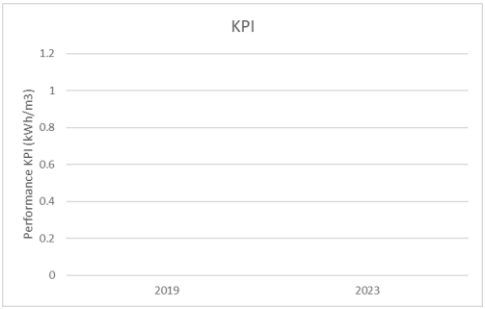
Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	586,166
Electrical energy used by Wastewater Disposal	kWh/y	927,327
Electrical energy used (Total)	kWh/y	1,513,493

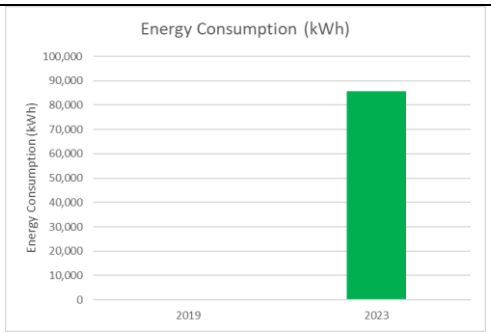
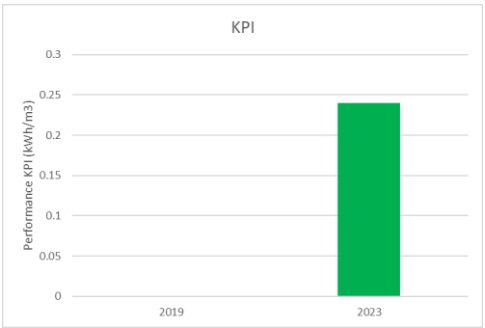
A comparison of current electricity consumption by the MC's water supply and disposal assets compared to results of the energy audit activity carried out in 2019, is presented in the following table:

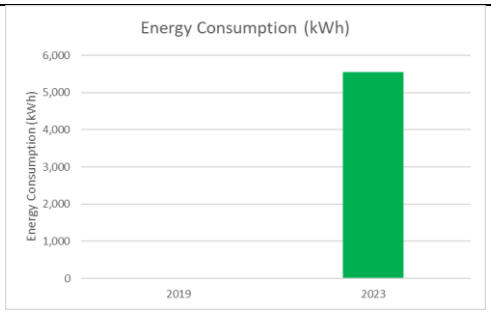
		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	13	17	708,723	586,166	122,557	0.39 kWh/m3	0.20 kWh/m3	Replacement of 5 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 4 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	8	10	922,235	927,327	-5,092	0.06 kWh/m3	0.07 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. The overall energy consumption per cubic meter of wastewater disposed has increased.

Replacement of 5 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken installation of 4 new pumpsets. A discussion on each newly installed asset is presented below:

Pump No. 13 LBDC (Unique ID: 81306137)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
267 kWh	264 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. Previously, this site was abandoned by the MC. However, due to unavailability of electrical supply, the pump site has remained non-functional. No Key Performance Indicators (KPIs) have been calculated for this pumpset, as its operational performance could not be assessed during both audits.	

Pump No. 19 (Unique ID: 81406164)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
1,017 kWh	2,200 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. Previously, this site was abandoned by the MC. However, due to unavailability of electrical supply, the pump site has remained non-functional. No Key Performance Indicators (KPIs) have been calculated for this pumpset, as its operational performance could not be assessed during both audits.	

Tehsil Road Old w.w (Unique ID: 81306124-5)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
N/A	85,789 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.24 kWh/m3
	
Comments:	
A new pumpset has been installed at this waterworks. Efficiency of the new pumpset is satisfactory. i.e., above 55%. The Consultant had recommended replacement of a different pump at the waterworks. However, the MC has added a new pump in parallel to the existing pumps in the waterworks. Annual energy consumption of this waterworks in 2019 was 194,080 kWh whereas, annual energy consumption of the complete waterworks is 171,577 kWh with an annual energy savings of 22,503 kWh.	

Akber Tank Water Works (Unique ID: 81306131-5)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
N/A	5,551 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.01 kWh/m3
	
Comments:	
A new pumpset has been installed at this waterworks. Efficiency of the new pumpset is satisfactory. i.e., above 55%. The Consultant had recommended replacement of a different pump at the waterworks. However, the MC has added a new pump in parallel to the existing pumps in the waterworks. Annual energy consumption of this waterworks in 2019 was 43,348 kWh whereas, annual energy consumption of this waterworks is 11,102 kWh with an annual energy savings of 32,246 kWh.	

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.

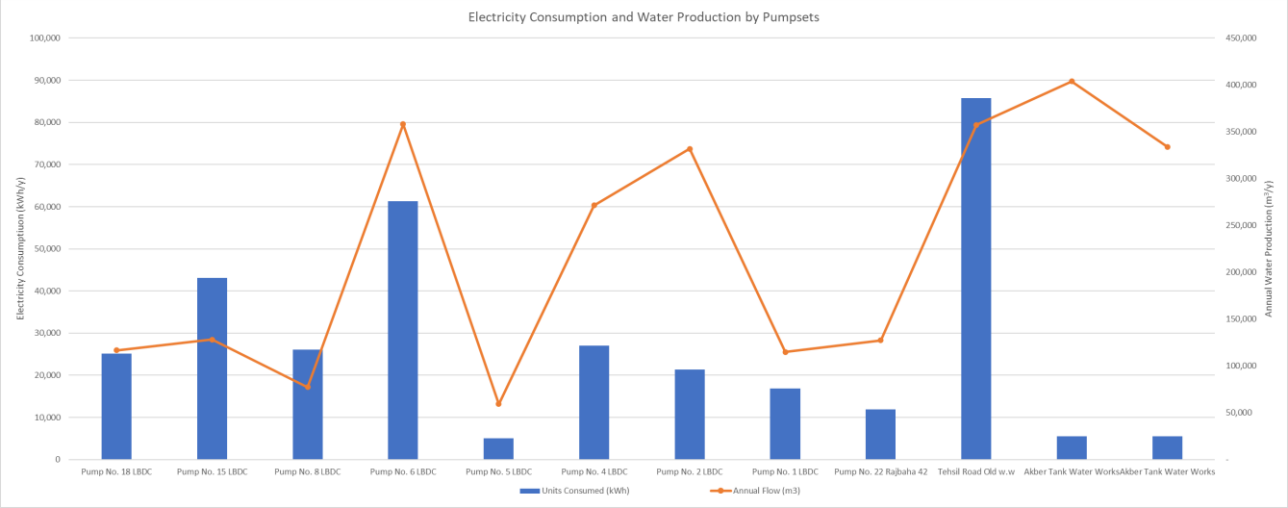
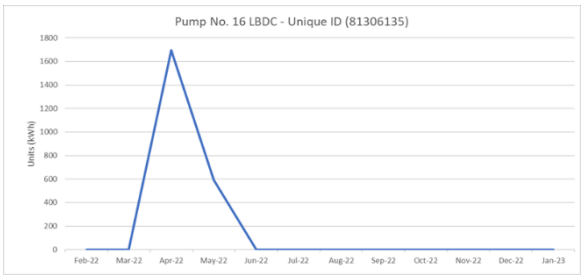


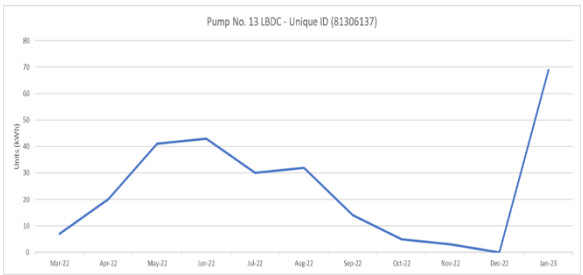
Figure 2: Electricity Consumption and Water Production by Pumpsets

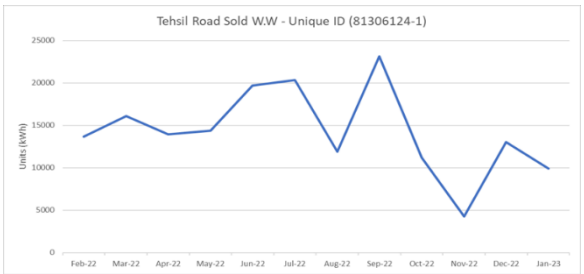
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

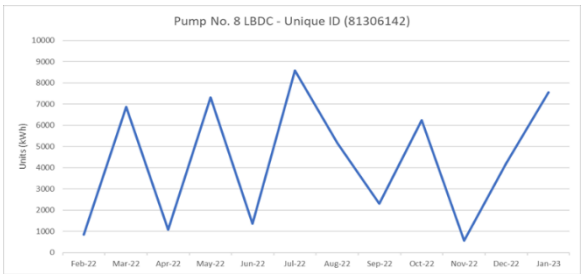
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

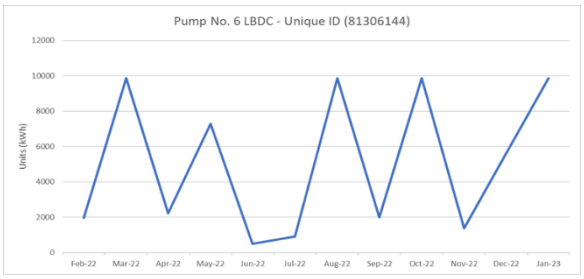
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

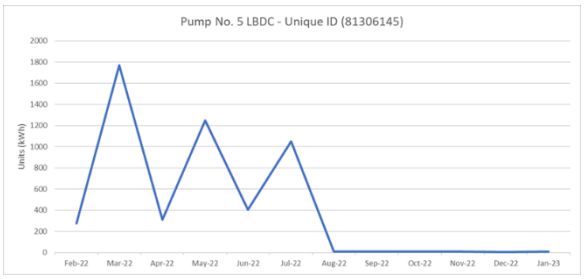


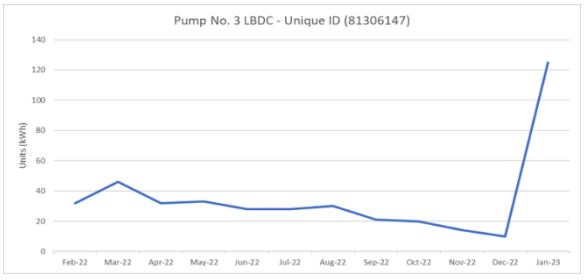


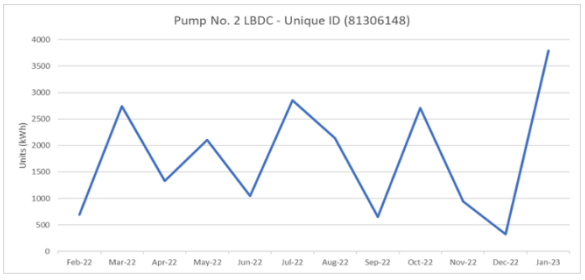


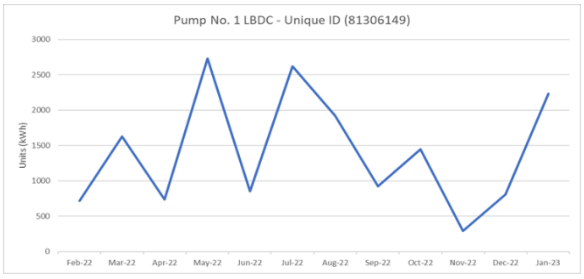


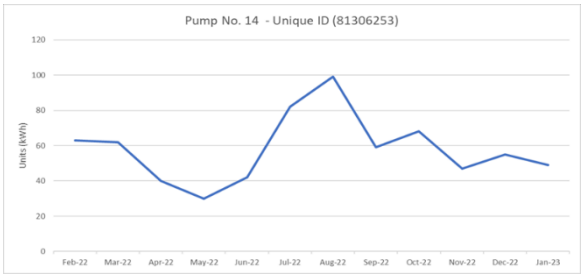

Pump No. 6 LBDC - Unique ID (81306144)
Units (kWh)
12000
10000
8000
6000
4000
2000
0
Feb-22 Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23

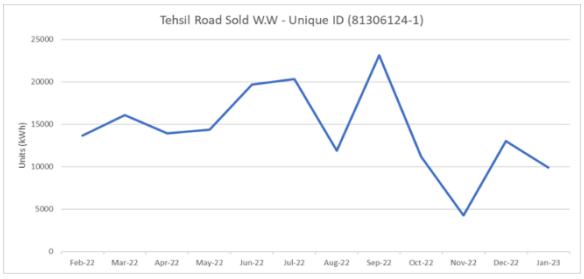

Pump No. 5 LBDC - Unique ID (81306145)
Units (kWh)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Feb-22 Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23

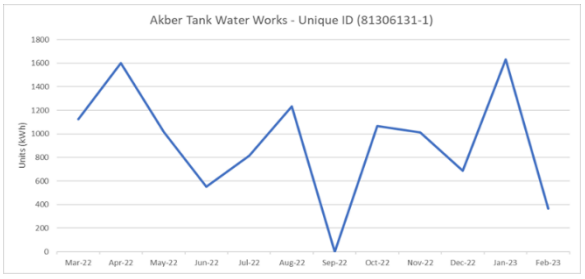

Pump No. 3 LBDC - Unique ID (81306147)
Units (kWh)
140
120
100
80
60
40
20
0
Feb-22 Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23

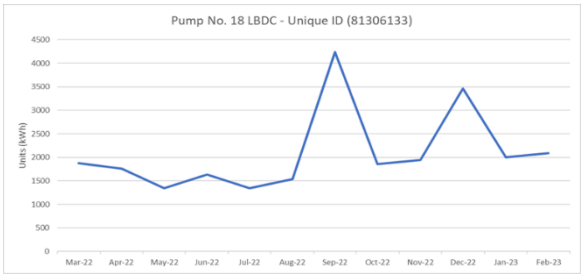

Pump No. 2 LBDC - Unique ID (81306148)
Units (kWh)
4000
3500
3000
2500
2000
1500
1000
500
0
Feb-22 Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23

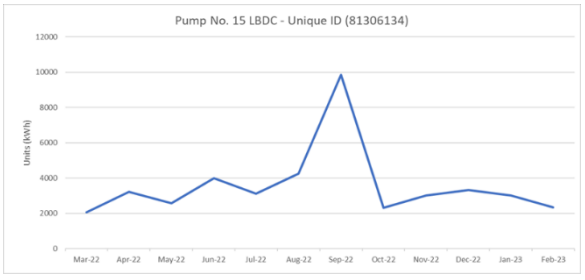

Pump No. 1 LBDC - Unique ID (81306149)
Units (kWh)
3000
2500
2000
1500
1000
500
0
Feb-22 Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23


Pump No. 14 - Unique ID (81306253)
Units (kWh)
120
100
80
60
40
20
0
Feb-22 Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23


Tehsil Road Sold W.W - Unique ID (81306124-1)
Units (kWh)
25000
20000
15000
10000
5000
0
Feb-22 Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23


Akber Tank Water Works - Unique ID (81306131-1)
Units (kWh)
1800
1600
1400
1200
1000
800
600
400
200
0
Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23 Feb-23


Pump No. 18 LBDC - Unique ID (81306133)
Units (kWh)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23 Feb-23


Pump No. 15 LBDC - Unique ID (81306134)
Units (kWh)
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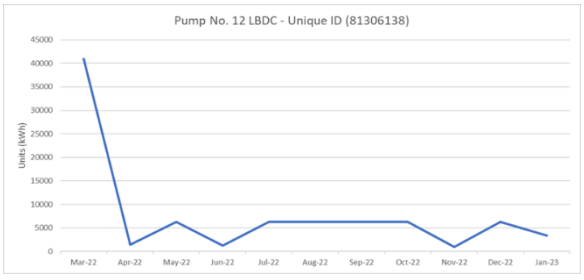
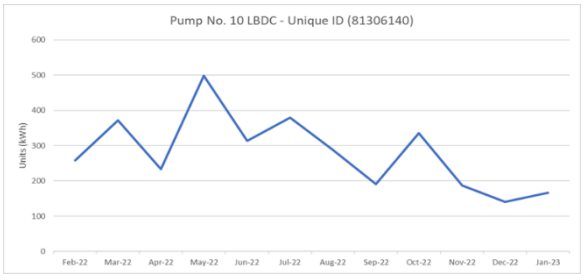
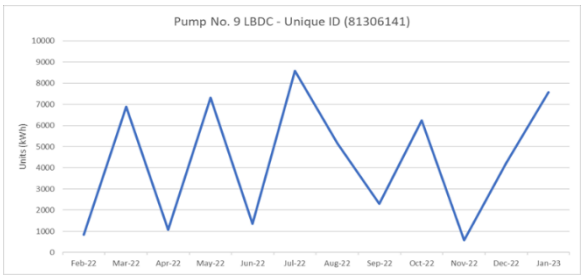
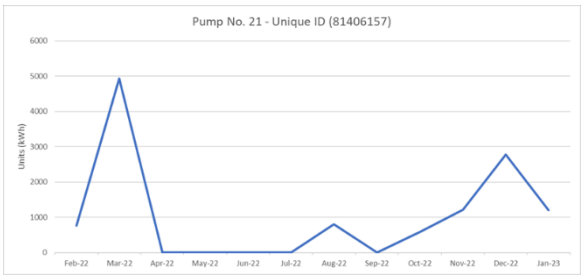
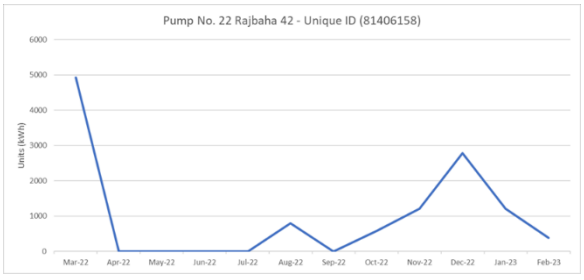
10000
8000
6000
4000
2000
0
Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23 Feb-23

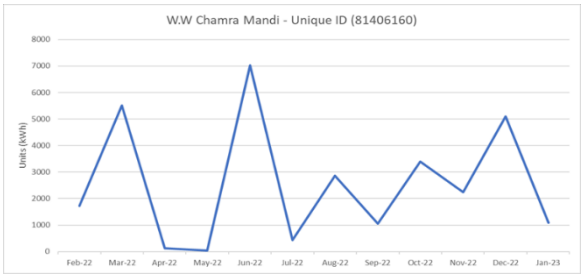

Pump No. 12 LBDC - Unique ID (81306138)
Units (kWh)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23

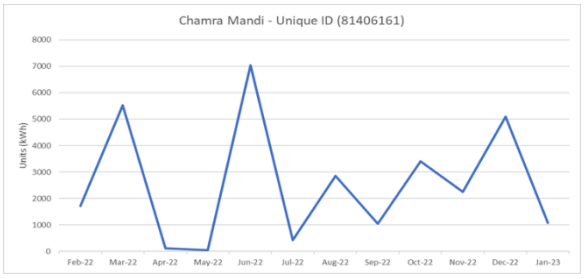

Pump No. 10 LBDC - Unique ID (81306140)
Units (kWh)
600
500
400
300
200
100
0
Feb-22 Mar-22 Apr-22 May-22 Jun-22 Jul-22 Aug-22 Sep-22 Oct-22 Nov-22 Dec-22 Jan-23

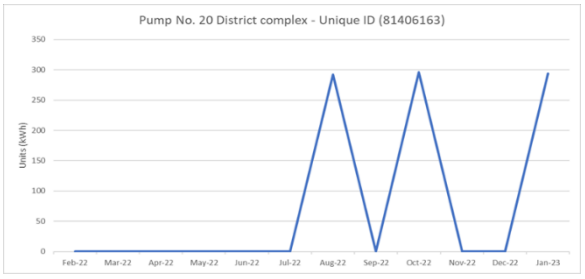

Pump No. 9 LBDC - Unique ID (81306141)
Units (kWh)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

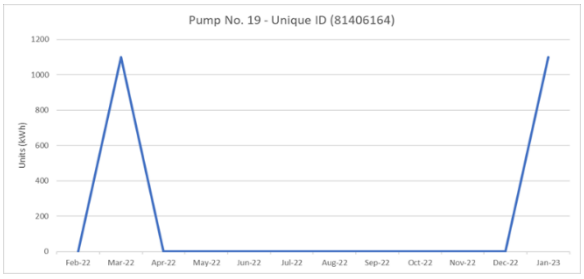

Pump No. 21 - Unique ID (81406157)
Units (kWh)
6000
5000
4000
3000
2000
1000
0
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

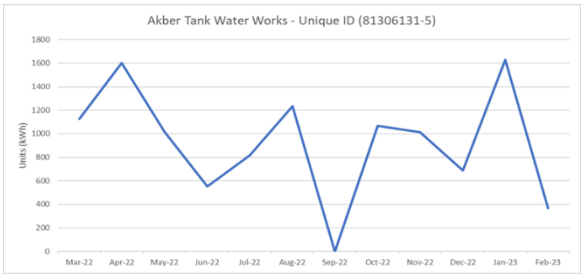

Pump No. 22 Rajbaha 42 - Unique ID (81406158)
Units (kWh)
6000
5000
4000
3000
2000
1000
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23

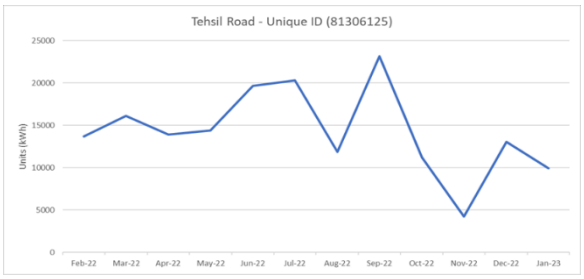

W.W Chamra Mandi - Unique ID (81406160)
Units (kWh)
8000
7000
6000
5000
4000
3000
2000
1000
0
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

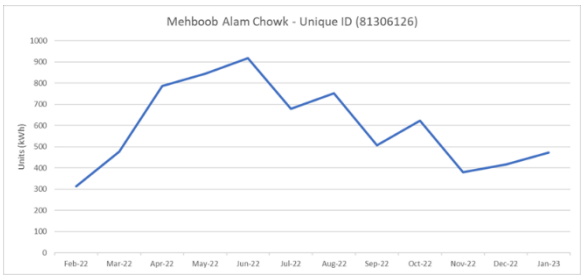

Chamra Mandi - Unique ID (81406161)
Units (kWh)
8000
7000
6000
5000
4000
3000
2000
1000
0
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

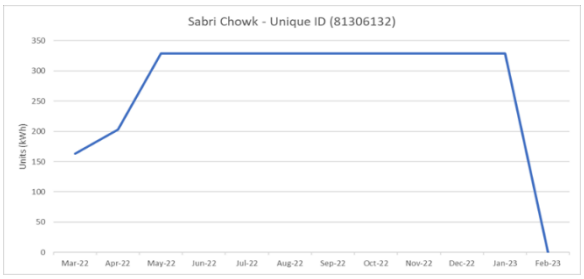

Pump No. 20 District complex - Unique ID (81406163)
Units (kWh)
350
300
250
200
150
100
50
0
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

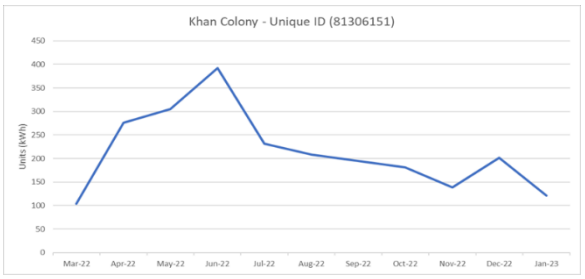

Pump No. 19 - Unique ID (81406164)
Units (kWh)
1200
1000
800
600
400
200
0
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

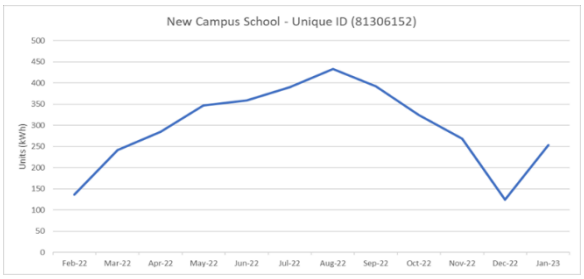

Akber Tank Water Works - Unique ID (81306131-5)
Units (kWh)
1800
1600
1400
1200
1000
800
600
400
200
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23

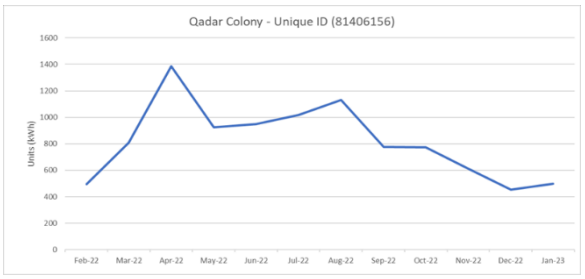

Tehsil Road - Unique ID (81306125)
Units (kWh)
25000
20000
15000
10000
5000
0
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

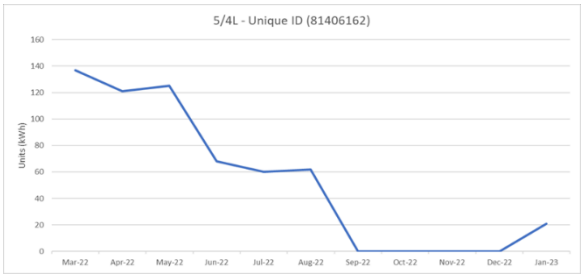

Mehboob Alam Chowk - Unique ID (81306126)
Units (kWh)
1000
900
800
700
600
500
400
300
200
100
0
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

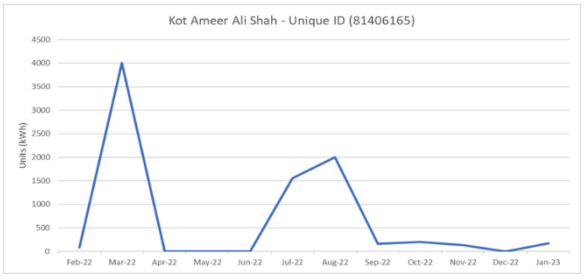

Sabri Chowk - Unique ID (81306132)
Units (kWh)
350
300
250
200
150
100
50
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23

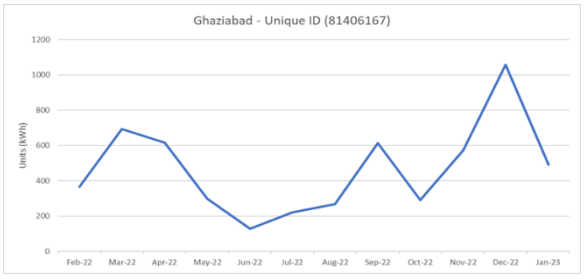

Khan Colony - Unique ID (81306151)
Units (kWh)
450
400
350
300
250
200
150
100
50
0
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

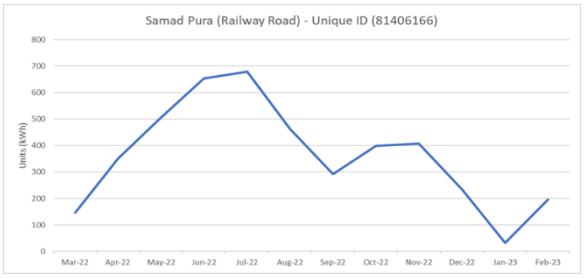

New Campus School - Unique ID (81306152)
Units (kWh)
0
50
100
150
200
250
300
350
400
450
500
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

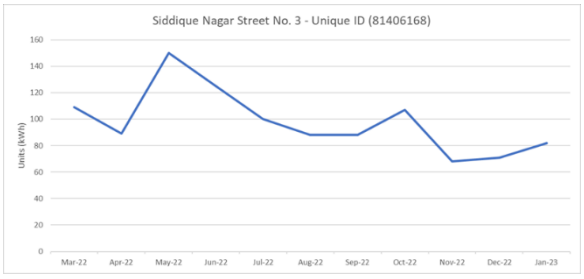

Qadar Colony - Unique ID (81406156)
Units (kWh)
0
200
400
600
800
1000
1200
1400
1600
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

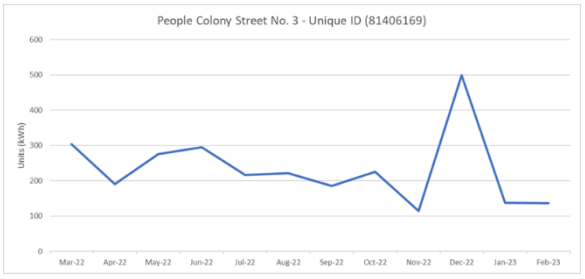

5/4L - Unique ID (81406162)
Units (kWh)
0
20
40
60
80
100
120
140
160
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

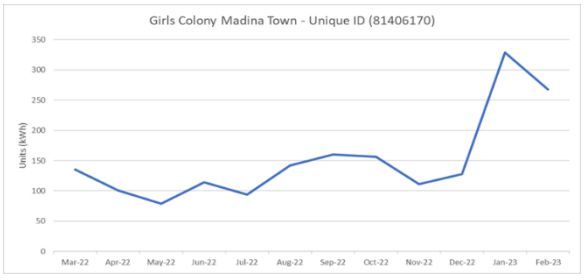

Kot Ameer Ali Shah - Unique ID (81406165)
Units (kWh)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

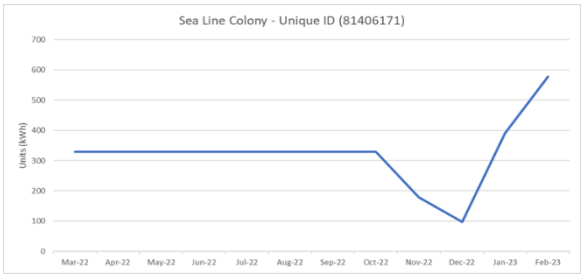

Ghaziabad - Unique ID (81406167)
Units (kWh)
0
200
400
600
800
1000
1200
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

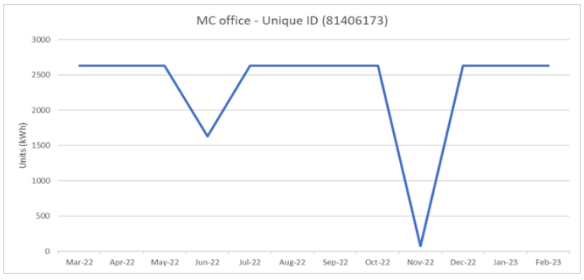

Samad Pura (Railway Road) - Unique ID (81406166)
Units (kWh)
0
100
200
300
400
500
600
700
800
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23


Siddique Nagar Street No. 3 - Unique ID (81406168)
Units (kWh)
0
20
40
60
80
100
120
140
160
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23


People Colony Street No. 3 - Unique ID (81406169)
Units (kWh)
0
100
200
300
400
500
600
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23


Girls Colony Madina Town - Unique ID (81406170)
Units (kWh)
0
50
100
150
200
250
300
350
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23


Sea Line Colony - Unique ID (81406171)
Units (kWh)
0
100
200
300
400
500
600
700
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23


MC office - Unique ID (81406173)
Units (kWh)
0
500
1000
1500
2000
2500
3000
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23

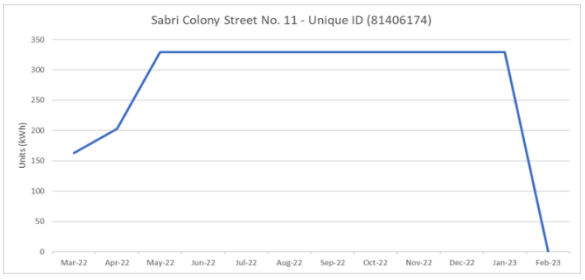

Sabri Colony Street No. 11 - Unique ID (81406174)
Units (kWh)
0
50
100
150
200
250
300
350
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23

Figure 3: Energy Consumption Trend for Water Pumps

Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Okara MC has thirty-five (35) tubewells for groundwater, all of which are manually operated. Out of these, 17 pumpsets were found to be in working condition.

Performance evaluation of pumpsets could be carried out at only 12 locations due to the reasons specified under section 2. Performance analysis was carried out for the operational tubewells, by simultaneous measurement of flow and electrical consumption. The list of audit equipment used by the Consultant is attached as Annexure 2. Since the Sluice valves at several pumping stations were either jammed or broken, it was not possible to determine system resistance and/or assess the pumpset performance at its duty point. Nevertheless, the purpose of the energy audit is to evaluate the energy consumption of MC's water supply

network based on their actual/existing working condition. Therefore, any measurements made by altering the actual field operating mode/conditions will not be a true representation of the energy consumption of assets.

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

Figure 5: Sample pictures from field audit of pumpsets

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

Table 14: Matrix of Pumpset Assessment and Billing Data Availability

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
1	81306133	Pump No. 18 LBDC	Yes	Yes
2	81306134	Pump No. 15 LBDC	Yes	Yes
3	81306135	Pump No. 16 LBDC	Yes	No
4	81306137	Pump No. 13 LBDC	Yes	No
5	81306138	Pump No. 12 LBDC	Yes	No
6	81306139	Pump No. 11 LBDC	Yes	Yes
7	81306140	Pump No. 10 LBDC	Yes	No
8	81306141	Pump No. 9 LBDC	Yes	No
9	81306142	Pump No. 8 LBDC	Yes	Yes
10	81306143	Pump No. 7 LBDC	Yes	No
11	81306144	Pump No. 6 LBDC	Yes	No
12	81306145	Pump No. 5 LBDC	Yes	Yes
13	81306146	Pump No. 4 LBDC	Yes	Yes
14	81306147	Pump No. 3 LBDC	Yes	No
15	81306148	Pump No. 2 LBDC	Yes	Yes
16	81306149	Pump No. 1 LBDC	Yes	Yes
17	81306253	Pump No. 14	Yes	No
18	81406157	Pump No. 21	Yes	No
19	81406158	Pump No. 22 Rajbaha 42	Yes	Yes
20	81406159	Pump No. 23 Rajbaha 42	Yes	No
21	81406160	W.W Chamra Mandi	Yes	No

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
22	81406163	Pump No. 20 District complex	Yes	No
23	81406164	Pump No. 19	Yes	No
24	81406172	Pump No. 17 LBDC	Yes	No
25	81306124-1	Tehsil Road Sold W.W	Yes	No
26	81306124-2	Tehsil Road Sold W.W	Yes	No
27	81306124-3	Tehsil Road Sold W.W	Yes	No
28	81306124-4	Tehsil Road Sold W.W	Yes	No
29	81306124-5	Tehsil Road Old w.w	Yes	Yes
30	81306131-1	Akber Tank Water Works	Yes	Yes
31	81306131-2	Akber Tank Water Works	Yes	No
32	81306131-3	Akber Tank Water Works	Yes	No
33	81306131-4	Akber Tank Water Works	Yes	No
34	81306131-5	Akber Tank Water Works	Yes	Yes
35	81406160-1	W.W Chamra Mandi	Yes	No

Table 15: Pumpset Primary Performance Parameters

Sr No.	Unique ID	Location	Rated Pump Flow m^3/hr	Measured Flow m^3/hr	Dynamic Head m	Power Consumption kW	Pump Efficiency %	Measured Power Factor	Comments
1	81306133	Pump No. 18 LBDC	101.9	35.4	25.93	9.80	30%	0.51	The efficiency of the pumpset is unsatisfactory. Previously, no reliable readings for the power consumption were recorded due to phase imbalance in all three phases.
2	81306134	Pump No. 15 LBDC	101.9	64.8	26.23	20.00	27%	0.80	The efficiency of the pumpset is unsatisfactory. Previously, it was recommended to replace the pumpset.
3	81306139	Pump No. 11 LBDC	101.9	110.4	25.32	15.97	56%	0.88	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 54%.
4	81306142	Pump No. 8 LBDC	51.0	26.1	23.33	10.10	19%	0.49	Efficiency of the pumpset is unsatisfactory. Sluicegate valve is non-functional. Previously, this site was abandoned by the MC.
5	81306145	Pump No. 5 LBDC	101.9	25.6	23.33	11.50	17%	0.84	Efficiency of the pumpset is unsatisfactory. Sluicegate valve is non-functional. Previously, this site was non-functional.
6	81306146	Pump No. 4 LBDC	101.9	91.4	23.33	21.10	32%	0.89	Efficiency of the pumpset is unsatisfactory. Sluicegate valve is non-functional. Previously, it was recommended to replace the pumpset.
7	81306148	Pump No. 2 LBDC	101.9	111.7	22.27	13.20	60%	0.83	Efficiency of the pumpset is satisfactory. Sluicegate valve is non-functional. Previously, the efficiency of the pumpset was 65%.
8	81306149	Pump No. 1 LBDC	101.9	49.7	26.84	13.00	33%	0.76	Efficiency of the pumpset is unsatisfactory. Sluicegate valve is non-functional. Previously, flow could not be detected due to ultrasonic flow meter due to very less flow in delivery line.
9	81406158	Pump No. 22 Rajbaha 42	51.0	64.3	26.84	13.10	42%	0.77	Efficiency of the pumpset is unsatisfactory. Sluicegate valve is non-functional. Previously, this site was non-functional.
10	81306124-5	Tehsil Road Old w.w	101.9	180.5	20.58	20.69	58%	0.86	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Gate/sluice valve was not operational.
11	81306131-1	Akber Tank Water Works	203.9	244.8	10.69	25.00	34%	0.77	Efficiency of the pumpset is satisfactory. Sluicegate valve is non-functional. Previously, it was recommended to replace the pumpset.

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
12	81306131-5	Akber Tank Water Works	101.9	168.6	22.15	21.80	55%	0.79	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory.

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

Table 16: Pumpset Secondary Performance Parameters

Unique ID	Motor Vibration Hz	Temperature of Motor	Winter Operational Hours	Summer Operational Hours	Motor Rated kW	Motor Rated Efficiency	Transformer kVA	Elec. Connection	Line Leakage	Rated Head of Pump	Motor Rated Voltage V	Full Load PF	PF (Measured)	Load factor %	Observations
81306133	53.05	-	10	10	30	-	50	Unsafe	Ok	-	-	-	0.51	33%	Low PF
81306134	106.10	34	6	6	22	-	50	Safe	Ok	-	380	-	0.80	89%	
81306139	5.79	38	8	8	30	-	100	Safe	Ok	100	400	-	0.88	54%	
81306142	79.58	25	9	9	30	-	50	Safe	Not Ok	-	-	-	0.49	34%	Low PF
81306145	79.58	24	6	8	30	-	50	Safe	Ok	-	-	-	0.84	39%	
81306146	106.10	27	9	9	30	-	50	Safe	Ok	200	400	0.88	0.89	71%	
81306148	5.49	25	9	9	30	-	50	Safe	Ok	-	-	-	0.83	44%	
81306149	106.10	29	6	8	30	-	50	Safe	Ok	-	-	-	0.76	44%	Low PF
81406158	35.98	54	6	6	31	-	25	Safe	Not Ok	125	380	-	0.77	42%	Low PF
81306124-5	115.75	35	6	6	30	90	100	Safe	Not Ok	180	400	0.85	0.86	69%	
81306131-1	53.05	-	5	5	30	-	-	Safe	Not Ok	100	-	-	0.77	84%	Low PF
81306131-5	79.58	51	6	6	22	90	-	Safe	Not Ok	180	460	0.85	0.79	97%	Low PF

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

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

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
1	81306139	Pump No. 11 LBDC	102	29.828	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	110.423	25.3	Flow at Existing Operating Conditions	15.97	56%
2	101.485	29.5	Flow nearest to duty point	16.40	59%
2	81306131-5	Akber Tank Water Works	102	22.371	

Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	168.63	22.1	Flow at Existing Operating Conditions	21.80	55%
2	103.96	36.2	Flow nearest to duty point	19.98	60%

2.4.3 Wastewater Disposal System

The MC has two (2) disposal station having twelve (12) pumps for suction of wastewater from collecting tanks to main sewage drain. All these pumps are manual and run as per requirement.

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

Table 18: Disposal Performance Parameters

Sr No	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	PITCO Comments
1	81306136-A	2/4L Disposal	713.6	695.0	7.92	31.10	57%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 48%.
2	81306136-B	2/4L Disposal	713.6	519.7	7.92	21.70	61%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 37%.
3	81306136-C	2/4L Disposal	713.6	562.2	10.97	42.00	47%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 49%.
4	81306136-D	2/4L Disposal	713.6	544.9	10.97	47.60	40%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 46%.
5	81306136-E	2/4L Disposal	713.6	-	-			This pumpset is non-functional. Motor is faulty. Previously, the pumpset was non-functional.
6	81306136-F	2/4L Disposal	713.6	511.2	7.92	26.90	48%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 58%.
7	81306136-G	2/4L Disposal	509.7	-	-			This pumpset is non-functional. Motor is faulty. Previously, the efficiency of the pumpset was 58%.
8	81306150-A	1/4 L Disposal	407.8	552.0	10.36	35.30	52%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 42%.
9	81306150-B	1/4 L Disposal	509.7	-	11.43	33.40		No reliable readings for the flow could be measured as there was not enough water available in well. Previously, the pumpset was non-functional.
10	81306150-C	1/4 L Disposal	509.7	398.8	11.43	35.00	42%	Efficiency of the pumpset is satisfactory. Previously, the pumpset was non-functional.
11	81306150-D	1/4 L Disposal	509.7	441.9	11.43	35.20	46%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 59%.
12	81306150-E	1/4 L Disposal	509.7	218.8	11.43	21.10	38%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, the efficiency of the pumpset was 58%.

Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are nineteen (19) dewatering sets in the MC, out of which 15 are functional. It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.

Figure 7: Dewatering Sets

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

2.5 Proposed Resource Efficiency Measures- Water Pumps and Disposals

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

Table 19: Water Pumps and Wastewater Disposal System: Recommendations for improvement

Sr No.	Unique ID	Location	Comments	Recommendation
Pumps				
1	81306133	Pump No. 18 LBDC	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.
2	81306134	Pump No. 15 LBDC	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
3	81306142	Pump No. 8 LBDC	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.
4	81306145	Pump No. 5 LBDC	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
5	81306146	Pump No. 4 LBDC	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
6	81306149	Pump No. 1 LBDC	The power factor at the site is below	A 2.5 kVAr capacitor should be installed on each

Sr No.	Unique ID	Location	Comments	Recommendation
			0.8. Efficiency of the pumpset is below 55%	phase. It is recommended to replace the pumpset.
7	81406158	Pump No. 22 Rajbaha 42	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
8	81306131-1	Akber Tank Water Works	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.
9	81306131-5	Akber Tank Water Works	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
10	81306136-A	2/4L Disposal	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
11	81306136-B	2/4L Disposal	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
12	81306136-D	2/4L Disposal	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
13	81306136-F	2/4L Disposal	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
14	81306150-A	1/4 L Disposal	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
15	81306150-E	1/4 L Disposal	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
General Observations				
16	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
17	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 LESCO during the entire year are given in Annexure 1.
18	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.
19	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 Okara MC and gathered detailed information about streetlights including their numbers, pole/fixture types and operation details. Details of the surveyed lights are provided in the following tables.

Table 20: Inventory Detail of Streetlights

	Streetlights	MC Operated	Privately Operated
Operational Street Lights	1,307	1,307	N/A
Non-Operational Street Lights	1,721	1,721	N/A
Total	**3,028**	**3,028**	**N/A**

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

Out of the total streetlights operated by MC, there are 882 light fixtures installed on PC, 1304 fixtures are installed on steel structure, 285 fixtures are installed on tubular structure, 5 fixtures are installed on trees, 26 fixtures are installed on wires, 1 fixture is installed on a gate, 6 fixtures are installed on a ground and 207 fixtures are installed on walls. The streetlights' structural classification is tabulated below.

Table 21: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Tree	Wire	Gate	Wall Mounted	Ground	Grand Total
MC	882	1,304	285	5	26	1	207	6	2,716
Private	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

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

Table 22: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Benazir Road	69	44114312201300	2.07
2	Tank Chowk	38	44-11431-2201100	1.24
3	Sindhu Colony	256	44-11431-2201200	11.74
4	Saith Colony	121	44-11412-0618400	4.02
5	Mustafa Park	99	44-11412-0472900	4.22
6	G.T Road	87	44-11431-2200301	1.85
7	Government Colony 2	103	44-11412-0943203	4.59
8	Government Colony 1	125	44-11412-0948500	5.67
9	Chak No. 1-4L	137	44-11412-1329701	5.38
10	Faisalabad Road	146	44-11412-2198801	5.05
11	Rehmat Pura	37	44-11412-0779204	3.02
12	Sidra Ghafoor Colony	17	44-11431-2201601	0.65
13	Sabri Colony	47	44-11431-2201600	2.42
14	Chak No. 2-4L	100	44-11431-2201500	4.73
15	Akbar Road	110	44-11431-2201400	5.34

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
16	Mehboob Alam Chowk	64	06-11431-0565000	3.50
17	Data Chowk	62	44-11412-0494200	3.57
18	Model Town	52	44-11412-0653401	2.25
19	Rehmatullah Town	155	44-11412-0745000	7.54
20	Qadir Colony	32	44-11412-1044500	2.05
21	Press Corner Road	92	44-11412-0373000	2.77
22	Fector Chowk	4	44-11412-0625606	0.04
23	MCB Chowk	76	44-11431-2201200	3.33
24	Ada Tanga Deepalpor Road	82	44-11412-0107700	2.32
25	People Chowk	81	44-11412-0236200	3.36
26	Court Liaqat Hayat	31	44-11431-2200200	1.32
27	Faisal Mehmood Colony	56	44-11431-2200300	2.51
28	Sheikh Basti	31	44-11431-2200500	1.52
29	Garden Town	73	44-11431-2200400	3.07
30	Court Ameer Ali Shah	67	44-11434-2201002	2.37
31	Palace Chowk	57	44-11434-2201004	2.21
32	Samad Pura	146	44-11434-2198000 44-11434-2201000	6.05
33	People Colony	47	44-11434-2200900	2.15
34	Rafi Colony	41	44-11434-2201006	1.55
35	Sadiq Nagar	57	44-11434-2200100	2.43
36	Ghazi Abad	38	44-11434-2197800	1.36
37	Ada Road	74	44-11434-2197900	1.92
38	Riyaz-ul-Muslimeen	37	44-11434-2199300	1.76
39	Rehman Colony	81	44-11412-0616400	5.05

Out of the 3,028 surveyed lights in the MC, 1,307 lights were found to be operational. Details are given in the following table:

Table 23: Details of Operational Streetlights

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours[5]	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	12	85		12.0	4,468	0
LED	18	147		12.0	11,589	0
LED	20	2		12.0	175	0
LED	24	4		12.0	420	0
LED	25	7		12.0	767	0
LED	30	159		12.0	20,893	0
LED	40	105		12.0	18,396	0
LED	50	446		12.0	97,674	0
LED	100	21		12.0	9,198	0
LED	120	62		12.0	32,587	0
LED	150	2		12.0	1,314	0
LED	200	1		12.0	876	0
CFL	12	27		12.0	1,419	0
CFL	16	5		12.0	350	0
CFL	18	1		12.0	79	0
CFL	20	1		12.0	88	0
CFL	30	9		12.0	1,183	0
CFL	40	2		12.0	350	0
CFL	42	46		12.0	8,462	0
CFL	60	2		12.0	526	0
CFL	65	34		12.0	9,680	0
CFL	85	5		12.0	1,862	0

[5] Based on Interview with Client.

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours[5]	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
Tube Light	40	22		12.0	3,854	0
Mercury Bulb	120	4		12.0	2,102	0
Sodium Light	250	107		12.0	117,165	0
ILB	100	1		12.0	438	0
Total					**345,915**	-

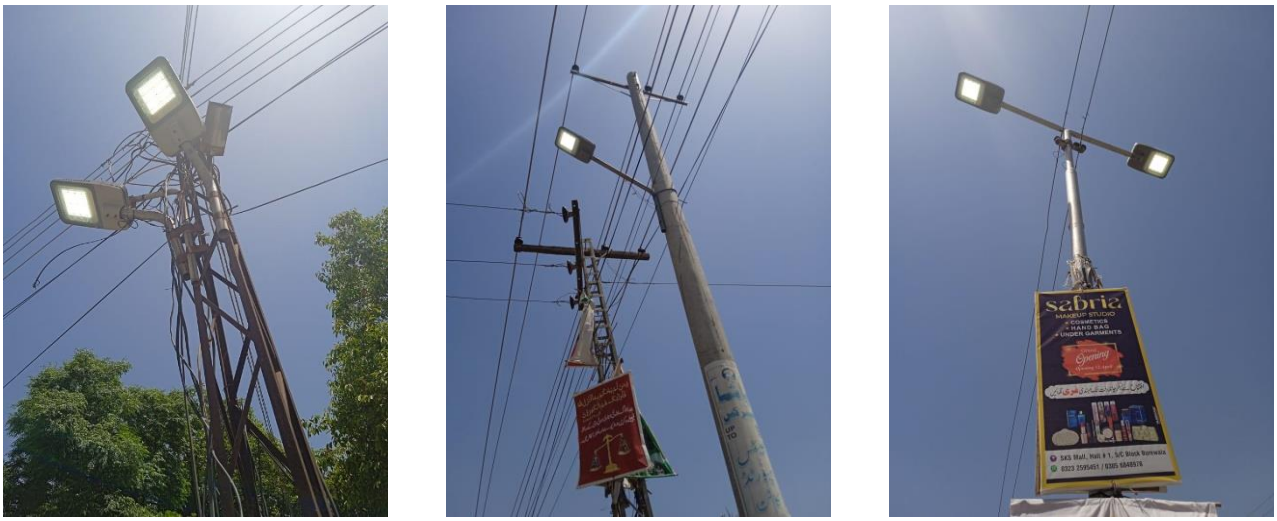


Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

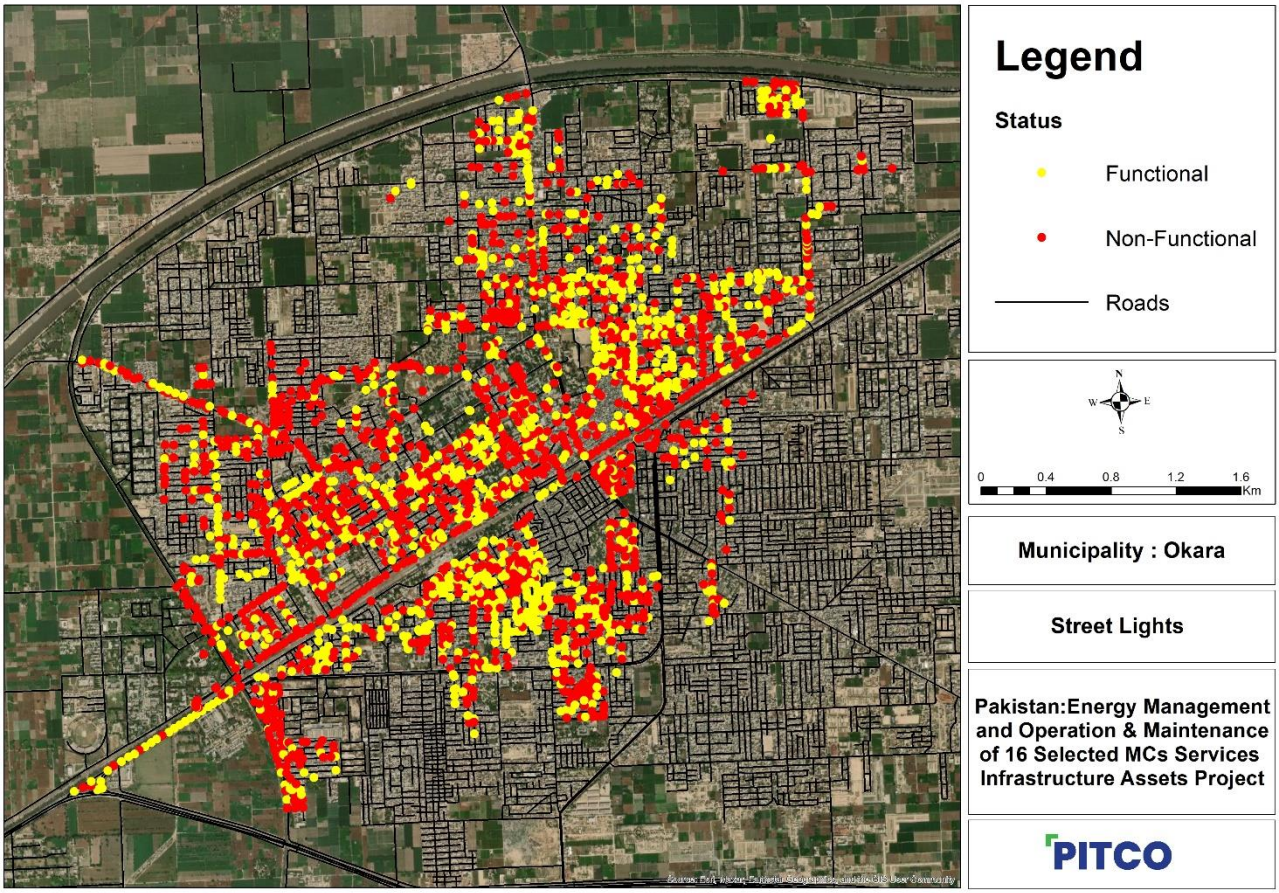


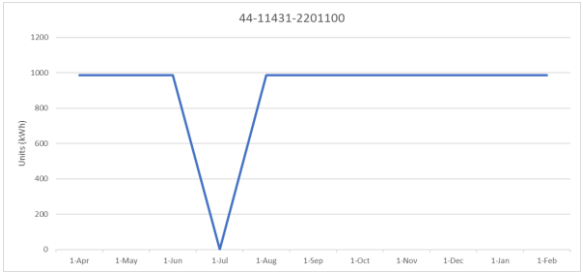
Figure 9: GIS Mapping of street lights in Okara MC

3.3 Baseline Energy Consumption Trend

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

Table 24: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy consumed	kWh/y	144,964
Total number of operational lights	No.	1,307

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Units (kWh)
1000
900
800
700
600
500
400
300
200
100
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11412-0618400
Units (kWh)
2500
2000
1500
1000
500
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb


44-11431-2200301
Units (kWh)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
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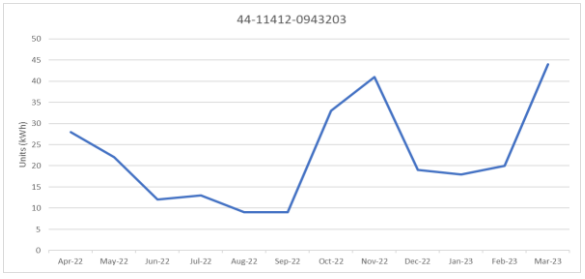
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11412-0943203
Units (kWh)
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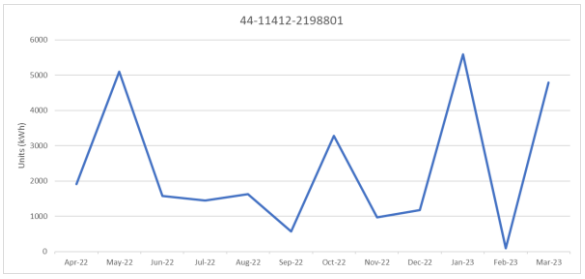
45
40
35
30
25
20
15
10
5
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23


44-11412-0948500
Units (kWh)
350
300
250
200
150
100
50
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23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Units (kWh)
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5000
4000
3000
2000
1000
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23


44-11412-0779204
Units (kWh)
25
20
15
10
5
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23


44-11431-2201600
Units (kWh)
1600
1400
1200
1000
800
600
400
200
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23

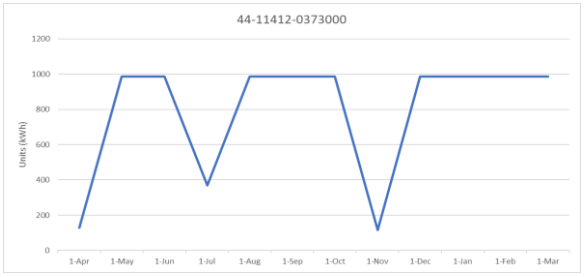

44-11431-2201400
Units (kWh)
120
100
80
60
40
20
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23


06-11431-0565000
Units (kWh)
350
300
250
200
150
100
50
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23


44-11412-0494200
Units (kWh)
700
600
500
400
300
200
100
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23


44-11412-0653401
Units (kWh)
140
120
100
80
60
40
20
0
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23


44-11412-0745000
Units (kWh)
0
100
200
300
400
500
600
700
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23


44-11412-0373000
Units (kWh)
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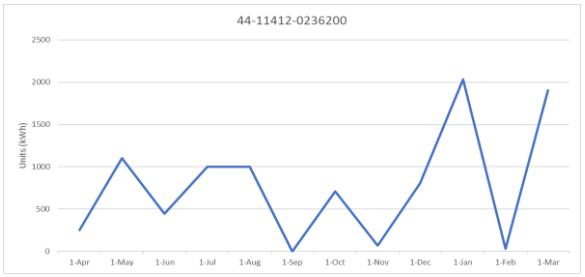
200
400
600
800
1000
1200
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11412-0625606
Units (kWh)
0
50
100
150
200
250
300
350
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11431-2201200
Units (kWh)
0
100
200
300
400
500
600
700
800
900
1000
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11412-0107700
Units (kWh)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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1000
1500
2000
2500
1-Apr
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1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11431-2200200
Units (kWh)
0
100
200
300
400
500
600
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11431-2200300
Units (kWh)
0
50
100
150
200
250
300
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11431-2200500
Units (kWh)
0
20
40
60
80
100
120
140
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11431-2200400
Units (kWh)
0
50
100
150
200
250
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
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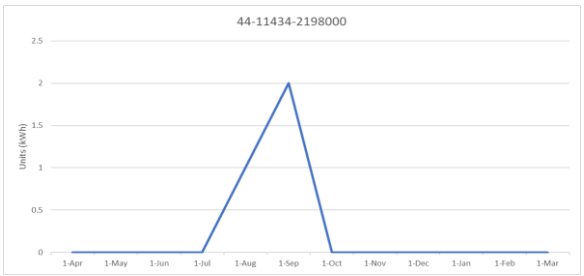
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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1.5
2
2.5
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


44-11434-2201000
Units (kWh)
0
50
100
150
200
250
300
350
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar

Figure 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	897	1,307	208,775	144,964	63,811	2,836 kWh/km	1,133 kWh/km	Based on the previous assessment, there were only 897 operational lights with an average consumption of 232kWh/light/annum, whereas, currently there are 1307 operational lights with average energy consumption of 110.9kWh/light/annum.

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 Okara.

3.5 Observations

- All Streetlights in Okara MC are operated by MC.
- All operational streetlights are LEDs.
- Approximately 6% of the LED streetlights have a rating of 120 Watts.
- Okara MC is not maintaining any record or database of streetlights.

3.6 Action plan for Energy Efficiency Measures – Streetlights

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

Table 25: Streetlights - recommendations for improvement

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

Table 26: Vehicle Inventory Detail

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (CC/HP)
1	SAJ-718	Truck	Hino	NR-300	2022	4WD	No task assigned	50012	104600011	4009
2	SAJ-708	Truck	Hino	NR-300	2022	4WD	No task assigned	50009	104600008	4009
3	SAJ-709	Truck	Hino	NR-300	2022	4WD	Transport of Solid Waste	50003	804600006	4009
4	SAJ-706	Truck	Hino	NR-300	2022	4WD	Transport of Solid Waste	50011	4600010	4009
5	SAJ-705	Truck	Hino	NR-300	2022	4WD	Transport of Solid Waste	50004	4600007	4009
6	SAJ-711	Truck	Hino	NR-300	2022	4WD	No task assigned	50026	404600021	4009
7	SAJ-713	Truck	Hino	NR-300	2022	4WD	No task assigned	50010	304600009	4009
8	SAJ-716	Truck	Hino	NR-300	2022	4WD	No task assigned	50002	604600005	4009
9	SAJ-714	Truck	Hino	NR-300	2022	4WD	Transport of Solid Waste	50001	404600004	4009
10	SAJ-712	Truck Hydraulic Aerial Plant form	Hino	NR-300	2022	4WD	Use By Lighting Branch	10109	308000000	4009
11	SAJ-699	Tractor Front loader	Millat	MF-385	2022	4WD	No task assigned	507181-H	85499/02/22	85HP
12	SAJ-698	Tractor Front blade	Millat	MF-385	2022	4WD	No task assigned	506700-H	85388/02/22	85HP
13	SAJ-702	Tractor Front blade	Millat	MF-385	2022	4WD	Transport of Solid Waste	506690-H	85388/03/22	85HP
14	SAJ-703	Tractor Front loader	Millat	MF-385	2022	4WD	Transport of Solid Waste	506653-H	85379/04/22	85HP
15	Unregistered Vehicle 1	Wheel Excavator	Doosan	Dx140W	2022	4WD	Transport of Solid Waste	DB58TIS143866E01	DHKCFWAZTM5005919	137HP
16	SAJ-734	Car	Suzuki	Bolan	2022	2WD	Equipment Transport	1016363	113292	796
17	SAJ-715	Truck	Hino	NR-500	2022	4WD	Transport of Solid Waste	10415	FG8JKLB10217	4465
18	SAJ-710	Truck	Hino	NR-500	2022	4WD	Transport of Solid Waste	10417	FG8JKLB10219	4465
19	SAJ-731	Car Mini tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	376238	480892	796
20	SAJ-728	Car Mini tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	376282	481031	796
21	SAJ-727	Car Mini tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	374956	479525	796
22	SAJ-730	Car Mini tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	375008	479726	796
23	SAJ-726	Car Mini tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	377784	482446	796
24	SAJ-732	Car Mini tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	376638	481277	796
25	SAJ-729	Car Mini tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	376583	481238	796
26	SAJ-725	Car Mini tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	376726	481426	796
27	OK-3861	Car	Suzuki	Mehran	1991	2WD	Transport of Staff	N/A	N/A	796
28	KSA-4913	Car	Suzuki	FX	1992	2WD	N/A	N/A	N/A	796
29	OkA-8800	Car	Nissan	Sunny	1989	2WD	N/A	166195	1267	1600
30	Unregistered Vehicle 2	Truck Sucker Machine	Hino	FGIJ500	1996	4WD	Suction	30927E	PKB21G00404	4465
31	Unregistered Vehicle 3	Truck Jetting Machine	Hino	FGIJ500	2007	4WD	Jetting	J08CFM118554	14707	4465

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 (CC/HP)
32	Unregistered Vehicle 4	Tractor	Millat	MF-240	2007	2WD	Water Browser	140481	1867501	50HP
33	Unregistered Vehicle 5	Truck	Bedford	N/A	1995	4WD	Firefighting	N/A	N/A	4500
34	Unregistered Vehicle 6	Truck	Bedford	N/A	1995	4WD	Firefighting	N/A	N/A	4500
35	Unregistered Vehicle 7	Truck	Bedford	N/A	1984	4WD	Firefighting	N/A	N/A	4500
36	Unregistered Vehicle 8	Water Bowser	Hino	N/A	1995	4WD	N/A	11411	Fb113k4/15504	4500
37	Unregistered Vehicle 9	Tractor Trolley	Millat	MF-375	2015	4WD	Transport of Solid Waste	LM9B602V514563F	K12175/12/15	75HP
38	Unregistered Vehicle 10	Tractor Trolley	Millat	MF-375	2015	4WD	Transport of Solid Waste	LM9B602V514568A	K72175/11/15	75HP
39	Unregistered Vehicle 11	Tractor Front blade	Millat	MF-375	2015	4WD	Transport of Solid Waste	LM9B602V514579A	K72176/03/45	75HP
40	Unregistered Vehicle 12	Tractor	Millat	MF-385	2008	4WD	Digging machine	LM9B750V514582P	N/A	85HP
41	OK 7973	Tractor	Millat	MF-385	2001	4WD	N/A	LM9B70V501124G	N/A	85HP
42	Unregistered Vehicle 13	Tractor Container	Millat	MF-240	2008	2WD	Transport of Solid Waste	CE9900120560527P	N/A	50HP
43	OK 3591	Tractor Trolley	Millat	MF-240	2000	2WD	Transport of Solid Waste	N/A	N/A	50HP
44	Unregistered Vehicle 14	Tractor Front loader	Millat	MF-385	2015	4WD	Transport of Solid Waste	LM9B572502970A	G84522/03/15	85HP
45	Unregistered Vehicle 15	Tractor Trolley	Millat	MF-375	1996	4WD	Transport of Solid Waste	N/A	N/A	75HP
46	Unregistered Vehicle 16	Tractor Trolley	Millat	MF-375	1996	4WD	Transport of Solid Waste	N/A	N/A	75HP
47	OKC 3592	Tractor Trolley	Millat	MF-240	2000	2WD	Transport of Solid Waste	57111970	1686507	50HP
48	OK 3331	Tractor Trolley	Millat	MF-240	2007	2WD	Transport of Solid Waste	N/A	N/A	50HP
49	OK 7972	Tractor Trolley	Millat	MF-240	2000	2WD	Transport of Solid Waste	N/A	N/A	50HP
50	Unregistered Vehicle 17	Tractor Grass Cutter	Millat	MF-240	2001	2WD	Grass Cutter	N/A	N/A	50HP
51	OK 7974	Tractor Trolley	Millat	MF-385	2001	4WD	Transport of Solid Waste	N/A	053/15	85HP
52	OK 1005	Tractor Front loader	Millat	MF-385	2007	4WD	Transport of Solid Waste	N/A	N/A	85HP
53	OK 381	Tractor Trolley	Millat	MF-240	2007	2WD	Transport of Solid Waste	CE9900120557164P	N/A	50HP
54	OK-6733	Car	Suzuki	Mehran	1991	2WD	Transport of Staff	SB308PK623416	436764	796
55	OKG 3330	Tractor Trolley	Millat	MF-240	2007	2WD	Encroachment Department	CEG9900120541842N	943246	50HP
56	LXO-7047	Jeep	Suzuki	Potohar	1999	4WD	Transport of Staff	J107784	330207	1000
57	OKC-7876	Car	Suzuki	Cultus	2001	2WD	Transport of Staff	PB11727	953698	1000
58	Unregistered Vehicle 18	Truck Jetting Machine	Hino	Dutro	2007	4WD	Jetting	71031	JHFY20H206001205	4465
59	Unregistered Vehicle 19	Truck Sucker Machine	Hino	FGIJ500	2007	4WD	Suction	N/A	14342	4465
60	Unregistered Vehicle 20	Pickup	Suzuki	Ravi	2007	2WD	Equipment Transport	N/A	N/A	796
61	OKI-19-251	Jeep	Suzuki	Potohar	1983	4WD	Transport of Staff	F6A71191	JA11152	1000

4.2 Baseline Fuel Consumption Trend

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

Table 27: On-field fuel Consumption analysis of MC vehicles

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)				
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption
1	SAJ-718	2:35 PM	3:35 PM	0.24	0.24 Liters/hr	12:50 PM	2:35 PM	24	6.58	0.27 Liters/km
2	SAJ-709	2:12 PM	3:12 PM	10.99	10.99 Liters/hr	12:58 PM	2:12 PM	15	23.14	1.54 Liters/km
3	SAJ-732	2:10 PM	3:10 PM	0.9	0.9 Liters/hr	12:55 PM	2:10 PM	15	3.76	0.25 Liters/km
4	Unregistered Vehicle 14	14:50	15:50	1.29	1.29 Liters/hr	13:45	14:50		2.8	2.58 Liters/hr
5	OKC 3592	3:35 PM	4:35 PM	1.75	1.75 Liters/hr	2:20 PM	3:25 PM		6.24	5.76 Liters/hr

Table 28: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook	
		(liter/hr)	(km/ltr)
1	SAJ-706		3.56
2	SAJ-716		3.61
3	SAJ-714		3.57
4	Unregistered Vehicle 1	7.9	
5	SAJ-734		7.76
6	SAJ-715	5.3	
7	SAJ-710	5.3	
8	SAJ-731		6.14
9	SAJ-728		4.96
10	SAJ-727		6.07
11	SAJ-730		6.32
12	SAJ-726		6.57
13	SAJ-732		6.59
14	SAJ-729		6.24
15	SAJ-725		5.31

The logbooks of remaining vehicles are not available in MC.

The MC made 5 of its vehicles available to the Consultant for carrying out on-field testing. The average fuel consumption of the vehicles in idle condition was found to be 3.47 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 4.17 liters/hour and 0.69 Liter/km (for two vehicles with working odometers).

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

Table 29: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	19,320
Annual Cost of Fuel (Diesel)	PKR/y	5,660,760
Annual Consumption of Fuel (Petrol)	Liter/y	7,416
Annual Cost of Fuel (Petrol)	PKR/y	2,017,152

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 Okara 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 Okara 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 8 MC owned buildings in the MC. Detailed assessment of these is given in the following section

5.1 GIS Map

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

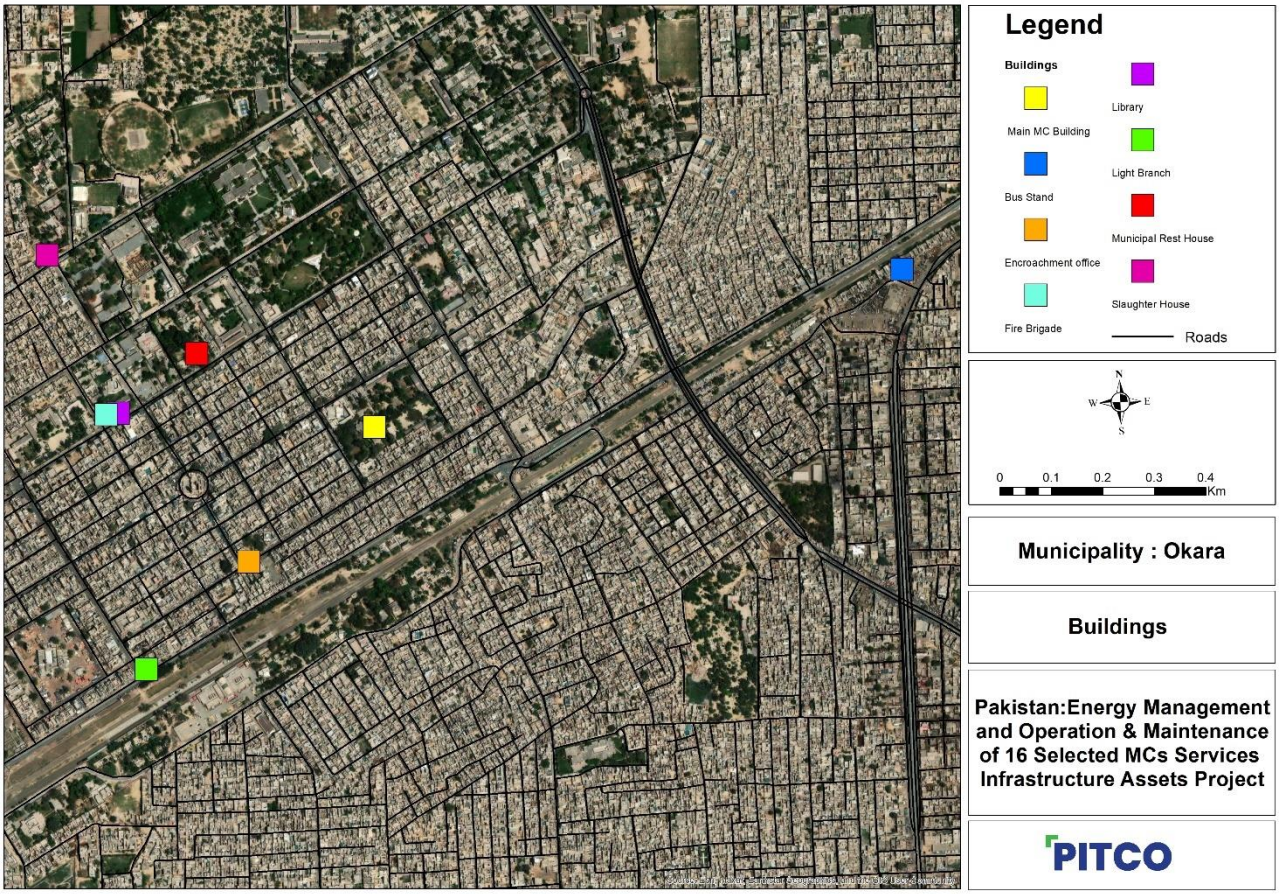

Figure 12: Map for Buildings

5.2 Building Details

Details of the MC buildings are given below.

Table 30: Buildings' Details

Sr. No.	Address	GPS	Unique ID	Ownership	Age of Building	Condition of Building	Total Area (m2)	Insulation of Building	Number of Floors
1	Library	N:30.810122 E:73.442854	81306127	MC	18	Satisfactory	2,023	No Proper Insulation	1
2	Encroachment office	N:30.80744 E:73.44537	81406154	MC	53	Un-Satisfactory	101	No Proper Insulation	1
3	Municipal Rest House	N:30.811113 E:73.444483	81306153-1	MC	N/A	Satisfactory	1,000	No Proper Insulation	1
4	Light Branch	N:30.80564 E:73.44321	81406155	MC	63	Satisfactory	126	No Proper Insulation	1
5	Fire Brigade	N:30.810108 E:73.442602	81306128	MC	43	Satisfactory	250	No Proper Insulation	1
6	Slaughter House	N:30.812928 E:73.441542	81306130	MC	43	Satisfactory	607	No Proper Insulation	1
7	Bus Stand	N:30.812084 E:73.458825	81306153-2	MC	N/A	Satisfactory	100.04	No Proper Insulation	1
8	Main MC Building	N:30.809700 E:73.448017	81306153	MC	43	Satisfactory	10775	No Proper Insulation	2

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

Table 31: Number of Heating Units in MC Buildings

Sr. No.	Name of Room	Type of Heating Equipment	Equipment Count	Capacity in Watts	Daily operating hours[6]	No. of months used per year	Operating days per year	Annual Energy consumption (kWh/year)
Municipal Rest House								
1	**Kitchen**	Electric Heater	1	1000	0	0	0	0
Bus Stand								
1	**Main office**	Electric Heater	1	1000	2	4	104	208
Main MC Building								
1	**IT Section**	Electric Heater	1	1000	0	0	0	0
2	**Pension section**	Electric Heater	1	1000	0	0	0	0
3	**Budget Section**	Electric Heater	1	1000	0	0	0	0
4	**IPS Superintendent**	Electric Heater	2	1000	0	0	0	0
	Total							**208**

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

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Library								
1	**Office**	Ceiling Fan	2	80	6	8	208	200
2	**Reading Room**	Bracket Fan	8	50	7	8	208	582
3	**Reading Room**	Ceiling Fan	2	80	4	8	208	133
4	**Library Incharge**	Ceiling Fan	1	80	4	8	208	67
5	**Library Incharge**	Window AC	1	0	0	0	0	0
6	**Reading Room 3**	Bracket Fan	8	50	4	8	208	333
7	**Reading Room 3**	Ceiling Fan	2	80	3	8	208	100
8	**Newspaper Record**	Ceiling Fan	2	80	2	8	208	67
9	**Reading Room**	Ceiling Fan	1	80	4	8	208	67
10	**Newspaper Room**	Ceiling Fan	1	80	6	8	208	100
11	**Union Council**	Ceiling Fan	1	80	8	8	208	133
12	**Store 1**	Ceiling Fan	2	80	2	8	208	67
13	**Store 2**	Ceiling Fan	2	80	2	8	208	67
Encroachment Office								
1	**Room 1**	Ceiling Fan	1	80	8	8	208	133
2	**Office**	Ceiling Fan	1	80	8	8	208	133
Municipal Rest House								
1	**Washroom Room**	Ceiling Fan	1	80	14	8	208	233
2	**Open Area**	Ceiling Fan	1	80	4	8	208	67
3	**Rest Room 1**	Ceiling Fan	1	80	10	8	208	166
4	**Rest Room 1**	Split AC	1	1800	4	6	156	1,123
5	**Rest Room 2**	Ceiling Fan	4	80	10	8	208	666
6	**Rest Room 2**	Pedestal Fan	1	125	2	8	208	52
7	**Open Hall**	Ceiling Fan	1	80	8	8	208	133
8	**Rest Room 4**	Ceiling Fan	1	80	10	8	208	166
9	**Rest Room 4**	Split AC	1	1800	4	6	156	1,123
10	**Rest Room 3**	Ceiling Fan	1	80	10	8	208	166
11	**Rest Room 3**	Window AC	1	5000	1	6	156	780
12	**Rest Room 3**	Exhaust Fan	1	30	2	8	208	12
13	**Rest Room 5**	Ceiling Fan	1	80	10	8	208	166
14	**Rest Room 5**	Window AC	1	5000	1	6	156	780
Light Branch								
1	**Light Branch Office**	Ceiling Fan	1	80	6	8	208	100
2	**Light Branch Office**	Air Cooler	1	125	2	8	208	52
Fire Brigade								
1	**Staff Room**	Ceiling Fan	2	80	12	8	208	399
2	**Open Area**	Ceiling Fan	1	80	12	8	208	200
3	**Superintendent Office**	Ceiling Fan	1	80	12	8	208	200

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
				Bus Stand				
1	**Main office**	Exhaust Fan	1	30	0	0	0	0
2	**Main office**	Inverter Ac	1	1452	4	6	156	906
3	**Main office**	Bracket Fan	2	50	8	8	208	166
4	**Main office**	Pedestal Fan	1	125	4	6	156	78
				Main MC Building				
1	**CO Office**	Ceiling Fan	2	80	4	8	208	133
2	**CO Office**	Inverter	1	1452	2	4	104	302
3	**General Branch**	Ceiling Fan	1	80	8	8	208	133
4	**Administration Office**	Bracket Fan	5	50	2	8	208	104
5	**Administration Office**	Inverter	1	1452	2	4	104	302
6	**Administration Office**	Exhaust Fan	1	30	0	8	208	0
7	**PA2 Administration**	Ceiling Fan	1	80	8	8	208	133
8	**PA1 Administration**	Ceiling Fan	1	80	8	8	208	133
9	**PA1 Administration**	Split AC	1	1650	4	4	104	686
10	**Superintendent office**	Bracket Fan	2	50	4	8	208	83
11	**Superintendent office**	Inverter	1	1452	4	4	104	604
12	**Superintendent office**	Exhaust Fan	2	30	4	8	208	50
13	**Gallery**	Ceiling Fan	3	80	6	8	208	300
14	**One Window Cell**	Ceiling Fan	3	80	8	8	208	399
15	**One Window Cell**	Split AC	1	2700	0	0	0	0
16	**One Window Cell**	Split AC	1	1150	4	6	156	718
17	**Revenue Section**	Ceiling Fan	1	80	8	8	208	133
18	**IT office**	Ceiling Fan	1	80	8	8	208	133
19	**IT office**	Inverter Ac	1	1452	4	6	156	906
20	**Tax Section**	Ceiling Fan	2	80	8	8	208	266
21	**Pension Section**	Ceiling Fan	1	80	8	8	208	133
22	**Sanitation Branch**	Ceiling Fan	1	80	8	8	208	133
23	**Sanitation Branch**	Window AC	1	0	0	0	0	0
24	**CBA Room**	Ceiling Fan	1	80	8	8	208	133
25	**Budget Section**	Ceiling Fan	1	80	8	8	208	133
26	**Budget Section**	Split AC	1	0	0	0	0	0
27	**Budget Section**	Bracket Fan	1	50	8	8	208	83
28	**MOF office**	Ceiling Fan	1	80	4	8	208	67
29	**MOF office**	Split AC	1	1800	4	6	156	1,123
30	**Gallery 2**	Ceiling Fan	2	80	6	8	208	200
31	**Meeting Hall**	Ceiling Fan	15	80	2	8	208	499
32	**IPS Superintendent**	Ceiling Fan	1	80	8	8	208	133
33	**IPS Office**	Ceiling Fan	2	80	8	8	208	266
34	**IPS Office**	Window AC	1	5000	4	6	156	3,120
35	**IPS Office**	Bracket Fan	1	50	8	8	208	83
36	**IPS Office**	Exhaust Fan	2	30	4	8	208	50
37	**P&S officer**	Ceiling Fan	1	80	4	8	208	67

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
38	P&S officer	Split AC	1	1452	2	6	156	453
39	Vehicle Superintendent Branch	Ceiling Fan	2	80	6	8	208	200
40	Vehicle Superintendent Branch	Exhaust Fan	1	30	4	8	208	25
41	Vehicle Superintendent Branch	Split AC	1	1800	2	66	1716	6,178
42	Sanitary Inspector	Ceiling Fan	1	80	6	8	208	100
43	Death of Birth branch	Ceiling Fan	1	80	8	8	208	133
44	Death of Birth branch	Split AC	1	2700	2	6	156	842
45	Dispatch Branch	Ceiling Fan	1	80	8	8	208	133
46	Record room	Ceiling Fan	1	80	8	8	208	133
47	Planning Branch Record Room	Ceiling Fan	2	80	8	8	208	266
48	MOP office	Ceiling Fan	1	80	4	8	208	67
49	MOP office	Split AC	1	1650	2	6	156	515
50	MOP office	Bracket Fan	1	50	4	8	208	42
51	Assistant Planning Branch	Bracket Fan	1	50	8	8	208	83
52	Superintendent water dispenser	Ceiling Fan	1	80	8	8	208	133
53	Superintendent water dispenser	Exhaust Fan	1	30	4	8	208	25
54	Superintendent office	Ceiling Fan	1	80	8	8	208	133
55	Superintendent office	Exhaust Fan	1	30	6	8	208	37
56	Superintendent office	Bracket Fan	1	50	8	8	208	83
57	Death of birth branch	Ceiling Fan	2	80	8	8	208	266
58	Death of birth branch	Exhaust Fan	1	30	4	8	208	25
59	Complaint Cell office	Ceiling Fan	1	80	8	8	208	133
60	Complaint Cell office	Air Cooler	1	125	6	6	156	117
61	Finance Section	Ceiling Fan	1	80	8	8	208	133
62	Regulation branch	Ceiling Fan	1	80	8	8	208	133
63	Regulation branch	Exhaust Fan	1	30	6	8	208	37
64	Litigation Branch	Ceiling Fan	1	80	6	8	208	100
65	Litigation Branch	Split AC	1	1800	2	6	156	562
66	Litigation Branch	Exhaust Fan	1	30	2	8	208	12
67	Kachiabadi	Ceiling Fan	1	80	8	8	208	133
68	Store	Ceiling Fan	2	80	1	8	208	33
69	Store 2	Ceiling Fan	1	80	1	8	208	17
70	Store 2	Pedestal Fan	1	125	0	0	0	0
71	Sub-Engineer office	Ceiling Fan	1	80	4	8	208	67
72	Sub-Engineer office	Split AC	1	1800	4	6	156	1,123
73	Sub-Engineer office	Exhaust Fan	1	30	2	8	208	12
74	Garden Branch	Ceiling Fan	1	80	6	8	208	100
75	Store 3	Ceiling Fan	1	80	2	8	208	33
76	Gallery 4	Ceiling Fan	1	80	6	8	208	100
77	Ware House	Ceiling Fan	1	80	2	8	208	33
78	Ware House	Air Cooler	2	125	0	0	0	0
79	Audit of Account Office	Ceiling Fan	1	80	4	8	208	67
80	Audit of Account Office	Split AC	1	1650	1	4	104	172

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
81	**Audit of Account Office**	Bracket Fan	1	50	4	8	208	42
82	**Deputy director audit & account**	Ceiling Fan	1	80	4	8	208	67
83	**Deputy director audit & account**	Split AC	1	1650	1	4	104	172
84	**Record Room**	Ceiling Fan	1	80	1	8	208	17
85	**Kachiabadi Store 4**	Ceiling Fan	1	80	1	8	208	17
	Total							34,961

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

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Energy consumption (kWh/year)
Library							
1	**Office**	CFL	7	25	0	312	0
2	**Office**	LED	6	18	8	312	270
3	**Reading Room**	CFL	23	18	0	312	0
4	**Reading Room**	LED	9	18	8	312	404
5	**Reading Room**	CFL	3	25	6	312	140
6	**Reading Room 2**	LED	2	18	6	312	67
7	**Library Incharge**	Tube light	2	40	6	312	150
8	**Library Incharge**	CFL	2	25	6	312	94
9	**Library Incharge**	LED	2	12	8	312	60
10	**Library Incharge**	CFL	3	18	0	312	0
11	**Reading Room 3**	CFL	8	25	0	312	0
12	**Reading Room 3**	LED	11	18	4	312	247
13	**Reading Room 3**	CFL	24	18	0	312	0
14	**Reading Room 4**	Tube light	2	40	0	312	0
15	**Reading Room 4**	CFL	1	25	6	312	47
16	**Newspaper Room**	CFL	1	18	0	312	0
17	**Newspaper Room**	LED	6	18	8	312	270
18	**Union Council Room**	LED	2	18	8	312	90
19	**Union Council Room**	LED	1	40	0	312	0
Encroachment office							
1	**Room 1**	LED	4	18	8	312	180
2	**Room 1**	LED	1	12	8	312	30
3	**Office**	LED	1	30	8	312	75
4	**Office**	LED	4	7	6	312	52
5	**Outside**	LED	1	12	10	312	37
Municipal Rest House							
1	**watchman room**	LED	1	18	12	312	67
2	**Open Area**	LED	3	12	8	312	90
3	**Rest Room 1**	Tube light	2	40	8	312	200

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

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Energy consumption (kWh/year)
4	**Rest Room 1**	CFL	2	25	8	312	125
5	**Rest Room 1**	LED	5	18	10	312	281
6	**Washroom**	CFL	1	125	8	312	312
7	**Rest Room 2**	CFL	1	25	8	312	62
8	**Rest Room 2**	LED	1	12	8	312	30
9	**Rest Room 2**	LED	2	18	8	312	90
10	**Open Hall**	Tube light	1	40	0	312	0
11	**Open Hall**	LED	5	12	8	312	150
12	**Kitchen**	LED	3	12	10	312	112
13	**Rest Room 4**	LED	10	12	8	312	300
14	**Rest Room 3**	CFL	1	25	6	312	47
15	**Rest Room 3**	LED	7	12	6	312	157
16	**Rest Room 3**	Tube light	1	40	6	312	75
17	**Rest Room 3**	LED	2	18	6	312	67
18	**Rest Room 5**	Tube light	2	40	0	312	0
19	**Rest Room 5**	CFL	1	25	6	312	47
20	**Rest Room 5**	LED	5	12	8	312	150
21	**Outside**	LED	6	50	10	312	936
22	**Outside**	LED	2	12	12	312	90
23	**Outside**	LED	1	40	10	312	125
Light Branch							
1	**Light Branch office**	CFL	1	65	8	312	162
2	**Washroom**	CFL	1	25	4	312	31
3	**Outside**	CFL	1	42	8	312	105
4	**Outside**	LED	1	12	8	312	30
Fire Brigade							
1	**Staff Room**	Tube light	1	40	0	312	0
2	**Staff Room**	LED	2	12	12	312	90
3	**Open Area**	ILB	1	100	12	312	374
4	**Open Area**	CFL	1	45	12	312	168
5	**Open Area**	LED	2	12	12	312	90
6	**Superintendent office**	LED	1	12	8	312	30
7	**Superintendent office**	LED	1	18	8	312	45
Slaughter House							
1	**Open Area**	ILB	1	100	8	312	250
2	**Open Area**	LED	3	18	8	312	135
3	**Open Area**	LED	1	50	8	312	125
4	**Shade**	ILB	6	100	8	312	1,498
Bus Stand							
1	**Main office**	LED	2	18	8	312	90
Main MC Building							
1	**CO Office**	Tube light	1	40	0	312	0
2	**CO Office**	CFL	1	125	0	312	0

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Energy consumption (kWh/year)
1	CO Office	LED	6	7	8	312	105
2	CO Office	LED	2	12	4	312	30
3	General Branch	Tube light	2	40	8	312	200
4	General Branch	CFL	1	25	8	312	62
5	General Branch	LED	1	18	8	312	45
6	Administration Office	LED	6	50	2	312	187
7	Administration Office	LED	2	12	2	312	15
8	PA2 Administration	LED	1	12	8	312	30
9	PA1 Administration	Tube light	1	40	0	312	0
10	PA1 Administration	LED	2	18	8	312	90
11	Superintendent Office	LED	2	50	8	312	250
12	Superintendent Office	LED	5	40	2	312	125
13	Superintendent Office	LED	1	12	4	312	15
14	Gallery 1	CFL	2	25	8	312	125
15	Gallery 1	LED	1	18	8	312	45
16	Gallery 1	LED	3	50	0	312	0
17	One Window Cell	LED	16	18	8	312	719
18	Revenue Section	Tube light	3	40	8	312	300
19	Revenue Section	LED	2	12	8	312	60
20	IT officer	Tube light	3	40	8	312	300
21	IT officer	CFL	1	25	8	312	62
22	Tax Section	Tube light	3	40	8	312	300
23	Tax Section	LED	1	18	8	312	45
24	Pension Section	Tube light	3	40	8	312	300
25	Pension Section	LED	1	18	8	312	45
26	Sanitation Branch	Tube light	2	40	8	312	200
27	Sanitation Branch	CFL	1	12	8	312	30
28	CBA Room	Tube light	2	40	8	312	200
29	CBA Room	CFL	2	12	6	312	45
30	Budget Section	LED	5	18	8	312	225
31	Budget Section	LED	1	6	4	312	7
32	MOF office	CFL	1	12	2	312	7
33	MOF office	LED	4	50	8	312	499
34	MOF office	LED	1	18	8	312	45
35	Gallery 2	CFL	3	18	4	312	67
36	Meeting Hall	CFL	24	18	2	312	270
37	Meeting Hall	LED	2	18	12	312	135
38	Meeting Hall	CFL	6	42	2	312	157
39	Meeting Hall	LED	1	10	2	312	6
40	I&S Superintendent	LED	6	12	8	312	180
41	I&S office	CFL	2	25	8	312	125
42	I&S office	LED	3	18	8	312	135
43	I&S office	CFL	1	12	4	312	15

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Energy consumption (kWh/year)
44	**I&S office**	LED	3	18	8	312	135
45	**Gallery 3**	LED	1	18	8	312	45
46	**vehicle Superintendent Branch**	LED	3	18	8	312	135
47	**vehicle Superintendent Branch**	LED	2	7	8	312	35
48	**Sanitation Branch**	CFL	1	42	4	312	52
49	**Death of birth branch**	Tube light	1	40	4	312	50
50	**Death of birth branch**	LED	3	18	8	312	135
51	**death of birth branch**	Zero Bulb	1	12	4	312	15
52	**Dispatch Branch**	LED	2	18	8	312	90
53	**Record Room**	CFL	2	42	8	312	210
54	**Planning branch record room**	CFL	1	18	8	312	45
55	**Planning branch record room**	LED	2	18	8	312	90
56	**MOF office**	CFL	1	12	4	312	15
57	**MOF office**	LED	6	18	8	312	270
58	**Assistant planning branch**	CFL	1	12	4	312	15
59	**Assistant planning branch**	LED	5	18	8	312	225
60	**Superintendent water dispenser**	Tube light	3	40	8	312	300
61	**Superintendent water dispenser**	CFL	1	42	8	312	105
62	**Sub-Engineer office**	Tube light	2	40	8	312	200
63	**Sub-Engineer office**	LED	1	12	8	312	30
64	**Death of birth branch**	Tube light	1	40	8	312	100
65	**Death of birth branch**	LED	2	40	8	312	200
66	**Complaint Cell Office**	CFL	1	42	8	312	105
67	**Complaint Cell Office**	LED	1	12	8	312	30
68	**Open Area**	CFL	3	45	10	312	421
69	**Open Area**	LED	7	100	10	312	2,184
70	**Open Area**	Sodium Lights	4	250	10	312	3,120
71	**Open Area**	CFL	2	25	10	312	156
72	**Open Area**	LED	2	30	10	312	187
73	**Open Area**	LED	1	18	10	312	56
74	**Finance Section**	Tube light	2	40	0	312	0
75	**Finance Section**	CFL	1	18	4	312	22
76	**Finance Section**	LED	3	18	8	312	135
77	**Regulation Branch**	LED	1	18	8	312	45
78	**Litigation Branch**	CFL	1	42	4	312	52
79	**Litigation Branch**	LED	2	30	8	312	150
80	**Litigation Branch**	CFL	1	12	6	312	22
81	**Kachiabadi**	Tube light	3	40	0	312	0
82	**Kachiabadi**	CFL	1	42	8	312	105
83	**Store**	Tube light	3	40	1	312	37
84	**Store 2**	Tube light	1	40	1	312	12
85	**Sub-Engineer office**	Tube light	3	40	8	312	300
86	**Sub-Engineer office**	LED	2	30	8	312	150

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Energy consumption (kWh/year)
87	**Garden Branch**	Tube light	2	40	4	312	100
88	**Garden Branch**	CFL	1	12	2	312	7
89	**garden branch**	LED	2	30	4	312	75
90	**Store 3**	Tube light	2	40	1	312	25
91	**Gallery 4**	CFL	1	25	6	312	47
92	**Gallery 4**	LED	1	12	8	312	30
93	**Gallery 4**	LED	1	30	8	312	75
94	**Warehouse**	CFL	2	40	2	312	50
95	**Warehouse**	CFL	1	25	2	312	16
96	**Audit & Account Office**	LED	4	18	6	312	135
97	**Deputy Director Audit & Account**	LED	4	18	4	312	90
98	**Record Room Audit**	LED	1	18	2	312	11
99	**Kachiabadi Store 4**	Tube light	1	40	0	312	0
100	**Kachiabadi Store 4**	LED	1	12	2	312	7
	Total						**25,198**

5.3 Baseline Energy Consumption Trend

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

Table 34: Energy consumption in Office Buildings

SI No.	Description	Unit	Value[9]
1	Annual Electricity Consumption	kWh	62,005
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[9] Based on Utility Bills

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Buildings	6	8	66,356	44,211	22,145	3.67 kWh/m2	3.18 kWh/m2	Municipal resthouse and bus stand were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of municipal rest house building and bus stand have not been considered in the overall energy consumption and KPI calculations.

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

Table 35: Cooling Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Office	Ceiling Fan	73	0	71
MC Office	Air Cooler	6	0	3
MC Office	Split AC	10	0	12
MC Office	Inverter	1	0	4
MC Office	Window AC	1	1	1
MC Office	Exhaust Fan	11	0	12
MC Office	Bracket Fan	8	0	13
MC Office	Pedestal Fan	-		1
Library	Bracket Fan	9	0	16
Library	Ceiling Fan	18	0	16
Library	Window AC	1	1	0
Light Inspector Office	Ceiling Fan	1	0	1
Light Inspector Office	Air Cooler	-		1
Encroachment Office	Ceiling Fan	2	0	2
Encroachment Office	Air Cooler	1	0	0
Fire Brigade	Ceiling Fan	4	0	4

Table 36: Lighting Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Office	Tube Light	92	92	44
MC Office	LED	41	0	138
MC Office	CFL	89	89	67
MC Office	Incandescent light bulb	2	2	0
MC Office	Sodium Bulb	2	2	4
MC Office	Halogen light	9	9	0
MC Office	Zero Bulb	-	-	1
Library	CFL	148	148	72
Library	LED	1	0	39
Library	Tube Light	3	3	4
Slaughter House	Incandescent light bulb	10	10	7
Slaughter House	LED	-	-	4
Light Inspector Office	CFL	1	1	3
Light Inspector Office	LED	1	0	1
Encroachment Office	CFL	4	4	0
Encroachment Office	LED	-	-	11
Fire Brigade	CFL	5	5	1
Fire Brigade	Tube Light	1	1	1
Fire Brigade	Incandescent light bulb	2	2	1
Fire Brigade	LED	-	-	6

Table 37: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh
MC Office	50,888	27,981
Library	4,346	3,438
Slaughter House	3,662	4,367
Light Inspector Office	1,454	817
Encroachment Office	2,058	3,948
Fire Brigade	3,948	3,660
Overall	66,356	44,211

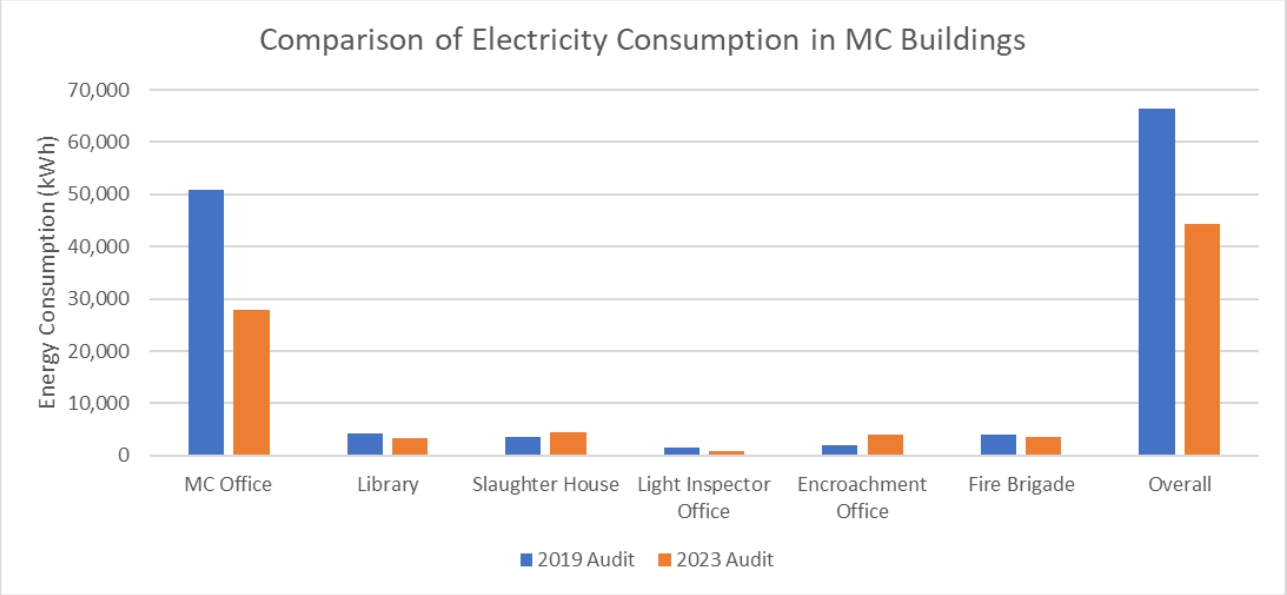

Figure 13:Comparison of Electricity Consumption in MC Buildings

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 Okara

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

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

MC Main Office Building has a Three Phase 400V electrical connection whereas, Library, Encroachment office, Municipal Rest House, Light Branch, Fire Brigade, Bus Stand and Slaughterhouse 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 38: Metering details at MC Okara

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Library	81306127	44114310471404	5	A3 (66)
2	Encroachment office	81406154	06114120576203	1	A3 (66)
3	Municipal Rest House	81306153-1	44114120471401	5	A3 (66)
4	Light Branch	81406155	02114120124805	1	A-1a (01)
5	Fire Brigade	81306128	06114310597900	1	A3 (66)
6	Slaughterhouse	81306130	06114310649700	1	A3 (66)
7	Bus Stand	81306153-2	02114120182510	1	A3 (66)
8	Main MC Building	81306153	44114120221102	8	A3 (66)

6.1 Main MC Building

The project site i.e Main Office Building is located near Block E Okara, Punjab, Pakistan while the geographical co-ordinates of location are 30.809700°N (latitude) and 73.448017°E (longitude).

Figure 14: Front view of MC Office Building

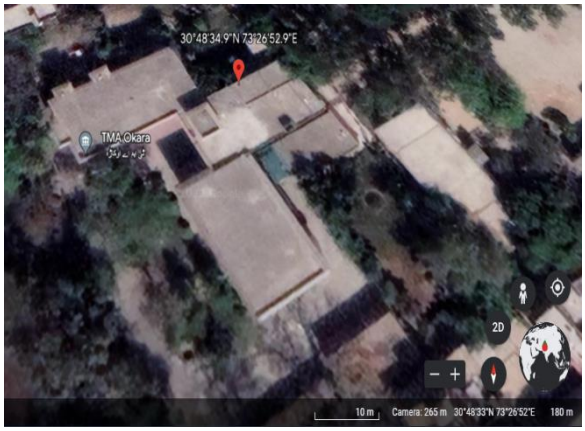

Figure 15: Aerial view of MC Office Buildings

6.1.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of MC Office Building is 27,981 kWh. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 39: Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
27,981	2,332	-	21

Note: Prima facie it appears that the MC Building is not charged based on its actual electricity consumption. 10 out of the 12 months have the same electricity consumption indicated on the electricity bill. Therefore, it is not possible for the Consultant to provide an accurate opinion on the peak demand of this building.

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Building is 115,981 ft^2 whereas, the total area of rooftop available for the solar installation is 8,425 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

Figure 16: Top View of complete building

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

Figure 17: Location for Solar Installation - A

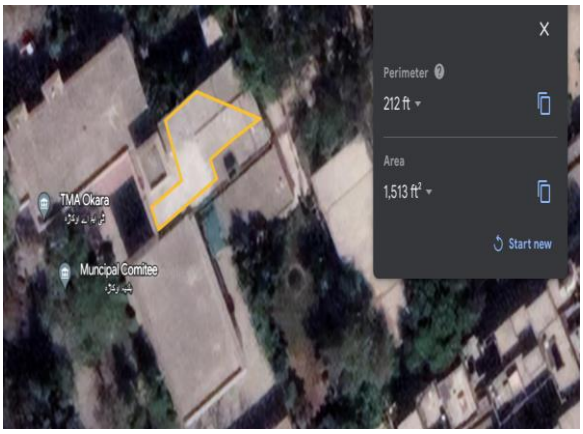

Figure 18: Location for Solar Installation - B

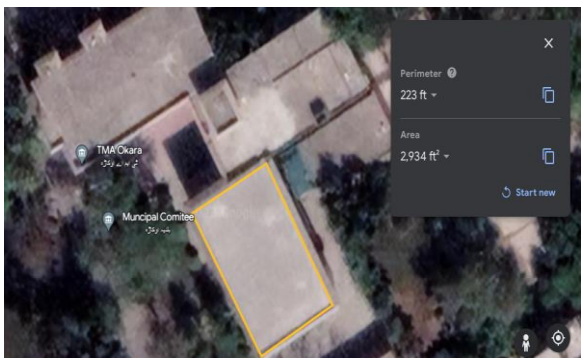

Figure 19: Location for Solar Installation-C

Table 40: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C
Area availability (ft²)	3,134	1,513	2,934
Solar system capacity (kW)	31	15	29

6.2 Municipal Rest House

The project site i.e. Municipal Rest House is located near Municipal Corporation Okara, Punjab, Pakistan while the geographical co-ordinates of location are 30.81090°N (latitude) and 73.44423°E (longitude).

Figure 20: Front view of Municipal Rest House

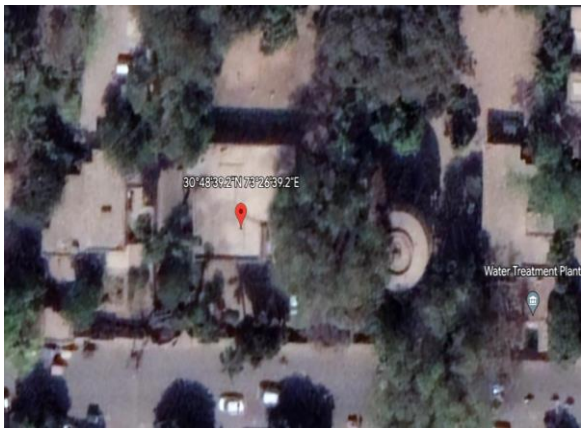

Figure 21: Aerial view of Municipal Rest House

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 16,095 kWh with the peak electricity consumption of 3,323 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 41 Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
16,095	1341	3,323	12

6.2.2 Roof Assessment

As per the Consultant's assessment, the total area of the Municipal Rest House is 10,764 ft^2 whereas, the total area of rooftop available for the solar installation is 1,584 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 22: Top View of Complete building

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

Figure 23: Location for Installation

Table 5: System Size Calculation with Respect to Area

Parameters	Location A
Area availability (ft²)	1,584
Solar system capacity (kW)	16

Note: Based on the assessment of the historical billings it is identified that the system requirement for this site is **12kW** with a single-phase connection. It is highly recommended to replace this single-phase connection to three-phase connection before the installation of solar system as estimated by the Consultant.

6.3 Encroachment office

The project site i.e. Encroachment office is located near Depalpur Rd, Block C Okara, Punjab, Pakistan while the geographical co-ordinates of location are 30.80744°N (latitude) and 73.44537°E (longitude).

Figure 24: Aerial view of the Encroachment Office

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 Encroachment Office 3,948 kWh. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 6: Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
3,948	329	-	3

Note: Prima facie it appears that the Encroachment Office is not charged based on its actual electricity consumption. All of the 12 months have the same electricity consumption indicated on the electricity bill. Therefore, it is not possible for the Consultant to provide an accurate opinion on the peak demand of this building**.** Moreover, based on the analysis of the historical billings it is identified that the system requirement for this site is **3kW** with a single-phase connection and 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 Bus Stand

The project site i.e. Main Office Building is located near General Bus Stand, Grand Trunk Rd, Okara, Punjab, Pakistan while the geographical co-ordinates of location are 30.812084°N (latitude) and 73.458825°E (longitude).

Figure 25: Aerial view of MC Office Buildings

6.4.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Bus Stand is 1,407 kWh with the peak electricity consumption of 200 kWh in August 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

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1,407	117	200	1

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

6.5 Library

The project site i.e. Library is located near Tehsil Rd, Okara, Punjab, Pakistan while the geographical co-ordinates of location are 30.810122°N (latitude) and 73.442854°E (longitude).

Figure 263: Front view of Library

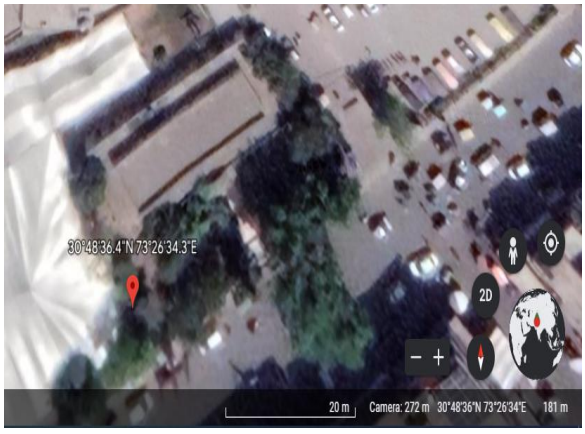

Figure 14: Aerial view of Library

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 Library is 3438 kWh with the peak electricity consumption of 527 kWh in January 2023. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 8: Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
3438	286.5	527	3

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

6.6 Slaughterhouse

The project site i.e. Slaughter House is located near Municipal Corporation Okara, Punjab, Pakistan while the geographical co-ordinates of location are 30.81291°N (latitude) and 73.44135°E (longitude).

Figure 15: Front view of Slaughter House

Figure 16: Aerial view of Slaughter House

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 Slaughterhouse 4,367 kWh with the peak electricity consumption of 575 kWh in December 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 9: Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
4,367	364	575	3

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

6.7 Fire Brigade

The project site i.e. Fire Brigade is located near Municipal Corporation Okara, Punjab, Pakistan while the geographical co-ordinates of location are 30.8106°N (latitude) and 73.4420°E (longitude).

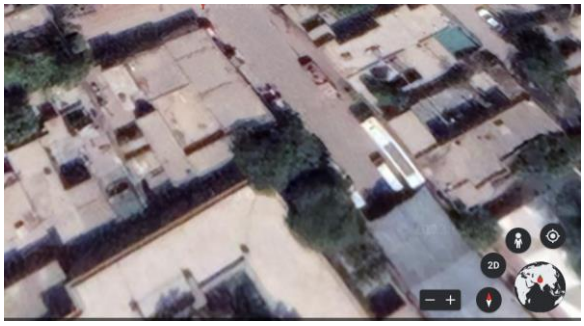

Figure 27: Front view of Fire Brigade

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 Fire Brigade 3,660 kWh with the peak electricity consumption of 488 kWh in December 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 10: Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
3,660	305	488	3

Note: Based on the assessment of the historical billings it is identified that the system requirement for this site is **3kW**, 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.

6.8 Light Branch

The project site i.e. Light Branch is located near Benazir Rd, Samadpura, Okara, Punjab, Pakistan while the geographical co-ordinates of location are 30.80564°N (latitude) and 73.44321°E (longitude).

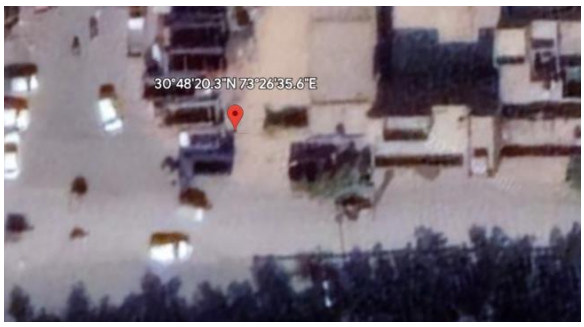

Figure 28: Aerial view of Light Branch

6.8.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Light Branch 817 kWh with the peak electricity consumption of 218 kWh in January 2023. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 11: Solar System Requirement

Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
817	68	218	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, it is not recommended to install the solar system at this site.

6.9 Net Metering Consideration

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

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

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

- A variation of ±5%in Voltage and ±1% in frequency is permissible to the nominal voltage and frequency respectively
- The Distributed Generator will furnish and install a manual disconnect device that has a visual break to isolate the Distributed Generation Facility from the Distribution facilities
- The grid connected inverters and generators shall comply with Underwriter Laboratories UL 1741 standard (Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources) which addresses the electrical interconnection design of various forms of generating equipment, IEEE 1547 2003, IEC 61215, EN
- The Distributed Generator shall not have any right to utilize Distribution Company's Interconnection Facilities for the sale of electricity to any other person.

6.9.1 Net-metering application procedure

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

- Any person who meets the requirements of a Distributed Generator as defined under the regulations 2(k) is eligible for submitting application. Regulation 2(k) states the definition of a Distributed Generator as "a Distribution Company's 3 Phase 400V or 11 kV consumer i.e: domestic, commercial or industrial and who owns and/or operates the Distributed Generation **Facility and** is responsible for the rights and regulations related to the agreement and licensed by the Authority under these regulations".
- Application to Distribution Company along with necessary documents shall be submitted by intending Distributed Generator.
- Within five working days of receiving an Application, the Distribution Company shall acknowledge its receipt and inform the Applicant whether the Application is completed in all respect. Provided that in case of any missing information or documents the Applicant shall provide the same to Distribution Company within seven working days of being informed by Distribution Company.
- Upon being satisfied that the Application is complete in all respect, the Distribution Company shall perform an initial review (20 days) to determine whether the Applicant qualifies for Interconnection Facility or may qualify subject to additional requirements.
- In case the initial review reveals that the proposed facility is not technically feasible, the Distribution Company shall return the Application and communicate the reasons to the Applicant within three working days after the completion of initial review.
- For connections up to 250 kW, no technical feasibility study is needed. Power Ministry, GOP has directed DISCOs to carry out relevant technical studies and approve the connections at sub-division level. If the DISCO is satisfied that the Applicant qualifies as a DG, then the DISCO and DG will enter into an agreement.
- The DISCO office will send the copy of the Agreement between DISCO and DG to NEPRA along with application for issuance of Generation License (GL). NEPRA will issue GL within forty (40) hours of submission of application by DISCOs.
- After the Agreement. DISCO will issue the Connection Charge Estimate, if any, to the Applicant for the proposed interconnection facility up to the interconnection point including net metering installation (it is the Applicant's choice to purchase Net Meter from DISCO or open market)
- The Applicant shall make the payment of Connection Charge Estimate within twenty days of its issuance.

- Within Thirty (30) days of payment by Applicant, the DISCO office will install and commission the proposed interconnection facility after the confirmation of GL license to the DG by NEPRA.

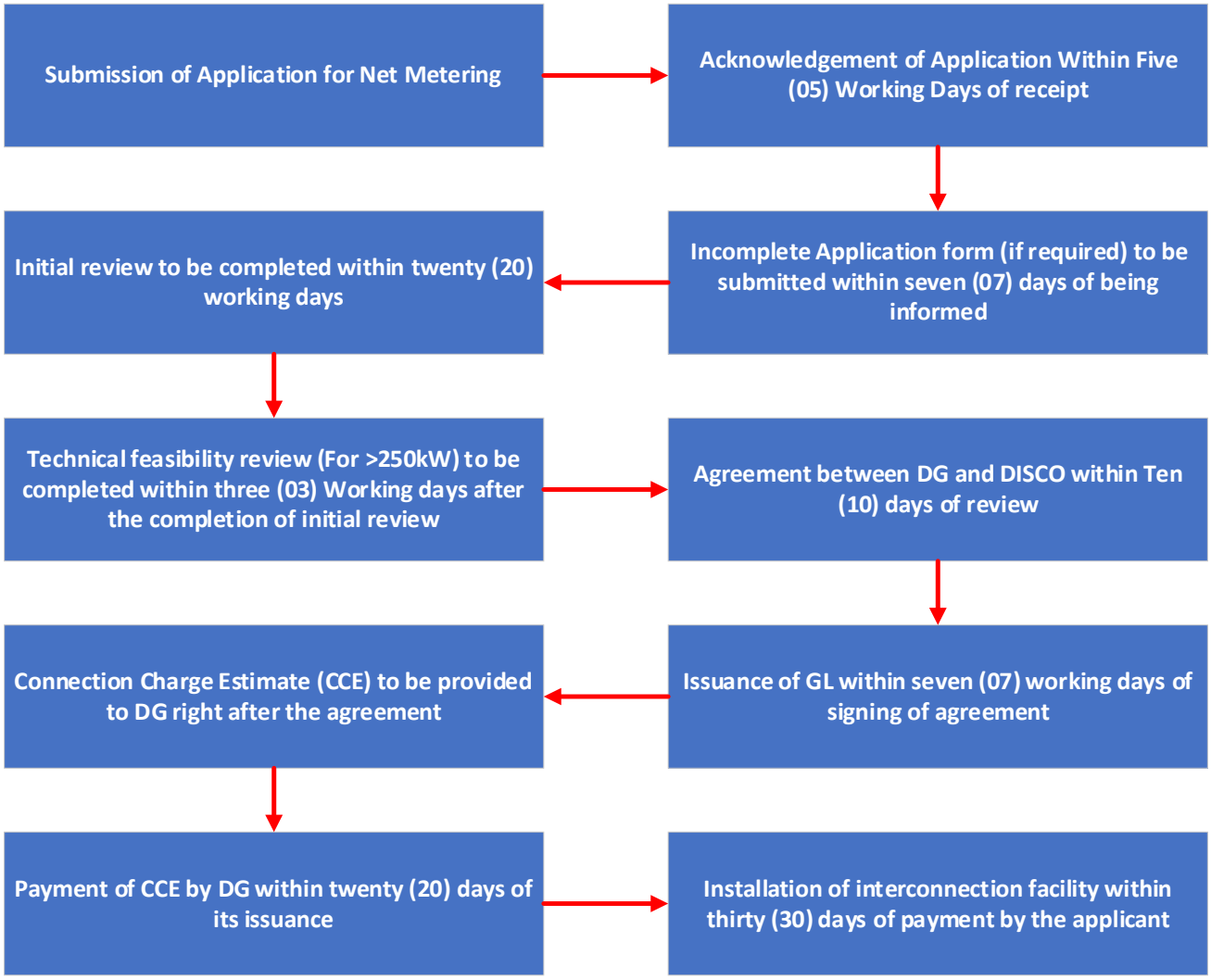

Figure 19: Pakistan Net Metering Application Process

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

7 Recommended Energy Efficiency Measures

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

7.1 Energy Efficiency Measures for Water Pumps & Wastewater Disposal System

7.1.1 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Pump No. 18 LBDC - Unique ID: 81306133)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 30%.

Recommended Action

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

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

Saving Assessment

Table 42: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	-
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	35
Measured Head	m	25.9
Measured Motor Power	kW	9.80
Pump Efficiency	%	30%
Existing Operational Hours	h	10.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	3.5
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	32,340
Energy Required by Proposed Pump	kWh/y	15,378
Saving Potential	kWh/y	16,962
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,724
Investment	US $	3,794
Simple Payback Period	months	17

7.1.2 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Pump No. 15 LBDC - Unique ID: 81306134)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 27%.

Recommended Action

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

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

Saving Assessment

Table 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	65
Measured Head	m	26.2
Measured Motor Power	kW	20.00
Pump Efficiency	%	27%
Existing Operational Hours	h	6.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	3.8
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	39,600
Energy Required by Proposed Pump	kWh/y	16,881
Saving Potential	kWh/y	22,719
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,649
Investment	US $	3,794
Simple Payback Period	months	12

7.1.3 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Pump No. 8 LBDC - Unique ID: 81306142)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 19%.

Recommended Action

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

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

Saving Assessment

Table 44: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	26
Measured Head	m	23.3
Measured Motor Power	kW	10.10
Pump Efficiency	%	19%
Existing Operational Hours	h	9.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	10.7
Motor Size of Proposed Pump	hp	20.0
Operational Hours of Proposed Pump	h	4.6
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	29,997
Energy Required by Proposed Pump	kWh/y	16,300
Saving Potential	kWh/y	13,697
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,200
Investment	US $	3,415
Simple Payback Period	months	19

7.1.4 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Pump No. 5 LBDC - Unique ID: 81306145)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 17%.

Recommended Action

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

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

Saving Assessment

Table 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	30
Measured Flow	m^3/h	26
Measured Head	m	23.3
Measured Motor Power	kW	11.50
Pump Efficiency	%	17%
Existing Operational Hours	h	7.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	1.8
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	26,565
Energy Required by Proposed Pump	kWh/y	7,793
Saving Potential	kWh/y	18,772
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,015
Investment	US $	3,794
Simple Payback Period	months	15

7.1.5 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Pump No. 4 LBDC - Unique ID: 81306146)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 32%.

Recommended Action

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

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

Saving Assessment

Table 46: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	200
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	91
Measured Head	m	23.3
Measured Motor Power	kW	21.10
Pump Efficiency	%	32%
Existing Operational Hours	h	9.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	8.1
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	62,667
Energy Required by Proposed Pump	kWh/y	35,732
Saving Potential	kWh/y	26,935
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	4,326
Investment	US $	3,794
Simple Payback Period	months	11

7.1.6 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Pump No. 1 LBDC - Unique ID: 81306149)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 33%.

Recommended Action

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

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

Saving Assessment

Table 47: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	50
Measured Head	m	26.8
Measured Motor Power	kW	13.00
Pump Efficiency	%	33%
Existing Operational Hours	h	7.0
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	3.4
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	30,030
Energy Required by Proposed Pump	kWh/y	15,123
Saving Potential	kWh/y	14,907
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,394
Investment	US $	3,794
Simple Payback Period	months	19

7.1.7 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Pump No. 22 Rajbaha 42 - Unique ID: 81406158)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 42%.

Recommended Action

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

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

Saving Assessment

Table 48: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	125
Design Motor Power of Existing Pump	kW	31
Measured Flow	m^3/h	64
Measured Head	m	26.8
Measured Motor Power	kW	13.10
Pump Efficiency	%	42%
Existing Operational Hours	h	6.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	8.1
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	7.6
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	25,938
Energy Required by Proposed Pump	kWh/y	20,122
Saving Potential	kWh/y	5,816
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	934
Investment	US $	3,237
Simple Payback Period	months	42

7.1.8 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Akber Tank Water Works - Unique ID: 81306131-1)

Study & Investigation

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

Recommended Action

Replacement of Pump with new PECO 12MC 2-Stage pumpset is recommended to get better efficiency. New energy efficient pumpset will have following impact:

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

Saving Assessment

Table 49: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	204
Design Head of Existing Pump	ft	100
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	245
Measured Head	m	10.7
Measured Motor Power	kW	25.00
Pump Efficiency	%	34%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	204
Proposed Head	m	32
Power Consumption of Proposed Pump	kW	18.6
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	6.0
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	41,250
Energy Required by Proposed Pump	kWh/y	36,929
Saving Potential	kWh/y	4,321
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	694
Investment	US $	4,657
Simple Payback Period	months	81

7.1.9 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 50: 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	Pump No. 18 LBDC	81306133	5.0	3.0	50	150
2	Pump No. 8 LBDC	81306142	5.0	3.0	50	150
3	Pump No. 1 LBDC	81306149	2.5	3.0	50	150
4	Pump No. 22 Rajbaha 42	81406158	2.5	3.0	50	150
5	Akber Tank Water Works	81306131-1	2.5	3.0	50	150
6	Akber Tank Water Works	81306131-5	2.5	3.0	50	150
7	2/4L Disposal	81306136-A	5.0	3.0	50	150
8	2/4L Disposal	81306136-B	5.0	3.0	50	150
9	2/4L Disposal	81306136-D	5.0	3.0	50	150
10	2/4L Disposal	81306136-F	5.0	3.0	50	150
11	1/4 L Disposal	81306150-A	2.5	3.0	50	150
12	1/4 L Disposal	81306150-E	2.5	3.0	50	150
Total						**1800**

7.1.10 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 47 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 51: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	2,971,647
Annual Water consumption (post-implementation)	m^3/y	2,941,931
Annual Water saving per year	m^3/y	29,716
Estimate of Investment (including the cost of the server)	US$	29,500

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 3,028 streetlights are being operated by the municipality. Out of these, 1,721 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 29: 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 52: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	1721
Number of non-functional streetlights (>20 feet)	#	187
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	1,534

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	88,401,825
Proposed number of photocell switches	#	39
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	39,000
Upfront investment cost	PKR	88,440,825
Upfront investment cost	US$	315,635
Annual Operating Electricity unit	kWh/yr	242,521
Annual Operating Cost	PKR/yr	10,913,427
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	1,029,452
Monthly diesel cost for operating fork lifter for two days	PKR/month	20,000
Monthly cost of renting Fork Lifter for two days	PKR/month	80,000
Miscellaneous Cost	PKR/month	20,000
Monthly maintenance cost	PKR/month	120,000

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

Project

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

Study & Investigation

During the assessment it was observed that there are 3,028 streetlights operated by municipality out of which 1,307 are operational. 1041 of the operational streetlights were LEDs so they are not recommended for replacement.

Out of the 266 operational non-LED streetlights 26 are installed at a height of 20 feet or more.

Recommended Action

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

Saving Assessment

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

Table 53: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	266
Number of functional streetlights (>20 feet)	#	26
Wattage of proposed LED lights	Watt	50

Parameters	Unit	Value
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	240
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Upfront investment cost	PKR	13,655,338
Upfront investment cost	US$	48,734
Annual Operating Electricity unit	kWh/yr	37,230
Annual Electricity Consumption of Existing Lights	kWh/yr	147,558
Financial Savings	US$/yr	17,719
Payback	months	33

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 54: Replacement of inefficient equipment at office buildings

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
Library											
1	CFL	3	25	75	187	LED Bulb 13 Watts	13	39	97	350	1,050
2	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
3	CFL	2	25	50	125	LED Bulb 13 Watts	13	26	65	350	700
4	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
Municipal Rest House											
5	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
6	CFL	2	25	50	125	LED Bulb 13 Watts	13	26	65	350	700
7	CFL	1	125	125	312	LED Bulb 50 Watts	50	50	125	6,800	6,800
8	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
9	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
10	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
11	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
12	Window AC	1	5000	5000	12,480	Inverter 1.5 ton	1,452	1,452	453	143,000	143,000
13	Window AC	1	5000	5000	12,480	Inverter 1.5 ton	1,452	1,452	453	143,000	143,000
Light Branch											
14	CFL	1	65	65	162	LED Bulb 50 Watts	50	50	125	6,800	6,800
15	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
16	CFL	1	42	42	105	LED Bulb 20 Watts	20	20	50	830	830
Fire Brigade											
17	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
18	CFL	1	45	45	112	LED Bulb 20 Watts	20	20	50	830	830
Slaughter House											
19	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
20	ILB	6	100	600	1,498	LED Bulb 13 Watts	13	78	195	350	2,100
Main MC Building											
21	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
22	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
23	CFL	2	25	50	125	LED Bulb 13 Watts	13	26	65	350	700
24	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
25	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
26	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
27	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
28	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
29	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
30	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
31	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
32	CFL	2	12	24	60	LED Bulb 8 Watts	8	16	40	330	660
33	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
34	CFL	3	18	54	135	LED Bulb 13 Watts	13	39	97	350	1,050
35	CFL	24	18	432	1,078	LED Bulb 13 Watts	13	312	779	350	8,400
36	CFL	6	42	252	629	LED Bulb 20 Watts	20	120	300	830	4,980
37	CFL	2	25	50	125	LED Bulb 13 Watts	13	26	65	350	700
38	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
39	CFL	1	42	42	105	LED Bulb 20 Watts	20	20	50	830	830
40	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
41	CFL	2	42	84	210	LED Bulb 20 Watts	20	40	100	830	1,660
42	CFL	1	18	18	45	LED Bulb 13 Watts	13	13	32	350	350
43	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
44	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
45	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
46	CFL	1	42	42	105	LED Bulb 20 Watts	20	20	50	830	830
47	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
48	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
49	CFL	1	42	42	105	LED Bulb 20 Watts	20	20	50	830	830
50	CFL	3	45	135	337	LED Bulb 20 Watts	20	60	150	830	2,490
51	Sodium Lights	4	250	1000	2,496	LED Bulb 150 Watts	150	600	1,498	21,000	84,000
52	CFL	2	25	50	125	LED Bulb 13 Watts	13	26	65	350	700
53	CFL	1	18	18	45	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	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
54	CFL	1	42	42	105	LED Bulb 20 Watts	20	20	50	830	830
55	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
56	CFL	1	42	42	105	LED Bulb 20 Watts	20	20	50	830	830
57	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
58	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
59	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
60	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
61	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
62	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
63	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
64	CFL	2	40	80	200	LED Bulb 20 Watts	20	40	100	830	1,660
65	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
66	Window AC	1	5000	5000	12,480	Inverter 1.5 ton	1,452	1,452	453	143,000	143,000
	Total										**685,720**

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 55: Saving & cost benefit analysis

Parameters	Unit	Value
Average Operational Days for Building Lighting Equipment	days/year	312
Average Operational Hours for Building Lighting Equipment	Hours/day	8
Average Operational Days for Building Cooling Equipment	days/year	156
Average Operational Hours for Building Cooling Equipment	Hours/day	2
Energy consumption of inefficient Equipment	kWh/yr	51,562
Energy consumption of Proposed Equipment	kWh/yr	8,246
Energy Savings	kWh/yr	43,317
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	6,957
Upfront Investment (including change in fixtures)	USD	2,447
Payback Period	Months	4

8 Investment Estimate (including Material Specification/Quantities)

8.1 Potable Water Pump

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

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

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

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

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

Price of pumping unit as specified above

Price/Unit Rs	Rs:	1,115,385
Sales Tax @ 17%	Rs:	189,615
Total Cost of Pumpset	Rs:	1,305,000

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

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

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

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

Price of pumping unit as specified above

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

8.1.3 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

8.1.4 Investment Estimate (including Material Specification/Quantities) for PECO 8 MC /7 Stages, 20hp 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	20 HP	Length of suction pipe	
Prime Mover (SEM/DE)	20 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 20 HP/4 Pole						included
DWT 8MC						included
Discharge head 4 " with top shaft						included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	817,949
Sales Tax @ 17%	Rs:	139,051
Total Cost of Pumpset	Rs:	957,000

8.2 Investment Estimate (including Material Specification/Quantities) Streetlights

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

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 50W	50	7000 Lm	140 Lm/Watt	187	53,873	10,074,251
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	1,534	51,061	78,327,574
3	Accessories	Photocell switch				39	1,000	39,000
Lumpsum Price (PKR)								**88,440,825**
Lumpsum Price (USD)								**315,635**

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 50W	50	7000 Lm	140 Lm/Watt	26	53,873	1,400,698
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	240	51,061	12,254,640
Lumpsum Price (PKR)								**13,655,338**
Lumpsum Price (USD)								**48,734**

8.3 Investment Estimate (including Material Specification/Quantities) Buildings

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

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

Sr. No	Proposed Equipment	Wattage of Proposed Equipment	Equipment Count	Overall Wattage of Proposed Equipment	Individual Cost of Proposed Equipment (PKR)	Cost of Proposed Equipment
1	LED Bulb 13 Watts	13	59	767	350	20,650
2	LED Rod 20 Watts	20	41	820	2,900	118,900
3	LED Bulb 50 Watts	50	2	100	6,800	13,600
4	Inverter 1.5 ton	1452	3	4,356	143,000	429,000
5	LED Bulb 20 Watts	20	20	400	830	16,600
6	LED Bulb 8 Watts	8	9	72	330	2,970
7	LED Bulb 150 Watts	150	4	600	21,000	84,000
Lumpsum Price (PKR)						**685,720**
Lumpsum Price (USD)						**2,447**

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9 Summary of Energy Efficiency Measures

MC Okara's annual energy consumption is 1,985,856 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$ 44,610** with an estimated investment of **US$ 428,216**
- Reduce electricity consumption by approx. **277,774 kWh**
- Reduce GHG Emissions by **148 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of LESCO

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