Gojra Municipal Committee

Energy Audit Report

June 2023

History of the Document

Version	Date	Description
01	May 20, 2023	First Draft
02	June 15, 2023	Final Version

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ACKNOWLEDGEMENT

PITCO express their sincere gratitude to the World Bank & Punjab Municipal Development Fund Company (PMDFC) team for their role in guiding and steering Energy Management and Operation & Maintenance of 16 Selected MCs Services Infrastructure Assets Project Under Punjab Cities Program (PCP). The consultant is grateful to the World Bank-Pakistan for vesting its confidence in the team for carrying out this prominent assignment for the assessment of the existing audits and for identification of energy efficiency interventions and for their full-fledged cooperation and support throughout the study.

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

Table of Contents

1 SUMMARY 11

1.1 Background 11
1.2 Scope of work 11
1.3 Process of the Energy Efficiency Assessment and Structure of the Report 11
1.4 Gojra MC Background 11
1.5 Key Performance Indicators 12
1.6 Impact of Energy Efficiency Investment 14
1.7 Energy Efficiency Recommendations Matrix 17

2 WATER PUMPS AND DISPOSALS 18

2.1 Inventory for water and wastewater pumping equipment 20
2.2 GIS Map of water pumps/Tubewells & wastewater disposals in Gojra, Punjab 22
2.3 Baseline Energy Consumption Trend 22
2.4 Observations and Recommendations 27
2.5 Proposed Resource Efficiency Measures- Water Pumps and Disposals 35

3 STREETLIGHTS 37

3.1 Inventory 37
3.2 GIS Map 39
3.3 Baseline Energy Consumption Trend 40
3.4 Maintenance & Replacement of Streetlights 46
3.5 Observations 46
3.6 Action plan for Energy Efficiency Measures – Streetlights 46

4 VEHICLES 48

4.1 Inventory 48
4.2 Baseline Fuel Consumption Trend 48
4.3 Maintenance Log of Vehicles 50
4.4 Observations and Recommendations 50

5 MUNICIPAL BUILDINGS 51

5.1 GIS Map 51
5.2 Building Details 52
5.3 Baseline Energy Consumption Trend 56
5.4 Maintenance Logs of Buildings 59

6 SOLAR ASSESSMENT FOR MC GOJRA 60

6.1 Main MC Office Building 60
6.2 MC Mosque 62
6.3 Bus Stand 64
6.4 Library 65
6.5 Net Metering Consideration 65

7 RECOMMENDED ENERGY EFFICIENCY MEASURES 69

7.1 Energy Efficiency Measures for Water Pumps & Wastewater Disposal System 69
7.2 Energy Efficiency Measures for Streetlights 74
7.3 Energy Efficiency Measures for Buildings 76

8 INVESTMENT ESTIMATE (INCLUDING MATERIAL SPECIFICATION/QUANTITIES) 78

8.1 Potable Water Pump 78
8.2 Investment Estimate (including Material Specification/Quantities) Streetlights 79

8.3 INVESTMENT ESTIMATE (INCLUDING MATERIAL SPECIFICATION/QUANTITIES) BUILDINGS 80

9 SUMMARY OF ENERGY EFFICIENCY MEASURES 80

10 ANNEXURES 81

List of Tables

Table 1: Baseline Energy Data 12
Table 2: KPIs for Potable Water & Wastewater pumps 12
Table 3: KPIs for Streetlights 12
Table 4: KPIs for Buildings 13
Table 5: KPIs for Vehicles 14
Table 6: High Priority Measures 17
Table 7: Medium Priority Measures 17
Table 8: Low Priority Measures 17
Table 9: Inventory of Tubewells/Water Pumps (Potable Water) 20
Table 10: Inventory Table of Disposal Works 21
Table 11: Inventory of Dewatering Sets 21
Table 12: Inventory of Filtration Units 21
Table 13: Baseline Energy Consumption Trend 22
Table 14: Matrix of Pumpset Assessment and Billing Data Availability 30
Table 15: Pumpset Primary Performance Parameters 32
Table 16: Pumpset Secondary Performance Parameters 33
Table 17: Comparison of Pumpset Efficiency at Existing Conditions and Duty Point 33
Table 18: Disposal Performance Parameters 34
Table 19: Water Pumps and Wastewater Disposal System: Recommendations for improvement 35
Table 20: Inventory Detail of Streetlights 37
Table 21: Details of Streetlight Poles 37
Table 22: Metering of Streetlights 37
Table 23: Details of Operational Streetlights 38
Table 24: Baseline Energy Consumption Trend 40
Table 25: Streetlights - recommendations for improvement 46
Table 26: Vehicle Inventory Detail 48
Table 27: On-field fuel Consumption analysis of MC vehicles 48
Table 28: Vehicle Fuel Consumption- logbook data 49
Table 29: Fuel Cost 50
Table 30: Buildings' Details 52
Table 31: Number of Cooling Units in Office Buildings of the MC 52
Table 32: Number of Lighting Unit in Office Buildings of the MC 54
Table 33: Energy consumption in Office Buildings 56
Table 34: Cooling Equipment Comparison 58
Table 35: Lighting Equipment Comparison 58
Table 36: Annual Units (kWh) Comparison 59
Table 37: Metering details at MC Gojra 60
Table 38: Solar System Requirement 61
Table 39: System Size Calculation with Respect to Area 62
Table 40: System Size Calculation with Respect to Area 64
Table 41: Solar System Requirement 65
Table 42: Solar System Requirement 65
Table 43: Saving & cost benefit for pumpset replacement 69

Table 44: Saving & cost benefit for pumpset replacement 70
Table 45: Saving & cost benefit for pumpset replacement 71
Table 46: Financial Analysis of installation of capacitors for improvement of Power Factor 72
Table 47: Financial analysis of installation of Smart Meters 73
Table 48: Financial Analysis of Replacement of Non-functional Streetlights 74
Table 49: Financial Analysis of Replacement of Inefficient functional Streetlights 75
Table 50: Replacement of inefficient equipment at office buildings 76
Table 51: Saving & cost benefit analysis 77

List of Figures

Figure 1: Map for Pumps and Disposal at MC Gojra 22
Figure 2: Electricity Consumption and Water Production by Pumpsets 27
Figure 3: Energy Consumption Trend for Water Pumps 29
Figure 4: Energy Consumption Trend for Disposal Units 29
Figure 5: Sample pictures from field audit of pumpsets 30
Figure 6: Wastewater Disposal 34
Figure 7: Dewatering Sets 35
Figure 8: Pictures of Streetlights 39
Figure 9: GIS Mapping of street lights in Gojra MC 39
Figure 10: Energy Consumption trend of Streetlights 44
Figure 11: MC Vehicles 50
Figure 12: Map for Buildings 51
Figure 13:Comparison of Electricity Consumption in MC Buildings 59
Figure 14: Front View Of Main MC Office Building 60
Figure 15: Aerial View of Main MC Office building 60
Figure 16: Top view of the building section-A 61
Figure 17: Top view of the building section-B 61
Figure 18: Location for Installation-A 62
Figure 19: Location for Installation-B 62
Figure 20: Location for Installation-C 62
Figure 21: Location for Installation-D 62
Figure 22: Front view of the Mosque 63
Figure 23: Aerial view of the Mosque 63
Figure 24: Top view of the building section-A 63
Figure 25: Top view of the building section-B 63
Figure 26: Location for Installation-A 64
Figure 27: Location for Installation-B 64
Figure 28: Front View Of Bus Stand 64
Figure 29: Aerial View of the Bus Stand 64
Figure 30: Aerial View of the Library 65
Figure 31: Pakistan Net Metering Application Process 68
Figure 32: Picture of proposed LED, Photocell switch and energy meter for streetlights 74

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 Gojra MC Background

Gojra is a city of Toba Tek Singh District in the Punjab province of Pakistan. The city is located at 31.1500 N 72.6833 E.

After independence from Britain, in view of its increasing size, it was declared as 2nd class Municipal Committee in 1960. The town was raised to the status of Tehsil town and affiliated with the newly established district Toba Tek Singh on 01.07.1982. After the introduction of Devolution of Powers Plan, the Municipal Committee Gojra came into being on 12.08.2001. Canal rest house is the oldest building constructed during British government in 1898.

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

Sr. No.	Name of Officer	Designation
1	Mr. Rizwan Ashraf Sindu	Administrator
2	Mr. Ishtiaq Ahmad Gondal	Chief Officer
3	Mr. Shahrukh Tariq*	Municipal Officer (Infrastructure)
4	Mr. Tauseef ur rehman	Municipal Officer (Regulation)
5	Mr. Ameen Iqbal	Municipal Officer (Finance)
6	Mr. Muhammad Asad	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Gojra

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	2,078,581
Electrical energy used by Wastewater Disposal[2]	kWh/year	342,960
Electrical energy used in Buildings[3]	kWh/year	61,029
Electrical energy used by Streetlights[4]	kWh/year	227,311
Diesel used by Vehicles	liter/year	30,150

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)	0.30
2	Energy Density of Wastewater Disposal	(kWh/m3)	0.03
3	Energy Density of Wastewater Treatment	(kWh/m3)	No wastewater treatment is carried out
4	Energy Cost for Potable Water Production	(PKR/m3)	13.41
5	Energy Cost for Wastewater Disposal	(PKR/m3)	1.22
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)	1,993
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	126
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	46,132
		PKR/Lighting Equipment	41,022
4	Average cost of installation of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	1,254

[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
		PKR/Lighting Equipment	370
5	Average annual maintenance costs	(PKR)	98,314
6	Average daily duration of operation	(Hour)	12.0
7	Average energy costs per kilometer of lit roads	(PKR/km)	89,673
8	Average energy costs per light pole/fixture	(PKR/ fixture)	5,667
9	Number and percentage of failed public lights		87%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	7.13
2	Average Energy Cost of Cooling	(PKR/m^2)	156
3	Average Energy Cost of Lighting	(PKR/m^2)	90

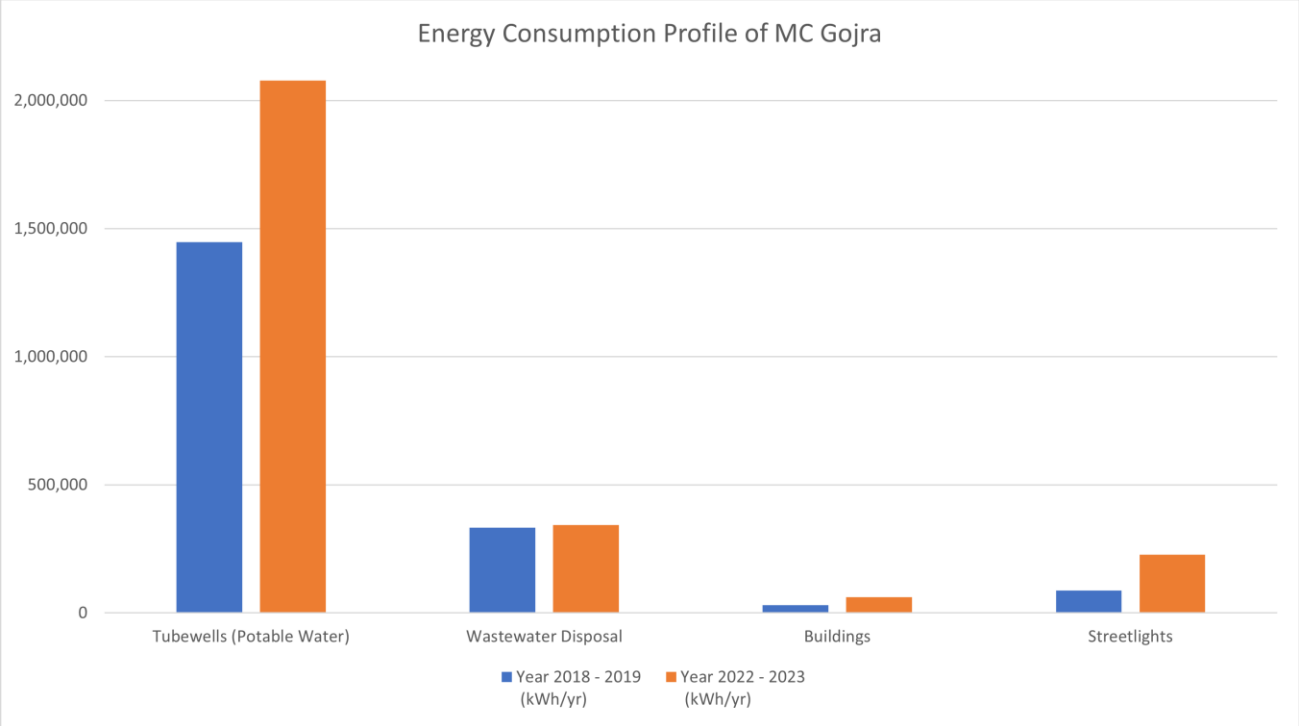
1.5.4 Vehicles

Table 5: KPIs for Vehicles

Sr. No	Description	Unit	KPI
1	Fuel consumption for staff transport vehicles	km/Liter	Cannot be Determined
2	Fuel consumption for solid/liquid waste transport	km/Liter	3.53
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	83

1.6 Impact of Energy Efficiency Investment

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



		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	20	13	1,446,568	2,078,581	-632,013	0.24 kWh/m3	0.30 kWh/m3	During the 2019 audit, the Consultant carried out complete assessment of 12 pumps out of 20 operational pumpsets; all the pumpsets are working efficiently and no pumpset replacement was recommended. In the current audit, the Consultant has undertaken complete assessment of 9 pumpsets out of 13 operational pumpsets. 3 out of the 9 pumpsets were found performing inefficiently due to which KPI of water supply has deteriorated and annual energy consumption of the pumpsets has increased. It should be noted that although the Consultant had not proposed any replacements based on the previous audit, the MC has undertaken replacement of 3 waster supply pumpsets. 2 of the 3 pumpsets were found to be operational.
2	Wastewater Disposal	6	9	333,400	342,960	-9,560	0.07 kWh/m3	0.03 kWh/m3	There were 6 operational pumpsets during the 2019 audit, whereas, 9 pumps were operational during the current audit. No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI

		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
									for water disposal has improved significantly. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.
3	Buildings	4	5	31,168	61,029	-29,861	3.64 kWh/m2	7.13 kWh/m2	General bus stand building and Slaughter House building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these buildings has not been considered in the overall energy consumption and KPI calculations. Electricity units (kWh) are increased due to increase in operating hours of electric appliances during summer.
4	Streetlights	150	266	88,274	227,311	-139,037	1,290 kWh/km	1,993 kWh/km	Although the MC has installed new LEDs undertaken replacement of inefficient streetlights withs LEDs, a twofold increase in the overall billing for streetlights has been observed. This points to potential misuse of the MC's electricity connections resulting in significantly increased billing for the MC. This needs to be further investigated.

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 (Mochi Wala Road # 4 - Unique ID: 52905151)	23,561	3,569	1,000,000	3,784	1,060,243	11	12
Replacement of Pumpset at (Sultan Pura Damma Bangla # 05 - Unique ID: 52905162)	21,135	3,794	1,063,000	3,394	951,065	13	11
Replacement of Pumpset at (Dijkot Road water works - Unique ID: 53105182-A)	8,949	3,794	1,063,000	1,437	402,723	32	4
Replacement/Installation of Capacitors	Not Quantifiable	1,350	378,270	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	314,639	88,161,891	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	3,532	440	123,210	567	158,933	9	2
Total:	**57,177**	**327,585**	**91,789,371**	**9,183**	**2,572,964**		**29**

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	Not Quantifiable	729	204,244	Not Quantifiable	Not Quantifiable	Not Quantifiable	0
Total:	**Not Quantifiable**	**729**	**204,244**	**Not Quantifiable**	**Not Quantifiable**	**Not Quantifiable**	**0**

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	35,918	42,000	11,768,400	0	0	0	Not Quantifiable
Total:	**35,918**	**42,000**	**11,768,400**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Gojra MC has thirty-three (33) tubewells for groundwater, all of which are manually operated. Out of these, 13 pumpsets were found to be in working condition.

The MC has three (3) disposal station having nine (9) pumps. All these 9 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are five (5) dewatering sets in the MC, all of which are functional. No record of their fuel consumption and operational hours is being maintained by the MC.

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

The team was unable to

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

(ii) Determine system resistance and duty point on eleven (11) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake assessment of the following pumpsets as these were non-functional either due to non-availability of electrical supply

1. Jhang Road # 10 (Unique ID: 52905152)
2. Mochi Road # 7 (Unique ID: 52905153)
3. Jhang Road # 03 (Unique ID: 52905154)
4. Jhang Road TB # 04 (Unique ID: 52905157)
5. Mochi Road # 5 (Unique ID: 52905158)
6. Mochi Road # 6 (Unique ID: 52905159)
7. Mochi Road # 8 (Unique ID: 52905160)
8. Mochi Road # 9 (Unique ID: 52905161)
9. Sultan Pura Damma Bangla # 06 (Unique ID: 52905163)
10. Sultan Pura Damma Bangla # 07 (Unique ID: 52905164)
11. Damma Bangla # 15 (Unique ID: 53005165)
12. Damma Bangla # 14 (Unique ID: 53005167)
13. Damma Bangla # 10 (Unique ID: 53005168)
14. Damma Bangla # 11 (Unique ID: 53005169)
15. Damma Bangla # 13 (Unique ID: 53005170)
16. Sultan Pura Damma Bangla # 8 (Unique ID: 53105175)
17. Damma Bangla # 1 (Unique ID: 53105178)

18. Water works Amamia Colony # 1 (Unique ID: 53105183)

(iv) Undertake assessment of the following pumpsets as these were abandoned by the MC

1. Mochi Road # 01 (Unique ID: 52905156)
2. Dijkot Road water works (Unique ID: 53105182-C)

(v) Undertake assessment of the following pumpsets as no flow was detected on these sites due to extremely rusty condition of the delivery pipes

1. Damma Bangla # 9 (Unique ID: 53005166)
2. WW. Sultan Pura (Unique ID: 53105180)
3. Anarkali Water works (Unique ID: 53105181)
4. Dijkot Road water works (Unique ID: 53105182-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	Existing Pump Type	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	Year of Motor Manufacturing	Latitude	Longitude
1	53105182-C	Dijkot Road water works	No Meter	N/A	N/A	N/A	PECO Newman	N/A	31.153245	72.695945
2	53105179	WW. Civil court	24-13331-5106300	Turbine	KSB	2021	Siemens	2021	31.15052	72.680369
3	53105180	WW. Sultan Pura	24-13331-5106400	Centrifugal	KSB	2014	Siemens	2014	31.145907	72.677038
4	53105181	Anarkali Water works	27-13331-5100237	Centrifugal	Local Made Pump	N/A	AE Motors UK	N/A	31.1493	72.688302
5	53105182-A	Dijkot Road water works	24-13331-5100500	Centrifugal	PECO	N/A	BECO Newman	N/A	31.153245	72.695945
6	53105182-B	Dijkot Road water works	24-13331-5100500	Centrifugal	N/A	N/A	N/A	N/A	31.153245	72.695945
7	53105183	Water works Amamia Colony # 1	No Meter	Turbine	KSB	2016	ABB Motors	2014	31.15345	72.688525
8	53105184	Water works Amamia Colony # 2	19-13331-0098808	Turbine	KSB	2016	ABB Motors	2014	31.153425	72.688534
9	52905151	Mochi Wala Road # 4	29-13333-3302191	Turbine	PECO	N/A	PECO	N/A	31.175325	72.668484
10	52905152	Jhang Road # 10	29-13333-3302200	Turbine	KSB	2014	Siemens	2014	31.177551	72.670364
11	52905153	Mochi Road # 7	29-13333-3302280	Turbine	KSB	2014	Siemens	2014	31.180859	72.673914
12	52905154	Jhang Road # 03	29-13333-3302240	Turbine	KSB	2014	Siemens	2014	31.186089	72.678006
13	52905155	Mochi Road #2	29-13333-3302230	Turbine	KSB	2014	Siemens	2014	31.187852	72.679094
14	52905156	Mochi Road # 01	29-13333-3302220	Turbine	KSB	2014	Siemens	2014	31.188622	72.679549
15	52905157	Jhang Road TB # 04	29-13333-3302250	Turbine	KSB	2014	Siemens	2014	31.184049	72.6768
16	52905158	Mochi Road # 5	29-13333-3302260	Turbine	KSB	2014	Siemens	2014	31.182921	72.675969
17	52905159	Mochi Road # 6	29-13333-3302270	Turbine	KSB	2014	Siemens	2014	31.181803	72.674985
18	52905160	Mochi Road # 8	29-13333-3302290	Turbine	KSB	2014	Siemens	2014	31.179834	72.672798
19	52905161	Mochi Road # 9	29-13333-3302100	Turbine	KSB	2014	Siemens	2014	31.178477	72.671364
20	52905162	Sultan Pura Damma Bangla # 05	29-13333-3300123	Turbine	KSB	2005	Siemens	2005	31.170063	72.661912
21	52905163	Sultan Pura Damma Bangla # 06	29-13333-3300124	Turbine	KSB	2005	Siemens	2005	31.167867	72.659435
22	52905164	Sultan Pura Damma Bangla # 07	29-13333-3300125	Turbine	KSB	2005	Siemens	2005	31.165735	72.657133
23	53005165	Damma Bangla # 15	29-13333-3300145	Turbine	KSB	2014	Siemens	2014	31.159431	72.650918
24	53005166	Damma Bangla # 9	29-13333-3300127	Turbine	KSB	2004	Siemens	2004	31.160355	72.652102
25	53005167	Damma Bangla # 14	29-13333-3300145	Turbine	KSB	2014	Siemens	2014	31.159429	72.650918
26	53005168	Damma Bangla # 10	29-13331-3100030	Turbine	KSB	2004	Siemens	2004	31.159498	72.649995
27	53005169	Damma Bangla # 11	29-13331-3100040	Turbine	KSB	2020	Siemens	2020	31.1578	72.648302
28	53005170	Damma Bangla # 13	29-13333-3300266	Turbine	KSB	2004	Siemens	2004	31.1534	72.64284
29	53005171	Damma Bangla # 12	29-13333-3300265	Turbine	KSB	2020	Siemens	2020	31.156259	72.646505
30	53105176	Mochi Wala Road # 3	29-13333-3302190	Turbine	PECO	2012	PECO	2012	31.177005	72.670478
31	53105177	Damma Bangla # 2	29-13333-3302192	Turbine	KSB	2013	Siemens	2013	31.17806	72.671432
32	53105178	Damma Bangla # 1	29-13333-3302180	Turbine	KSB	2013	Siemens	2013	31.179106	72.672747
33	53105175	Sultan Pura Damma Bangla # 8	29-13333-3300126	Turbine	KSB	2005	Siemens	2005	31.163842	72.655008

2.1.2 Disposal Works

Table 10: Inventory Table of Disposal Works

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Pump Capacity (Cusec)	Motor Manufacturer	Motor Capacity (Hp)	Latitude	Longitude
1	53005172-A	298/JB Balvand Pura	24-13331-5102300 24-13331-5102400	Centrifugal	KSB	5	Siemens	50	31.141177	72.679675
2	53005172-B	298/JB Balvand Pura		Centrifugal	KSB	5	Siemens	50	31.141177	72.679675
3	53005172-C	298/JB Balvand Pura		Centrifugal	KSB	5	Siemens	50	31.141177	72.679675
4	53005172-D	298/JB Balvand Pura		Centrifugal	KSB	5	Siemens	50	31.141177	72.679675
5	53005175-A	Model City Phase-2	24-13333-5305401	Centrifugal	KSB	5	Siemens	50	31.159903	72.697708
6	53005175-B	Model City Phase-2		Centrifugal	KSB	5	Siemens	50	31.159903	72.697708
7	35007771-A	Chak No. 371-JB Ganda Singh	24-13332-5205501	Centrifugal	KSB	5	Siemens	50	31.12746	72.678439
8	35007771-B	Chak No. 371-JB Ganda Singh		Centrifugal	KSB	5	Siemens	50	31.12746	72.678439
9	35007771-C	Chak No. 371-JB Ganda Singh		Centrifugal	KSB	5	Siemens	50	31.12746	72.678439

2.1.3 Dewatering Sets

Table 11: Inventory of Dewatering Sets

Sr. No.	Unique Id	Location	Quantity	Latitude	Longitude
1	50106187 A	Qabarstan Wala Road	1	31.151189	72.692964
2	50106187 B	Ashraf Colony, Gojra Road	1	31.139642	72.690516
3	50106187 C	Qadir Colony, Railway Road	1	31.138558	72.682349
4	50106187 D	Police Station Road	1	31.149314	72.680995
5	50106187 E	Tehsil Office Road, Gojra	1	31.149471	72.680669

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	70106086	Kacha Gojra	Connected with Mochi Wala Road # 1 (52905156)					31.156156	72.682776
2	70106087	Amamai Colony	Connected with Amamia Colony Water Works # 2					31.153538	72.689077
3	70106088	Samandari Road	Connected with Mochi Wala Road # 3 (53105176)					31.146518	72.693081
4	70106090	Ansar Colony	Connected with Dijkot Road Water Works (53105182)					31.143823	72.686285
5	70106091	Balvand Pura	Connected with Sultan Pura Water Works (53105180)					31.141883	72.680051
6	70106092	Lakar Mandi	Connected with Sultan Pura Water Works (53105180)					31.144272	72.68356

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

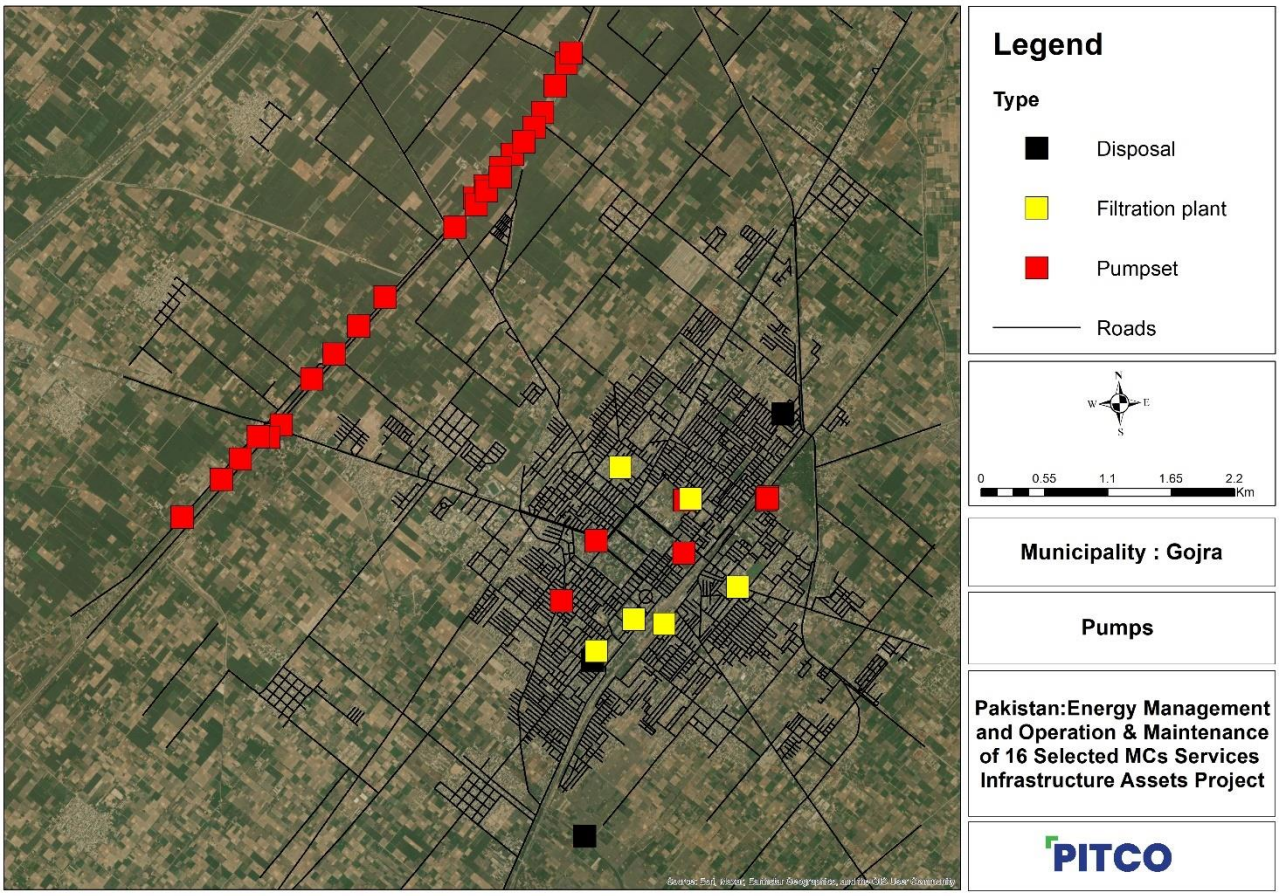


Figure 1: Map for Pumps and Disposal at MC Gojra

2.3 Baseline Energy Consumption Trend

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

Table 13: Baseline Energy Consumption Trend

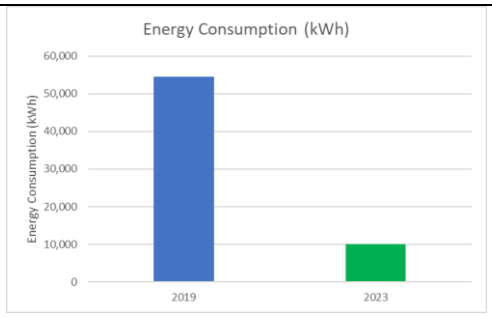
Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	2,078,581
Electrical energy used by Wastewater Disposal	kWh/y	342,960
Electrical energy used (Total)	kWh/y	2,421,541

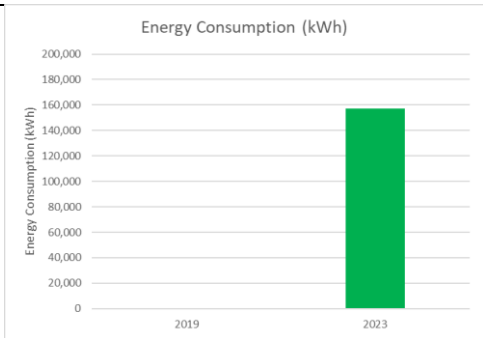
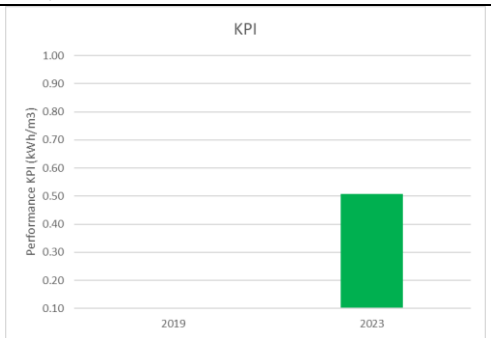
A comparison of current electricity consumption by the MC's water supply and disposal assets compared to results of the energy audit activity carried out in 2019, is presented in the following table:

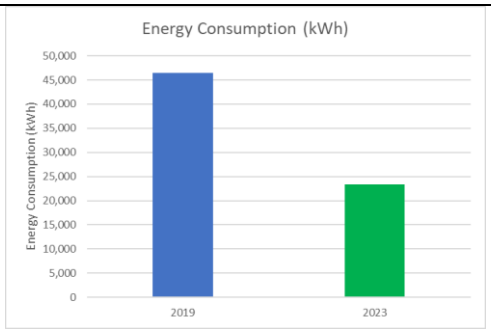
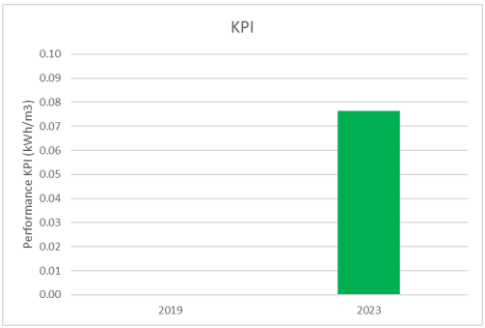
		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	20	13	1,446,568	2,078,581	-632,013	0.24 kWh/m3	0.30 kWh/m3	During the 2019 audit, the Consultant carried out complete assessment of 12 pumps out of 20 operational pumpsets; all the pumpsets are working efficiently and no pumpset replacement was recommended. In the current audit, the Consultant has undertaken complete assessment of 9 pumpsets out of 13 operational pumpsets. 3 out of the 9 pumpsets were found performing inefficiently due to which KPI of water supply has deteriorated and annual energy consumption of the pumpsets has increased. It should be noted that although the Consultant had not proposed any replacements based on the previous audit, the MC has undertaken replacement of 3 water supply pumpsets. 2 of the 3 pumpsets were found to be operational.
2	Wastewater Disposal	6	9	333,400	342,960	-9,560	0.07 kWh/m3	0.03 kWh/m3	There were 6 operational pumpsets during the 2019 audit, whereas, 9 pumps were operational during the current audit. No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and

		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
									maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal has improved significantly. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.

It should be noted that although the Consultant had not proposed any replacements based on the previous audit, the MC has undertaken replacement of 3 water supply pumpsets. 2 of the 3 pumpsets were found to be operational. A discussion on each newly installed asset is presented below:

Damma Bangla # 11 - Unique ID (53005169)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
54,491 kWh	9,972 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	N/A
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Annual energy consumption of this pumpset in 2019 was 54,491 kWh whereas, annual energy consumption of this pumpset of current year is 9,972 kWh with an annual savings of 44,519 kWh. No calculations of the KPI has been calculated for both the audit, as no flow was detected due to the extremly rusty condition of the pipe previously and was found to be non-functional due to non-availability of electrical supply during the current audit.	

Damma Bangla # 12 - Unique ID (53005171)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	157,386 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.51 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. No KPI calculations has been presented for the previous audit, as the pump was non-functional and no billing details were available. Based on the measured instantaneous power with 18 operational hours running for 365 days, the annual energy consumption should not exceed than 94,608 kWh. This points to potential misuse of the MC's electricity connections resulting in significantly increased billing for the MC. This needs to be further investigated. This has not been used in the overall KPI for water supply.	

WW. Civil court - Unique ID (53105179)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
46,466 kWh	23,400 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.08 kWh/m3
	
Comments:	
"A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Annual energy consumption of this pumpset in 2019 was 46,466 kWh whereas, annual energy consumption of this pumpset of current year is 23,400 kWh with an annual savings of 23,066 kWh. No calculations of the KPI has been calculated for the previous audit, as no flow was detected due to the extremely rusty condition of the pipe.	

2.4 Observations and Recommendations

The share of each pumpset in the total water generation and total electricity consumption is illustrated in the figure below.

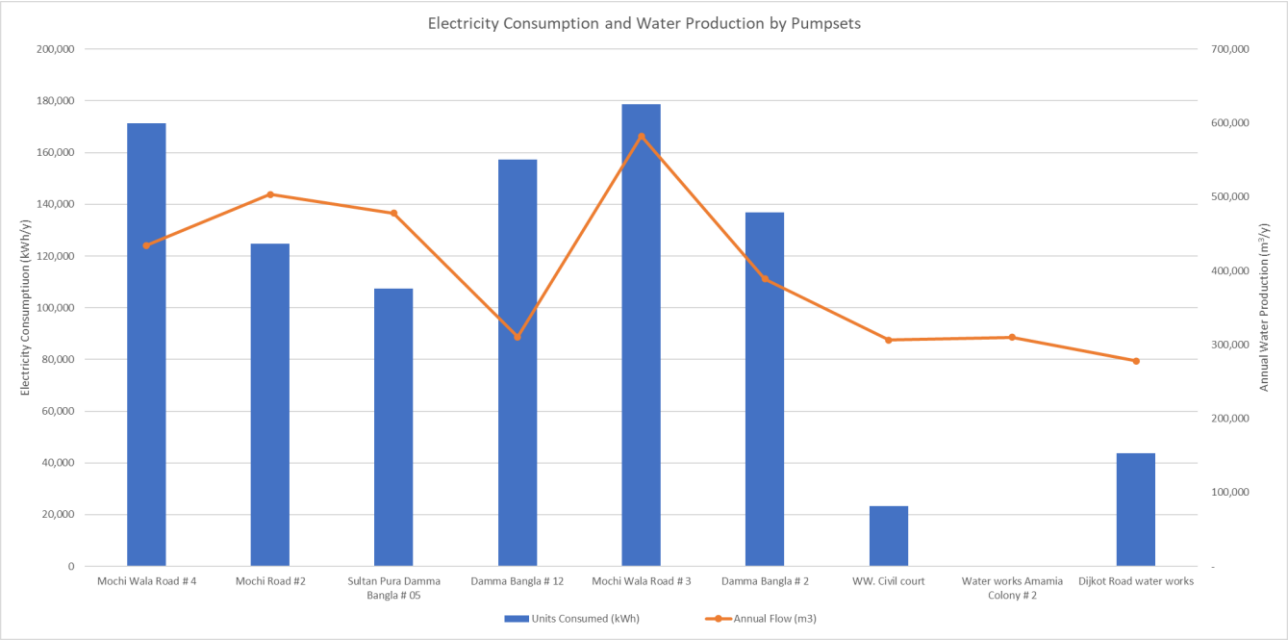
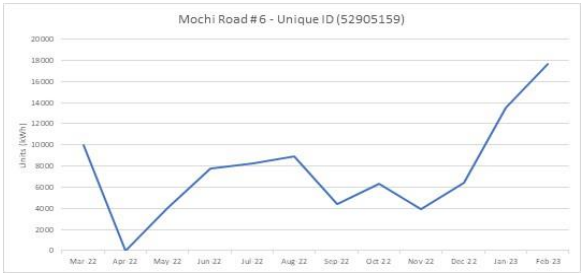


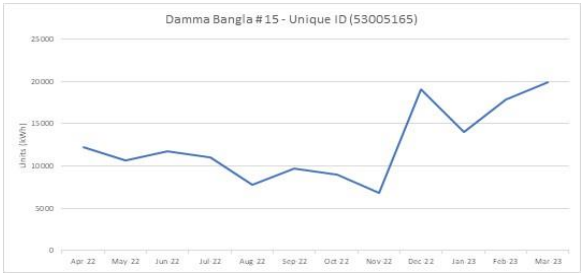
Figure 2: Electricity Consumption and Water Production by Pumpsets

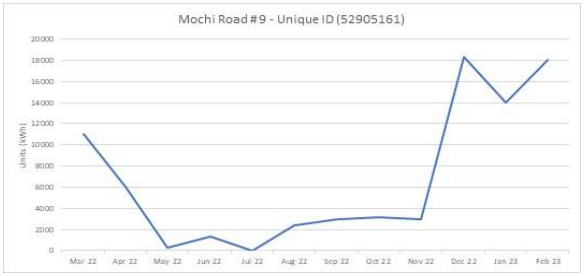
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

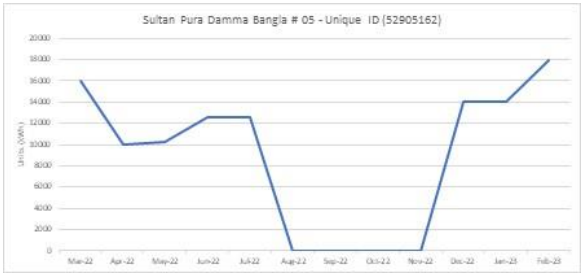
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

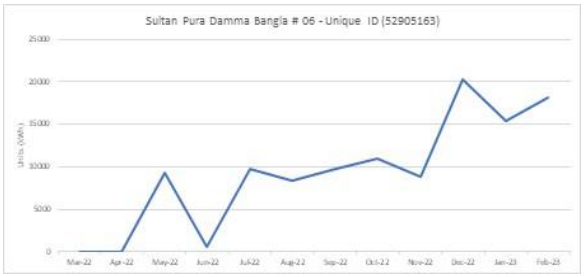
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.


Mochi Road # 6 - Unique ID (52905159)
Units (kWh)
Mar 22
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Nov 22
Dec 22
Jan 23
Feb 23

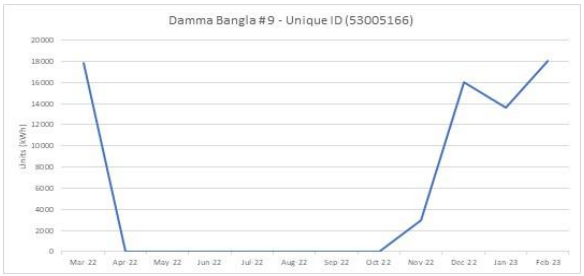

Damma Bangla # 15 - Unique ID (53005165)
Units (kWh)
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Nov 22
Dec 22
Jan 23
Feb 23
Mar 23


Mochi Road # 9 - Unique ID (52905161)
Units (kWh)
Mar 22
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Nov 22
Dec 22
Jan 23
Feb 23


Sultan Pura Damma Bangla # 05 - Unique ID (52905162)
Units (kWh)
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23


Sultan Pura Damma Bangla # 06 - Unique ID (52905163)
Units (kWh)
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23


Sultan Pura Damma Bangla # 07 - Unique ID (52905164)
Units (kWh)
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23


Damma Bangla # 9 - Unique ID (53005166)
Units (kWh)
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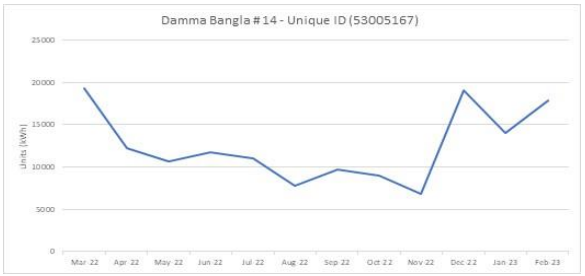
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Nov 22
Dec 22
Jan 23
Feb 23


Damma Bangla # 14 - Unique ID (53005167)
Units (kWh)
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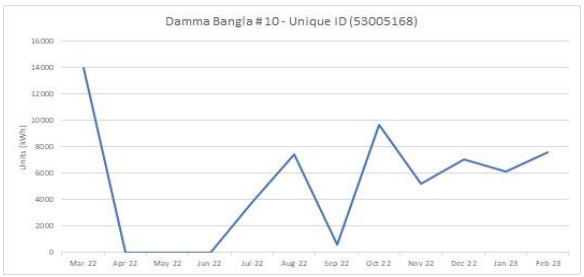
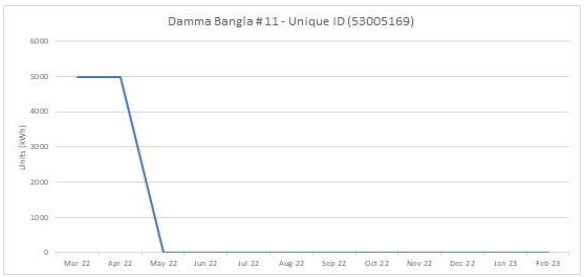
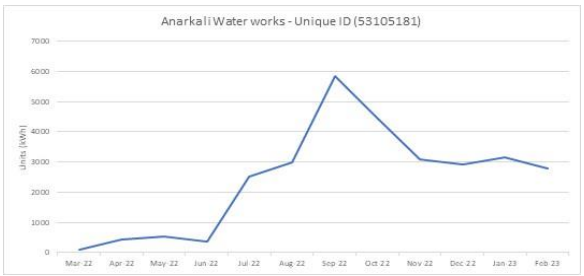
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Nov 22
Dec 22
Jan 23
Feb 23


Damma Bangla # 10 - Unique ID (53005168)
Units (kWh)
Mar 22
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Nov 22
Dec 22
Jan 23
Feb 23


Damma Bangla # 11 - Unique ID (53005169)
Units (kWh)
Mar 22
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Nov 22
Dec 22
Jan 23
Feb 23


Anarkali Water works - Unique ID (53105181)
Units (kWh)
Mar 22
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Nov 22
Dec 22
Jan 23
Feb 23

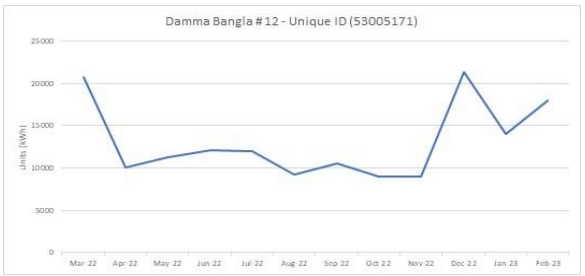

Damma Bangla # 12 - Unique ID (53005171)
Units (kWh)
Mar 22
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Nov 22
Dec 22
Jan 23
Feb 23

Figure 3: Energy Consumption Trend for Water Pumps

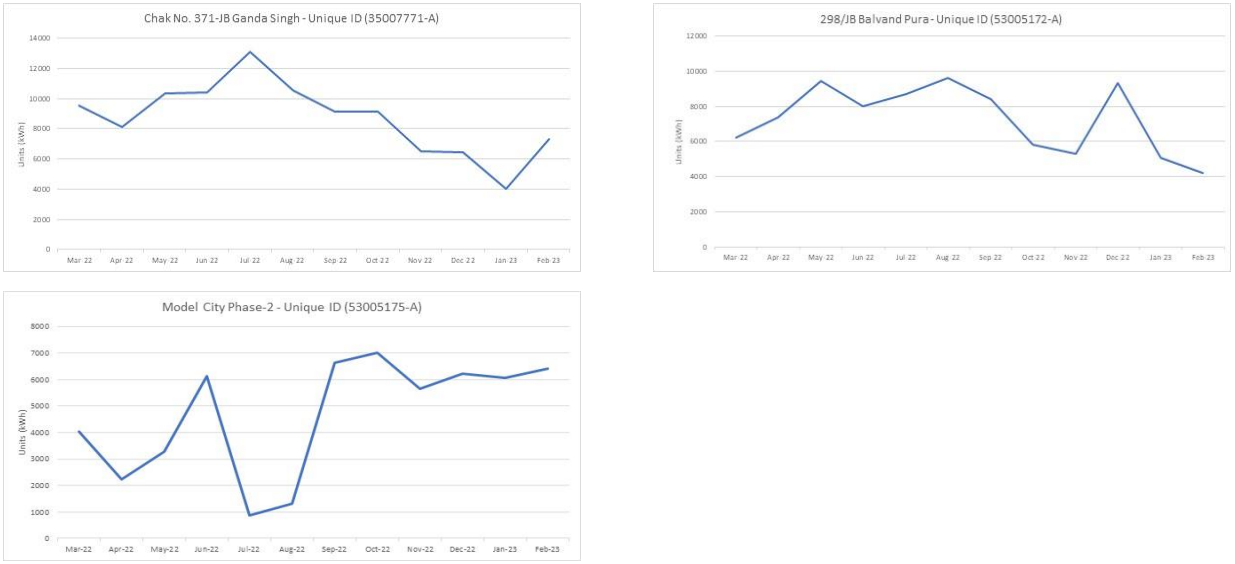


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Gojra MC has thirty-three (33) tubewells for groundwater, all of which are manually operated. Out of these, 13 pumpsets were found to be in working condition.

Performance evaluation of pumpsets could be carried out at only 9 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	52905151	Mochi Wala Road # 4	Yes	Yes
2	52905152	Jhang Road # 10	Yes	No
3	52905153	Mochi Road # 7	Yes	No
4	52905154	Jhang Road # 03	Yes	No
5	52905155	Mochi Road #2	Yes	Yes
6	52905156	Mochi Road # 01	Yes	No
7	52905157	Jhang Road TB # 04	Yes	No
8	52905158	Mochi Road # 5	Yes	No
9	52905159	Mochi Road # 6	Yes	No
10	52905160	Mochi Road # 8	Yes	No
11	52905161	Mochi Road # 9	Yes	No
12	52905162	Sultan Pura Damma Bangla # 05	Yes	Yes

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
13	52905163	Sultan Pura Damma Bangla # 06	Yes	No
14	52905164	Sultan Pura Damma Bangla # 07	Yes	No
15	53005165	Damma Bangla # 15	Yes	No
16	53005166	Damma Bangla # 9	Yes	No
17	53005167	Damma Bangla # 14	Yes	No
18	53005168	Damma Bangla # 10	Yes	No
19	53005169	Damma Bangla # 11	Yes	No
20	53005170	Damma Bangla # 13	Yes	No
21	53005171	Damma Bangla # 12	Yes	Yes
22	53105175	Sultan Pura Damma Bangla # 8	Yes	No
23	53105176	Mochi Wala Road # 3	Yes	Yes
24	53105177	Damma Bangla # 2	Yes	Yes
25	53105178	Damma Bangla # 1	Yes	No
26	53105179	WW. Civil court	Yes	Yes
27	53105180	WW. Sultan Pura	Yes	No
28	53105181	Anarkali Water works	Yes	No
29	53105183	Water works Amamia Colony # 1	Yes	No
30	53105184	Water works Amamia Colony # 2	Yes	Yes
31	53105182-A	Dijkot Road water works	Yes	Yes
32	53105182-B	Dijkot Road water works	Yes	No
33	53105182-C	Dijkot Road water works	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	52905151	Mochi Wala Road # 4	76.5	73.1	25.03	16.80	35%	0.88	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve is jammed. Previously, the efficiency of the pumpset was 55%.
2	52905155	Mochi Road #2	51.0	95.3	20.51	10.80	58%	0.65	Efficiency of the pumpset is satisfactory. Sluice/gate valve is jammed. Previously, the efficiency of the pumpset was 53%.
3	52905162	Sultan Pura Damma Bangla # 05	51.0	103.5	20.60	18.20	38%	0.86	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve is jammed. Previously, the efficiency of the pumpset was 52%.
4	53005171	Damma Bangla # 12	51.0	52.3	47.78	14.40	56%	0.90	New pumpset has been installed at this site. Efficiency of the pumpset is satisfactory. Sluice/gate valve is jammed. Previously, this site was non-functional.
5	53105176	Mochi Wala Road # 3	101.9	98.1	34.08	20.00	54%	0.81	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, this efficiency of the pumpset was 58%.
6	53105177	Damma Bangla # 2	51.0	59.0	35.42	11.70	57%	0.72	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, this efficiency of the pumpset was 53%.
7	53105179	WW. Civil court	101.9	123.7	28.43	17.70	64%	0.80	New pumpset has been installed at this site. The efficiency of the pumpset is satisfactory. Gate valve is jammed. Previously, no flow was detected due to the extremly rusty condition of the pipe.
8	53105184	Water works Amamia Colony # 2	101.9	134.1	33.80	25.07	58%	0.89	Efficiency of the pumpset is satisfactory. Sluice/gate valve is broken. Previously, the efficiency of the pumpset was 57%.
9	53105182-A	Dijkot Road water works	101.9	112.3	12.52	18.40	24%	0.85	Efficiency of the pumpset is unsatisfactory. Sluice/gate valve is jammed. Previously, no clear space was available to install the ultrasonic flowmeter.

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

Table 16: Pumpset Secondary Performance Parameters

Unique ID	Motor Vibration Hz	Temperature of Motor	Motor Rated kW	Motor Rated Efficiency	Transformer kVA	Elec. Connection	Line Leakage	Rated Head of Pump	Motor Rated Voltage V	Full Load PF	PF (Measured)	Load factor %	Observations
52905151	53.05	53	30	-	-	Safe	ok	-	-	-	0.88	56%	
52905155	0.00	41	15	89	-	Safe	ok	200	400	0.84	0.65	72%	Low PF
52905162	117.27	46	22	-	-	Safe	ok	250	380	0.86	0.86	81%	
53005171	45.47	51	15	91	-	Safe	ok	200	400	0.85	0.90	97%	
53105176	#DIV/0!	55	30	-	-	Safe	Not ok	-	-	-	0.81	67%	
53105177	#DIV/0!	81	15	-	-	Safe	Not ok	1	380	0.84	0.72	78%	Low PF
53105179	0.00	36	19	-	-	Safe	-	130	400	0.84	0.80	95%	
53105184	18.72	60	30	-	-	Safe	ok	200	400	0.87	0.89	84%	
53105182-A	0.00	56	19	-	-	Safe	ok	-	420	-	0.85	99%	

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

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

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
1	53005171	Damma Bangla # 12	51	14.914	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	52.2774	21.8	Flow at existing operating conditions is nearest to duty point	14.40	25%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
2	53105176	Mochi Wala Road # 3	102	29.828	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	98.05	34.1	Flow at existing operating conditions is nearest to duty point	20.00	54%

2.4.3 Wastewater Disposal System

The MC has three (3) disposal station having nine (9) 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	53005172-A	298/JB Balvand Pura	509.7	645.6	7.71	25.30	63%	The efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was 38%.
2	53005172-B	298/JB Balvand Pura	509.7	578.0	7.71	30.30	47%	The efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was 48%.
3	53005172-C	298/JB Balvand Pura	509.7	438.2	6.22	20.40	43%	The efficiency of the pumpset is satisfactory. Previously, this site was also non-functional.
4	53005172-D	298/JB Balvand Pura	509.7	449.8	6.22	17.30	52%	The efficiency of the pumpset is satisfactory. Previously, this site was also non-functional.
5	53005175-A	Model City Phase-2	509.7	772.6	9.48	31.10	75%	The efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was 52%.
6	53005175-B	Model City Phase-2	509.7	578.7	8.87	29.10	57%	The efficiency of the pumpset is satisfactory. Previously, efficiency of the pumpset was 39%.
7	35007771-A	Chak No. 371-JB Ganda Singh	509.7	800.0	6.10	28.90	54%	The efficiency of the pumpset is satisfactory.
8	35007771-B	Chak No. 371-JB Ganda Singh	509.7	320.0	8.53	22.60	39%	The efficiency of the pumpset is satisfactory.
9	35007771-C	Chak No. 371-JB Ganda Singh	509.7	751.4	6.10	25.20	58%	The efficiency of the pumpset is satisfactory.



Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are five (5) dewatering sets in the MC all of which are functional. It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.

Figure 7: Dewatering Sets

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

2.5 Proposed Resource Efficiency Measures- Water Pumps and Disposals

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

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

Sr No.	Unique ID	Location	Comments	Recommendation
Pumps				
1	Pumpset	Mochi Wala Road # 4	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
2	Pumpset	Mochi Road #2	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
3	Pumpset	Sultan Pura Damma Bangla # 05	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
4	Pumpset	Damma Bangla # 12	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
5	Pumpset	Mochi Wala Road # 3	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
6	Pumpset	Damma Bangla # 2	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
7	Pumpset	Dijkot Road water works	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
8	Disposal	298/JB Balvand Pura	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
9	Disposal	298/JB Balvand Pura	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
10	Disposal	Model City Phase-2	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
11	Disposal	Model City Phase-2	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
12	Disposal	Chak No. 371-JB Ganda Singh	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
13	Disposal	Chak No. 371-JB Ganda Singh	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
14	Disposal	Chak No. 371-JB Ganda Singh	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
General Observations				
15	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
16	General	Operating Time	Pumps should not be run during Peak electricity consumption hours.	Operational hours of pump should be scheduled keeping in mind the varying peak hours across the year to avoid peak charges. Peak hours for FESCO during the entire year are given in Annexure 1.

Sr No.	Unique ID	Location	Comments	Recommendation
17	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.
18	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 Gojra 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	266	266	-
Non-Operational Street Lights	1,723	1,723	-
Total	**1,989**	**1,989**	**0**

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

Out of total 1,989 streetlights operated by MC, 863 lights are installed on PC, 665 lights are installed on steel structure, 205 lights are installed on tubular structure, and 72 lights are installed on Wire. The streetlights' structural classification is tabulated below.

Table 21: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Wire	Grand Total
MC	863	665	205	72	**1,805**
Private	-	-	-	-	**0**

Streetlights of Gojra 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 Gojra are shown in table below.

Table 22: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Club Road	130	24-13331-5101800	3.535
2	Jhang Road	47	24-13331-5105401	1.621
3	Ali Asghar Park	59	24-13331-5105400	3.114
4	Ayoub Colony	8	24-13333-5304000	0.250
5	Javaid Park / Colony	7	24-13333-5303900	0.205
6	Jafa Pur	36	24-13333-5301800	2.556
7	Painsra Road	8	24-13333-5301000	1.175
8	Tower Colony	11	24-13333-5304300	0.755
9	Hazara Colony	13	24-13335-5500709	0.555
10	Kacha Gojra	65	No Meter	2.942
11	Millat Town	6	24-13333-5303400	0.192
12	Wazir Park	36	24-13331-5103800	1.716
13	Saman Zar	40	24-13331-5105700	2.611
14	Al-Faiz Society	14	24-13331-5105900	0.529
15	Saman Abad	31	24-13331-5103100	1.656
16	Kot Abdi	24	24-13331-5104700	0.983
17	Akbar Park	24	24-13331-5104000	2.100
18	Haider Park	40	24-13331-5103200	2.195
19	Imam Bargah	52	24-13331-5102900	3.577

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
20	Ghala Mandi	146	24-13331-5101900	8.057
21	Gulshan Colony	29	24-13331-5105500	1.059
22	Muhallah No Shahi	6	24-13331-5106900	0.272
23	Kot Ghulam Muhammad	105	24-13331-5105800	6.011
24	Mission Road	38	24-13331-5102901	1.178985
25	Shahabad Colony	27	24-13331-5104500	1.303804
26	Abdullah Pur	87	24-13331-5103500	4.645525
27	Model Town	31	24-13331-5104400	2.818832
28	Imamia Colony	32	24-13331-5105600	1.898211
29	Tariq Abad	18	24-13333-5304800	1.163803
30	New Plot	132	24-13331-5102500	9.029232
31	Habib Park	34	24-13331-5107000	2.606816
32	Dastgir Colony	34	24-13331-5103700	1.57735
33	Qadri Darbar	31	24-13333-5304400	1.466713
34	Asghar Colony	6	24-13335-5503100	2.307082
35	Qabristan	14	24-13331-5106500	1.398196
36	Lari Adda	24	24-13331-5100700	1.846432
37	Hasnia Colony (Outside)	44	24-13331-5106000	2.738535
38	Housing Colony	28	24-13331-5107300	1.782005
39	Samundri Road	34	24-13331-5107301	0.776105
40	Islam Pura	45	24-13332-5204900	2.436463
41	Hasnia Colony	55	24-13331-5103900	3.382516
42	Sharif Pura	23	24-13331-5107500	1.313337
43	Sharif Pura -2	19	24-13331-5105000	0.773561
44	Chak 371 J.B	65	24-13332-5205500	2.759746
45	Siraj Town	58	24-13331-5104600	2.963712
46	Ashraf / Ansar Colony	40	No Meter	5.016153
47	Takia Phuman Shah	54	24-13331-5104900	5.957522
48	Ladies Park	6	No Meter	0.278747
49	Shaheed Park	62	18-13331-1032002	1.124431
50	Bihar Colony	11	No Meter	1.85986

Out of the 1,989 surveyed lights in the MC, 266 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	27		12	1,419	0
LED	18	6		12	473	0
LED	50	44		12	9,636	0
LED	100	2		12	876	0
LED	120	183		12	96,185	0
Tube Light	40	3		12	526	0
Sodium Light	120	1		12	526	0
Total					**109,640**	**0**

[5] Based on Interview with Client.

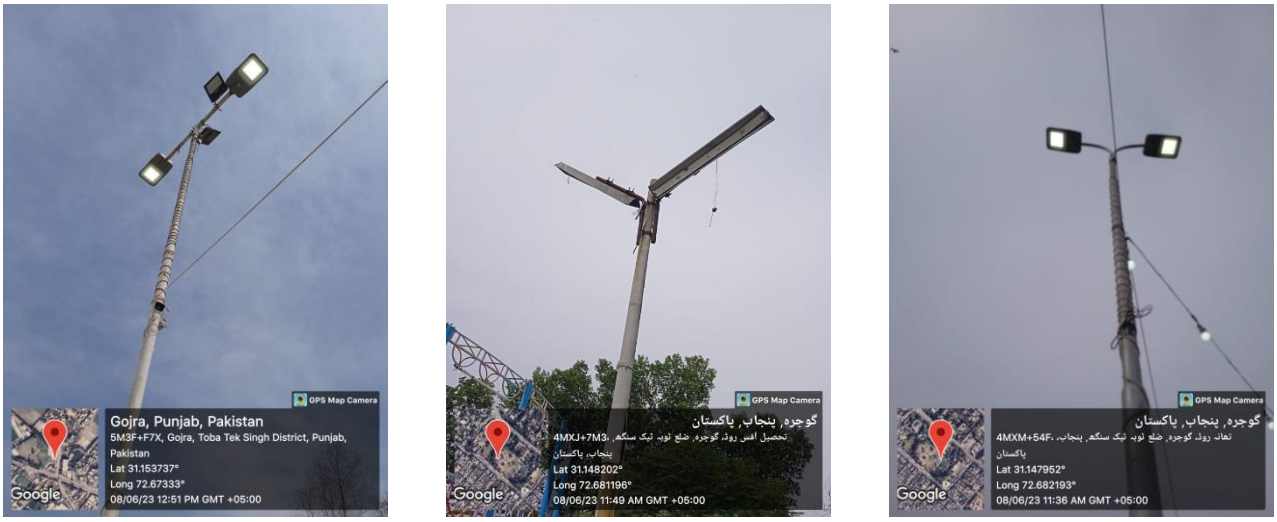


Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

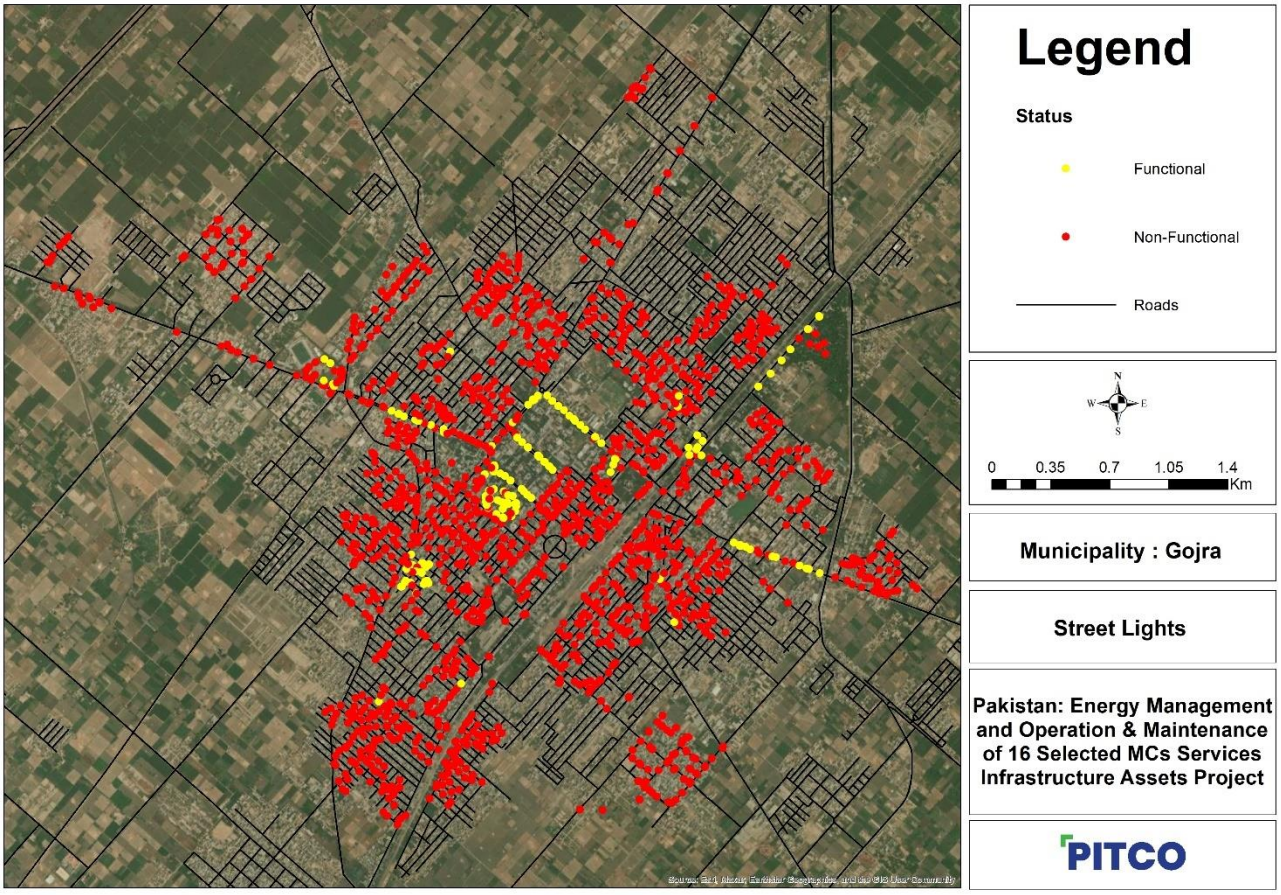


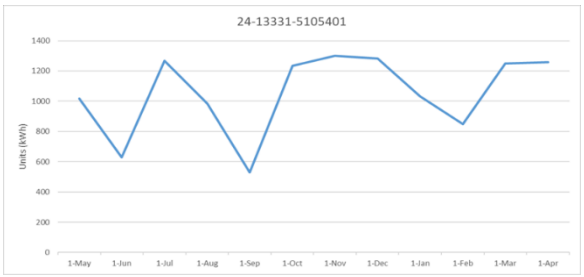
Figure 9: GIS Mapping of street lights in Gojra MC

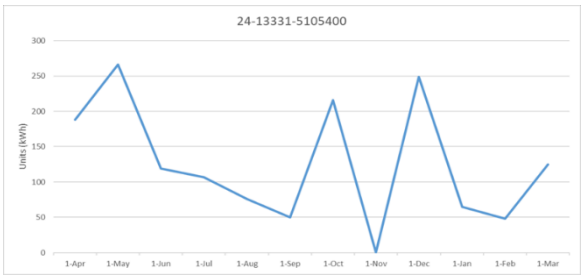
3.3 Baseline Energy Consumption Trend

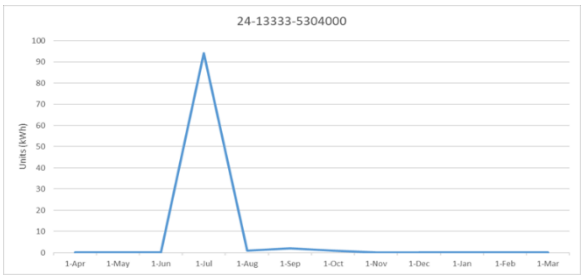
Details of energy consumption by the streetlights in the MC are given below.

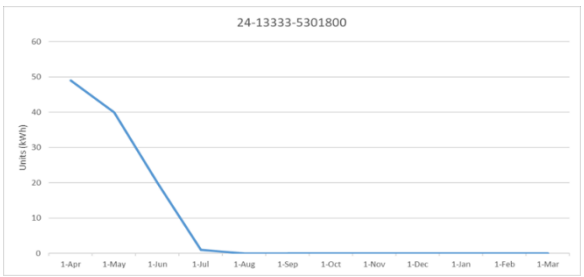
Table 24: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy consumed	kWh/y	**227,311**[6]
Total number of operational lights	No.	**266**

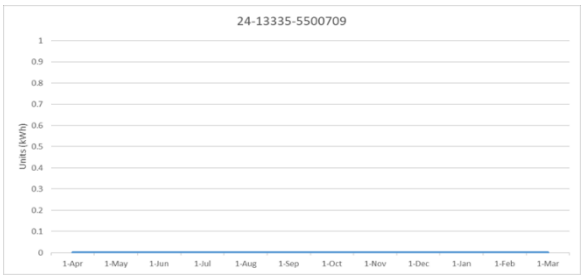








[6] Based on electricity bills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1-Sep
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1-Jan
1-Feb
1-Mar


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Units (kWh)
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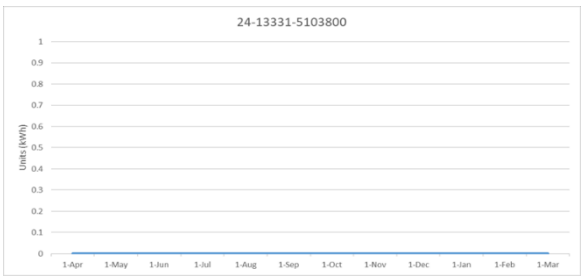
1-Mar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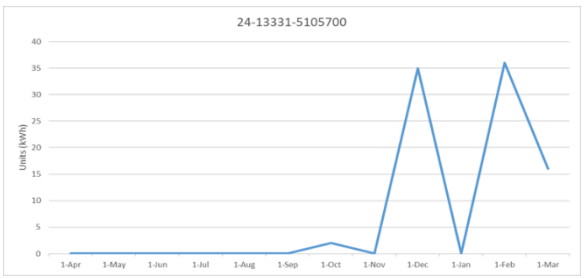
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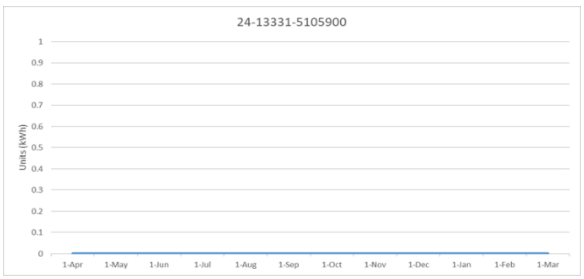
1-Mar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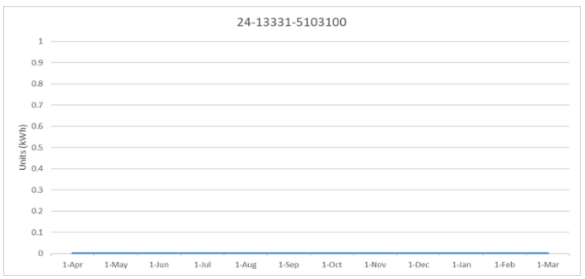
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1-Jan
1-Feb
1-Mar


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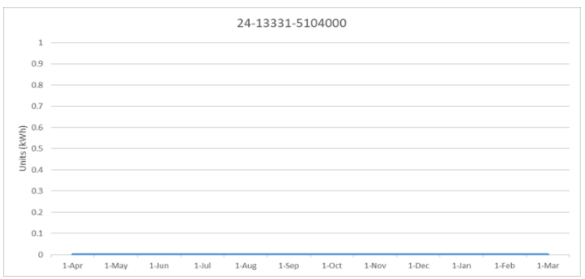
1-Mar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1-Mar


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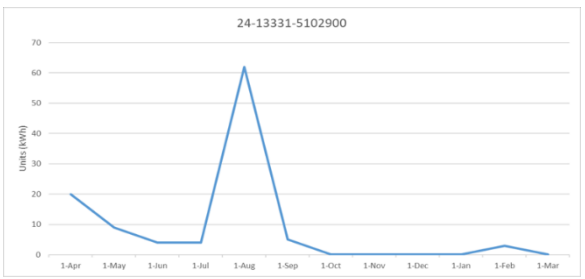
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1-Jan
1-Feb
1-Mar


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1-Mar


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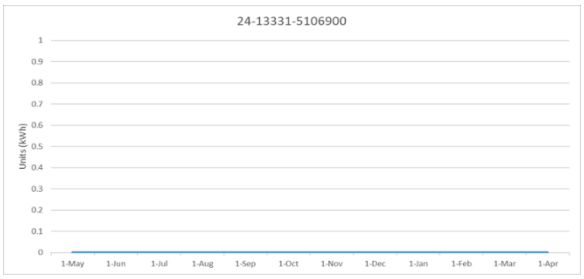
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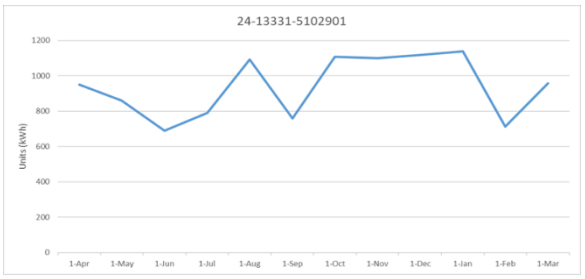
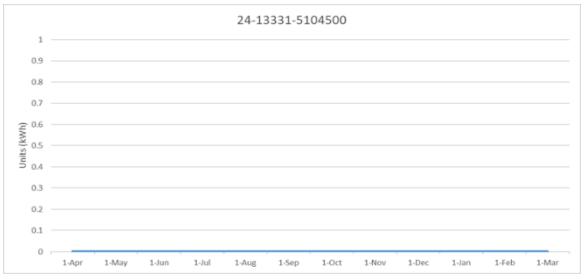
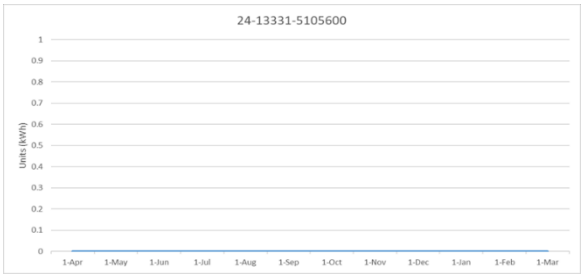
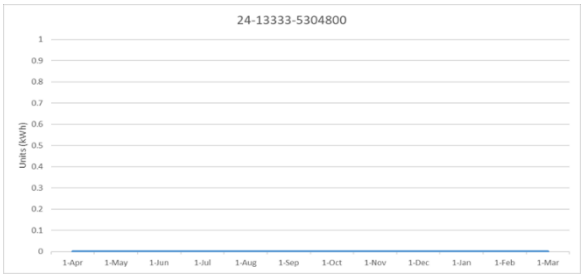
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr

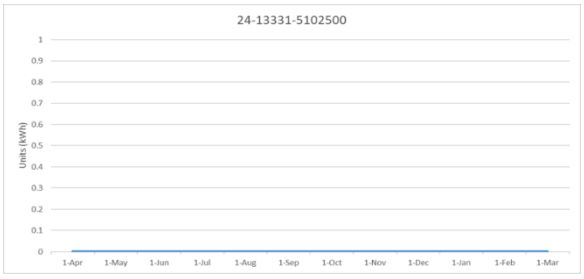

24-13331-5102901
Units (kWh)
1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar


24-13331-5104500
Units (kWh)
1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar


24-13331-5103500
Units (kWh)
1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar

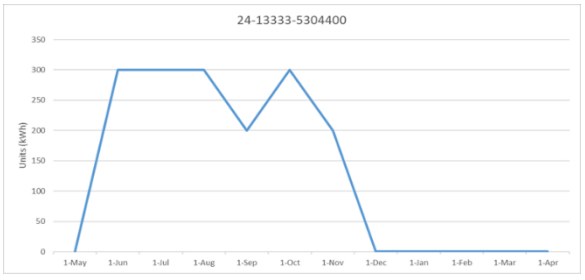

24-13331-5105600
Units (kWh)
1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar

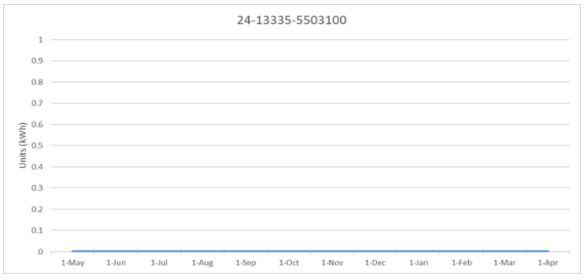

24-13333-5304800
Units (kWh)
1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar

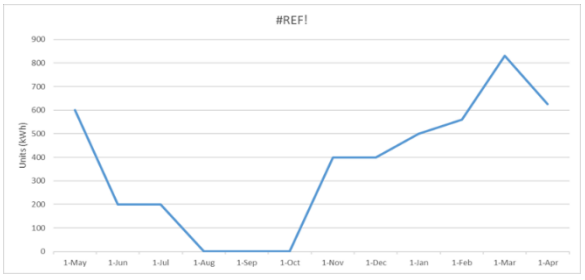

24-13331-5102500
Units (kWh)
1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar

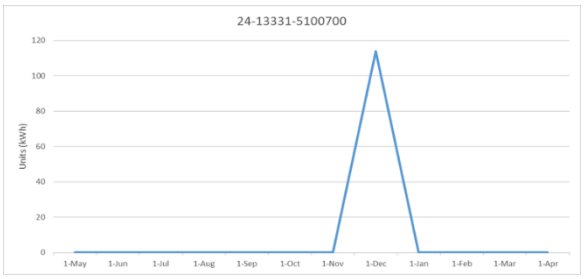

24-13331-5107000
Units (kWh)
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr

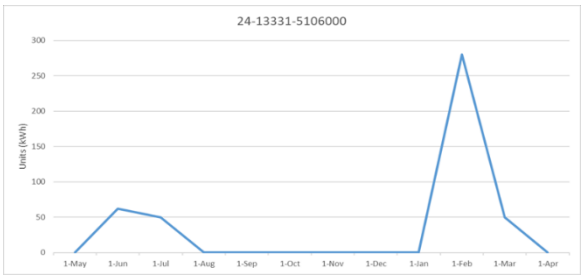

24-13331-5103700
Units (kWh)
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr

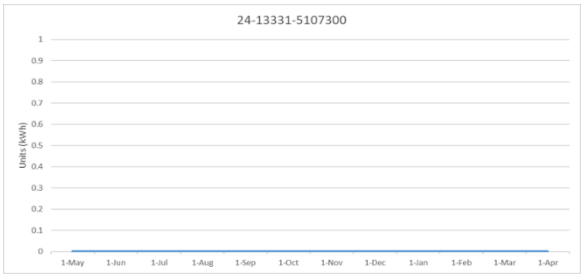

24-13333-5304400
Units (kWh)
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr


24-13335-5503100
Units (kWh)
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr

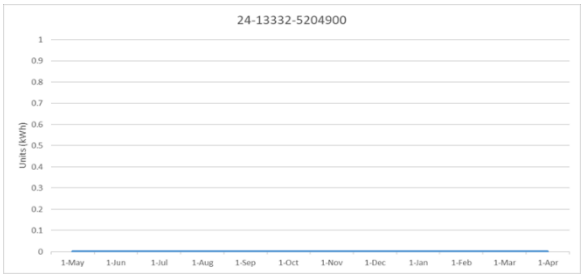

#REF!
Units (kWh)
1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr

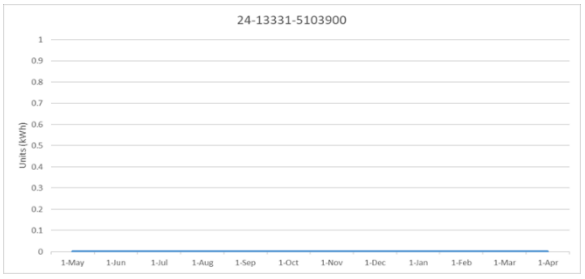

24-13331-5100700
Units (kWh)
120
100
80
60
40
20
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr

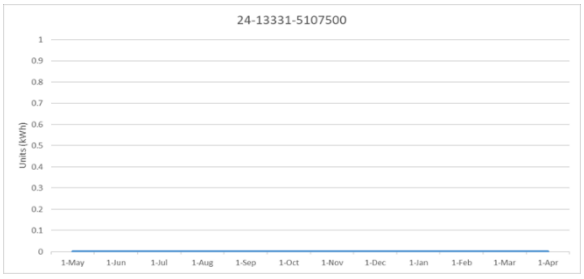

24-13331-5106000
Units (kWh)
300
250
200
150
100
50
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr

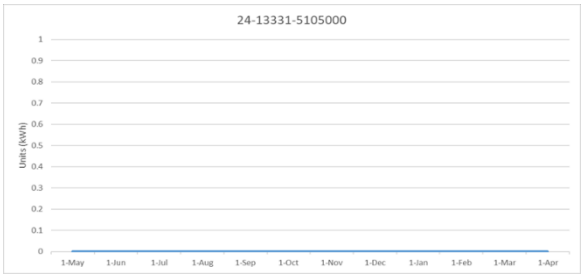

24-13331-5107300
Units (kWh)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr


24-13331-5107301
Units (kWh)
1600
1400
1200
1000
800
600
400
200
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr

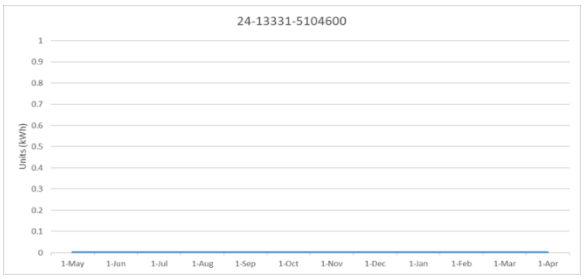

24-13332-5204900
Units (kWh)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr


24-13331-5103900
Units (kWh)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr

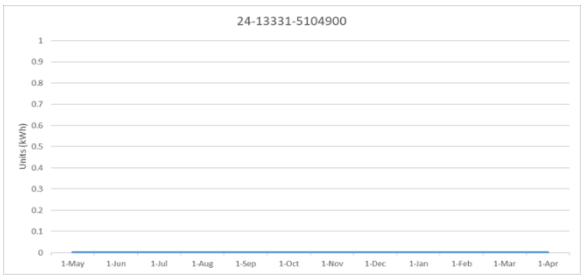

24-13331-5107500
Units (kWh)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr


24-13331-5105000
Units (kWh)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr


24-13332-5205500
Units (kWh)
8
7
6
5
4
3
2
1
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr


24-13331-5104600
Units (kWh)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr


24-13331-5104800
Units (kWh)
50
45
40
35
30
25
20
15
10
5
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr


24-13331-5104900
Units (kWh)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr

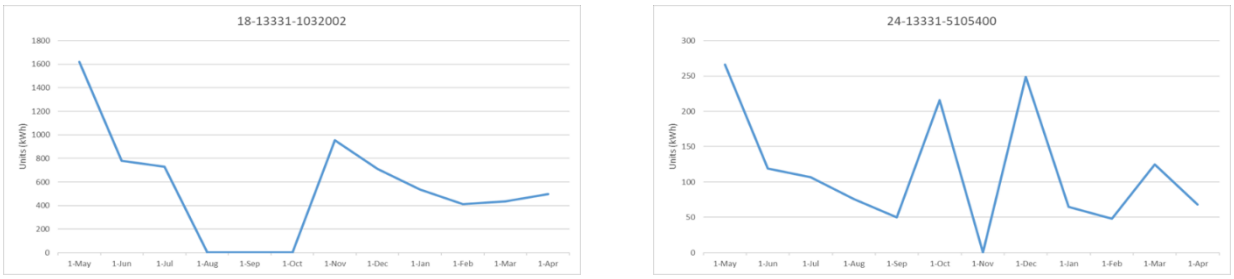


Figure 10: Energy Consumption trend of Streetlights

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Streetlights	150	266	88,274	227,311	-139,037	1,290 kWh/km	1,993 kWh/km	Although the MC has installed new LEDs undertaken replacement of inefficient streetlights withs LEDs, a twofold increase in the overall billing for streetlights has been observed. This points to potential misuse of the MC's electricity connections resulting in significantly increased billing for the MC. This needs to be further investigated.

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 Gojra.

3.5 Observations

- Streetlights in Gojra MC are operated by MC.
- Most of the operational streetlights are LEDs.
- Approximately 70% of the LED streetlights have a rating of more than 120 Watts.
- Gojra 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 Gojra 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	Gojra 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 Gojra MC is tabulated below.

Table 26: Vehicle Inventory Detail

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
1	TSG-11	Tractor Front loader	Millat	MF-385	2013	4WD	Transport of Solid Waste	LM9B572V502653X	G84455/02/13	85HP
2	TSG-102	Tractor Front loader	Millat	MF-385	2017	4WD	Transport of Solid Waste	LM9B575V505140C	82228/03/17	85HP
3	Unregistered vehicle 1	Truck Compactor	Hino	NR-300	2012	4WD	Transport of Solid Waste	12966	506002655	4009
4	TSG-4173	Tractor Trolley	Millat	MF-240	2002	2WD	Transport of Solid Waste	CE97065V605235J	1388/72	50HP
5	TSB-9095	Tractor Trolley	Fiat	Fiat-640	2001	2WD	Transport of Solid Waste	118919	26130/019	75HP
6	TSC-4171	Tractor Trolley	Millat	MF-240	2003	2WD	Transport of Solid Waste	CE97065V605052J	1388/58	50HP
7	FDE-9272	Tractor Trolley	Millat	MF-240	1980	2WD	Transport of Solid Waste	37111570	MTL/A-391/14	50HP
8	TSG-1003	Truck	Hino	NR-300	2010	4WD	Suction Sucker Jetting	JM12407	JHFYF20H306002301	4009
9	FDA-5361	Truck	Bedford	N/A	1972	4WD	Water Bowser	6154034	CJO-3B20/T687054	107HP
10	TSG-76	Tractor	Bull Power	IMT-549	2017	2WD	Encroachment Department	DM33TPK501041EE	PK0104152904EE	50HP
11	TSG-103	Tractor	Millat	MF-385	2017	4WD	Water Bowser	LM9B575V505182C	82228/12/17	85HP
12	TSG-8369	Tractor Back Hoe	Millat	MF-375	2008	2WD	Back Hoe	502275-P	70001/08/8	75HP
13	TSB-9093	Tractor	Fiat	Fiat-640	2001	2WD	No Task Assigned	117361	26106-019	75HP
14	TSJ-18	Rickshaw	Qingqi	CNE-100	2017	2WD	No Task Assigned	N/A	SQM1004TA252781	100
15	TSC-8306	Jeep	Suzuki	Potohar	2004	4WD	Transport of staff	J704442	333145	1000
16	TSC-306	Car	Suzuki	Cultus	2002	2WD	Transport of staff	P812068	955313	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)					Fuel Usage on logbook	
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption	(liter/hr)	(km/ltr)
1	TSG-11	9:55 AM	10:55 AM	1.49	1.49 Liters/hr	8:45 AM	9:55 AM		4.99	4.28 Liters/hr	5.8	
2	TSG-102	9:52 AM	10:52 AM	1.32	1.32 Liters/hr	8:45 AM	9:52 AM		5	4.48 Liters/hr	5.5	
3	Unregistered vehicle 1	9:50 AM	10:50 AM	2	2 Liters/hr	8:30 AM	9:33 AM	23	8	0.35 Liters/km		4.00
4	TSG-4173	10:01 AM	11:01 AM	0.81	0.81 Liters/hr	8:45 AM	10:01 AM		3.99	3.15 Liters/hr	2.7	
5	TSB-9095	10:03 AM	11:03 AM	1	1 Liters/hr	8:45 AM	10:03 AM		4.81	3.7 Liters/hr		
6	TSC-4171	10:08 AM	11:10 AM	1	0.97 Liters/hr	8:45 AM	10:08 AM	3	3	1 Liters/km		0.34
7	FDE-9272	10:32 AM	11:32 AM	0.5	0.5 Liters/hr	8:45 AM	10:32 AM		2.99	1.68 Liters/hr	2.3	
8	TSG-1003	10:23 AM	11:23 AM	1.7	1.7 Liters/hr	8:50 AM	10:23 AM		5	3.23 Liters/hr		1.07

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)					Fuel Usage on logbook	
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption	(liter/hr)	(km/ltr)
9	FDA-5361	10:10 AM	11:10 AM	2.3	2.3 Liters/hr	9:00 AM	10:10 AM		5.01	4.29 Liters/hr		
10	TSG-76	10:05 AM	11:05 AM	1.23	1.23 Liters/hr	9:05 AM	10:05 AM		5.82	5.82 Liters/hr		
12	TSG-8369	1:50 PM	2:50 PM	1.63	1.63 Liters/hr	12:20 PM	1:20 PM		3.65	3.65 Liters/hr	5.5	
15	TSC-8306	1:48 PM	2:48 PM	0.6	0.6 Liters/hr	12:30 PM	1:30 PM		1.33	1.33 Liters/hr		

Table 28: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	TSG-11	5.83
2	TSG-102	5.49
3	Unregistered vehicle 1	4.00
4	TSG-4173	2.74
5	TSC-4171	0.34
6	FDE-9272	2.25

The logbooks of remaining vehicles are not available in MC.

The MC made 15 of its vehicles available to the Consultant for carrying out on-field testing. The average fuel consumption of the vehicles in idle condition was found to be 1.29 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 3.56 liters/hour.

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

Table 29: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	30,150
Annual Cost of Fuel (Diesel)	PKR/y	8,833,950
Annual Consumption of Fuel (Petrol)	Liter/y	0
Annual Cost of Fuel (Petrol)	PKR/y	0

4.3 Maintenance Log of Vehicles

No record was available for the maintenance and repairing (if any) of the vehicles that are in use of the MC. Purchase record of newly bought vehicle is available with MC. Pictures of some of the vehicles owned by Gojra 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 Gojra 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 five 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.

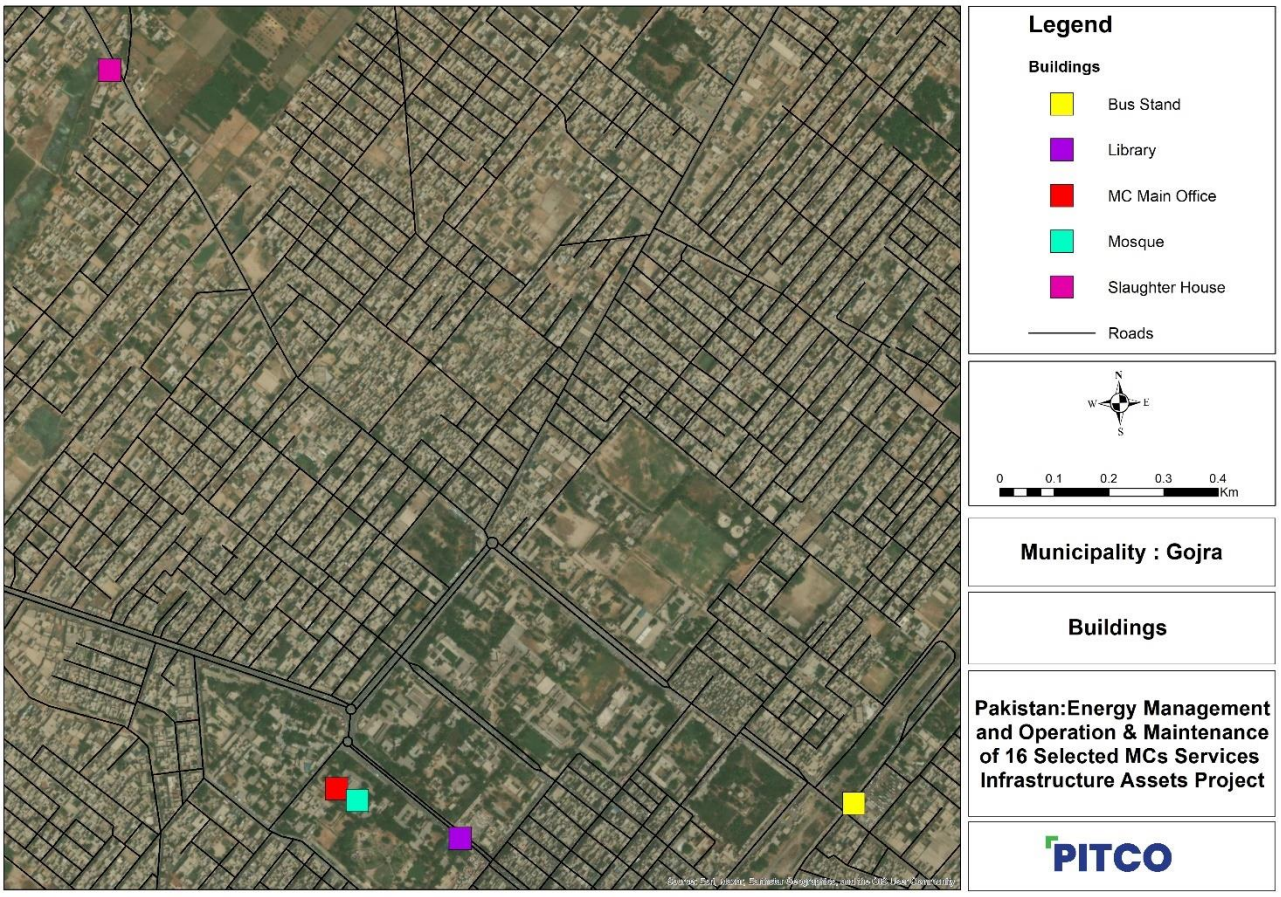


Figure 12: Map for Buildings

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	MC Main Office	N:31.149191 E:72.680857	52805148	Mc Office	N/A	Satisfactory	7,588	No Proper Insulation	1
2	Mosque	N:31.148987 E:72.681247	52805148-A	Mosque	N/A	Satisfactory	664	No Proper Insulation	1
3	Bus Stand	N:31.148670 E:72.690750	52805148-B	Bus stand	N/A	Satisfactory	4,047	No Proper Insulation	1
4	Slaughter House	N:31.161134 E:72.676967	52805149	Slaughter House	N/A	Satisfactory	1,518	No Proper Insulation	1
5	Library	N:31.148303 E:72.683194	52805150	Library	77	Un-Satisfactory	304	No Proper Insulation	1

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

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Main MC Building								
1	**MOI Office**	Ceiling Fan	1	80	8	8	208	133
2	**MOI Office**	Split AC	1	1800	4	8	208	1,498
3	**MOI Office**	Exhaust Fan	1	30	8	12	312	75
4	**MOR Office**	Ceiling Fan	1	80	8	8	208	133
5	**MOR Office**	Bracket Fan	1	50	8	8	208	83
6	**Planning Office**	Ceiling Fan	1	80	8	8	208	133
7	**Planning Office**	Exhaust Fan	1	30	8	12	312	75
8	**Audit Branch**	Ceiling Fan	2	80	8	8	208	266
9	**Audit Branch**	Split AC	1	1800	4	8	208	1,498
10	**Sub-Engineer Office**	Ceiling Fan	1	80	8	8	208	133
11	**Sub-Engineer Office**	Exhaust Fan	1	30	8	12	312	75
12	**English Branch**	Ceiling Fan	1	80	8	8	208	133
13	**Gallery 1**	Air Cooler	1	125	2	6	156	39
14	**Complaint Cell**	Ceiling Fan	1	80	8	8	208	133

[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)
15	**Complaint Cell**	Exhaust Fan	1	30	8	0	0	0
16	**Complaint Cell**	Pedestal Fan	1	125	4	8	208	104
17	**Hall Room**	Bracket Fan	6	50	4	8	208	250
18	**Hall Room**	Split AC	1	1800	0	0	0	0
19	**Hall Room**	Split AC	1	1650	0	0	0	0
20	**Engineering Branch**	Bracket Fan	1	50	8	8	208	83
21	**Engineering Branch**	Split AC	1	1800	4	8	208	1,498
22	**Tax branch**	Ceiling Fan	1	80	8	8	208	133
23	**Tax branch**	Split AC	1	1800	0	0	0	0
24	**Kitchen**	Bracket Fan	1	50	8	8	208	83
25	**Record Room**	Bracket Fan	2	50	8	8	208	166
26	**Gallery 2**	Bracket Fan	1	50	4	8	208	42
27	**Administration Room**	Bracket Fan	3	50	6	8	208	187
28	**Administration Room**	Split AC	1	1800	6	8	208	2,246
29	**Administration Room**	Exhaust Fan	1	30	0	0	0	0
30	**Retaining Room**	Bracket Fan	3	50	6	8	208	187
31	**Retaining Room**	Split AC	1	1800	6	8	208	2,246
32	**Washroom**	Bracket Fan	1	50	6	8	208	62
33	**Washroom**	Exhaust Fan	1	30	6	12	312	56
34	**Co-office**	Ceiling Fan	1	80	6	8	208	100
35	**Co-office**	Split AC	1	1800	6	8	208	2,246
36	**Finance Office**	Ceiling Fan	1	80	8	8	208	133
37	**Finance Office**	Split AC	1	1800	8	8	208	2,995
38	**Account Branch**	Ceiling Fan	1	80	8	8	208	133
39	**Account Branch**	Air Cooler	1	350	4	8	208	291
40	**Account Branch**	Bracket Fan	1	50	8	8	208	83
41	**Account Branch**	Exhaust Fan	1	150	4	12	312	187
42	**Pension Branch**	Bracket Fan	1	50	8	8	208	83
43	**Pension Branch**	Inverter AC	1	1150	8	8	208	1,914
44	**Gallery 3**	Ceiling Fan	1	80	4	8	208	67
Mosque+ Main Hall								
1	**Mosque Inside**	Ceiling Fan	6	80	2	8	208	200
2	**Mosque Inside**	Split AC	2	2700	2	6	156	1,685
3	**Mosque Inside**	Bracket Fan	3	50	2	8	208	62
4	**Mosque Outside**	Ceiling Fan	18	80	2	8	208	599
5	**Mosque Outside**	Bracket Fan	2	50	2	8	208	42
Bus Stand								
1	**Ticket Room**	Ceiling Fan	2	80	12	8	208	399
2	**Waiting Area**	Ceiling Fan	10	80	12	8	208	1,997
3	**Outside Area**	Ceiling Fan	3	80	0	0	0	0
Library								
1	**Library Office**	Ceiling Fan	1	80	8	8	208	133

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
2	**Washroom Area**	Ceiling Fan	1	80	2	8	208	33
3	**Hall**	Ceiling Fan	2	80	1	8	208	33
	Total Annual kWh							**25,167**

Table 32: 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)
Main MC Building							
1	**MOI office**	Tube light	2	40	8	312	200
2	**MOI office**	CFL	1	85	8	312	212
3	**MOI office**	LED	1	28	8	312	70
4	**MOI office**	CFL	1	15	8	312	37
5	**MOI office**	Zero Bulb	1	12	4	312	15
6	**MOR office**	Tube light	5	40	8	312	499
7	**Planning office**	CFL	1	24	6	312	45
8	**Planning office**	LED	2	12	8	312	60
9	**Planning office**	LED	1	40	6	312	75
10	**Audit Branch**	Tube light	2	40	8	312	200
11	**Audit Branch**	LED	2	12	8	312	60
12	**Audit Branch**	LED	3	18	4	312	67
13	**Audit Branch**	LED	2	28	4	312	70
14	**Sub-Engineer office**	Tube light	2	40	6	312	150
15	**Sub-Engineer office**	CFL	4	24	6	312	180
16	**Sub-Engineer office**	LED	2	12	8	312	60
17	**English Branch**	Tube light	2	40	8	312	200
18	**English Branch**	CFL	2	24	0	312	0
19	**English Branch**	LED	1	15	8	312	37
20	**English Branch**	LED	1	12	8	312	30
21	**Gallery 1**	Tube light	3	40	10	312	374
22	**Gallery 1**	LED	3	18	10	312	168
23	**Complaint Cell**	LED	2	45	8	312	225
24	**Hall Room**	LED	7	28	1	312	61
25	**Engineering Branch**	LED	1	12	8	312	30
26	**Engineering Branch**	LED	1	45	8	312	112
27	**Tax Branch**	Tube light	2	40	8	312	200
28	**Tax Branch**	LED	1	12	8	312	30
29	**Tax Branch**	LED	1	28	6	312	52
30	**Kitchen**	Tube light	1	40	0	312	0
31	**Kitchen**	LED	1	12	0	312	0

[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)
32	**Record Room**	CFL	2	30	8	312	150
33	**Gallery 2**	Tube light	1	40	0	312	0
34	**Gallery 2**	LED	3	12	12	312	135
35	**Gallery 2**	Tube light	2	40	12	312	300
36	**Administrator room**	LED	4	28	6	312	210
37	**Retaining Room**	LED	2	28	6	312	105
38	**Washroom**	LED	1	12	6	312	22
39	**Co-office**	Tube light	1	40	6	312	75
40	**Co-office**	LED	1	28	6	312	52
41	**Co-office**	LED Tube	3	40	6	312	225
42	**Finance Office**	Tube light	1	40	8	312	100
43	**Finance Office**	LED	3	40	8	312	300
44	**Finance Office**	LED	1	45	6	312	84
45	**Account Branch**	Tube light	4	40	8	312	399
46	**Account Branch**	LED	1	12	8	312	30
47	**Pension office**	Tube light	5	40	8	312	499
48	**Gallery 3**	CFL	1	85	12	312	318
49	**Gallery 3**	LED	1	12	12	312	45
50	**Outside Area**	LED	3	50	12	312	562
51	**Outside Area**	LED	6	15	12	312	337
52	**Outside Area**	LED	1	120	12	312	449
			Mosque				
1	**Mosque Inside**	LED	5	12	2	312	37
2	**Mosque Inside**	LED	2	28	2	312	35
3	**Mosque Outside**	Tube light	2	40	2	312	50
4	**Mosque Outside**	LED	4	12	8	312	120
5	**Wazu Area**	LED	7	12	1	312	26
			Bus Stand				
1	**Ticket Room**	LED	1	12	12	312	45
2	**Waiting Area**	ILB	1	100	12	312	374
3	**Waiting Area**	Tube Light	2	40	0	312	0
4	**Washroom**	ILB	5	100	24	312	3,744
5	**Outside Area**	LED	4	120	12	312	1,797
			Library				
1	**Library office**	Tube light	2	40	8	312	200
2	**Washroom Area**	Tube light	1	40	8	312	100
3	**Outside Area**	Tube light	4	40	0	312	0
4	**Hall**	Tube light	1	40	0	312	0
5	**Hall**	CFL	1	15	1	312	5
						Total Annual kWh	**14,448**

5.3 Baseline Energy Consumption Trend

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

Table 33: Energy consumption in Office Buildings

SI No.	Description	Unit	Value[9]
1	Annual Electricity Consumption	kWh	61,029
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	4	5	31,168	61,029	-29,861	3.64 kWh/m2	7.13 kWh/m2	General bus stand building and Slaughter House building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these buildings has not been considered in the overall energy consumption and KPI calculations. Electricity units (kWh) are increased due to increase in operating hours of electric appliances during summer.

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

Table 34: Cooling Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Office	Ceiling Fan	36	0	13
MC Office	Bracket Fan	9	0	21
MC Office	Air Cooler	7	0	2
MC Office	Exhaust Fan	-	-	7
MC Office	Pedestal Fan	-	-	1
MC Office	Inverter	-	-	1
MC Office	Split AC	9	0	10
Library	Ceiling Fan	4	0	4
Mosque	Ceiling Fan	21	0	24
Mosque	Bracket Fan	6	0	5
Mosque	Split AC	2	0	2

Table 35: Lighting Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Office	Tube light	72	72	33
MC Office	CFL	44	44	12
MC Office	LED	12	0	62
Library	Tube light	10	10	8
Library	CFL	-	-	1
Mosque	Tube light	16	16	2
Mosque	LED	6	0	18

Table 36: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh	Comments
MC Main Office	10,589	25,874	General bus stand building and Slaughter House building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these buildings has not been considered in the overall energy consumption and KPI calculations. Electricity units (kWh) are increased due to increase in operating hours of electric appliances during summer.
Mosque	19,863	33,874	
Library	716	1,281	
Overall	**31,168**	**61,029**	

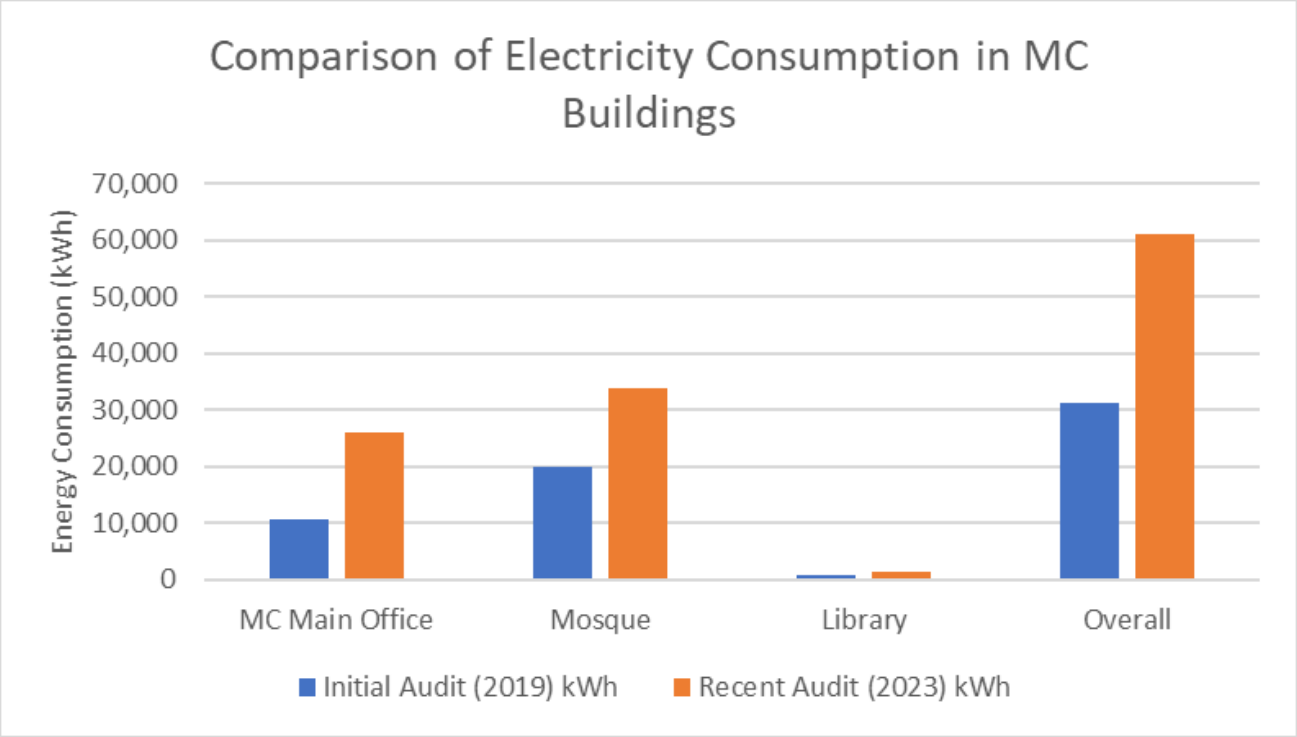


Figure 13:Comparison of Electricity Consumption in MC Buildings

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 Gojra

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

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

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

Table 37: Metering details at MC Gojra

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Main MC Office Building	52805148	04133310402100 (1ϕ)	1	A-3a (66)
			04133310403101 (1ϕ)	3	A-3a (66)
			04133310403200 (1ϕ)	4	A-3a (66)
2	Mosque	52805148-A	041333104031[10] (1ϕ)	1	A-3a (66)
3	Bus Stand	52805148-B	06133310570300 (1ϕ)	1	A-2a (04)
4	Library	52805150	04133310404200 (1ϕ)	1	A-3a (66)

6.1 Main MC Office Building

The project site i.e. Main MC Office Building is located near Police Station Rd, Gojra, Toba Tek Singh District, Punjab, Pakistan while the geographical co-ordinates of location are 31.149191°N (latitude) and 72.680857°E (longitude).

Figure 14: Front View Of Main MC Office Building

Figure 15: Aerial View of Main MC Office building

[10] This meter is shared with Main MC Office Building.

6.1.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption of Main MC Office Building is 25,874 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 38: Solar System Requirement

Sr. No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	04133310402100	4,561	380	1,008[11]	3
2	04133310403101	5,608	468	608[12]	4
3	04133310403200	15,705	1,309	3,130[13]	11
4	04133310403100	-	-	-	-
Total					**18**

Note: Based on the analysis of the historical billings it is identified that the total system requirement for this site is **18 kW** therefore, the Consultant has estimated the rooftop assessment of the Main MC Office building. However, it is highly recommended to replace the single-phase connection with three-phase connection before the installation of solar system.

It should be noted that Mosque is the main consumer of the meter 4 (04133310403100), therefore the Consultant has not included it in the total annual energy consumption.

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Office Building is 81,677 ft^2 whereas, the total area of rooftop available for the solar installation is 6,618 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 the building section-A

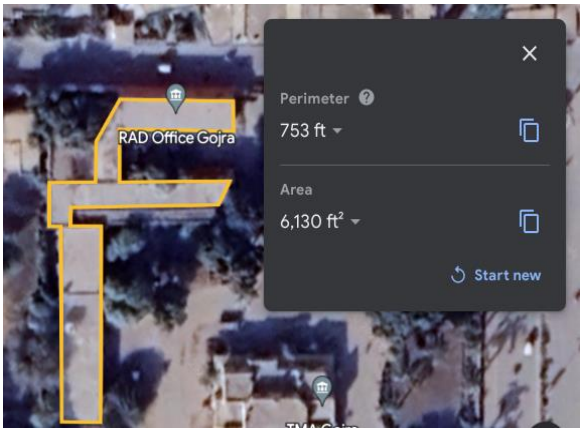


Figure 17: Top view of the building section-B

[11] This energy consumption peak is from the month of September 2022.
[12] This energy consumption peak is from the month of October 2022.
[13] This energy consumption peak is from the month of August 2022.

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

Figure 18: Location for Installation-A

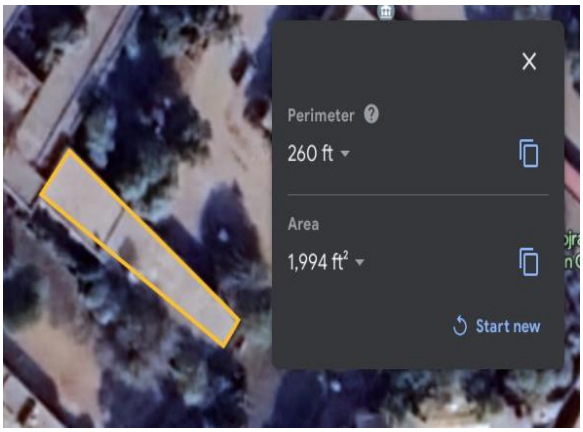


Figure 19: Location for Installation-B

Figure 20: Location for Installation-C

Figure 21: Location for Installation-D

Table 39: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Location – D	Total
Area availability (ft²)	474	1,994	1,196	1,518	5,182
Solar system capacity (kW)	5	20	12	15	52

6.2 MC Mosque

The project site i.e. MC Mosque near Police Station Rd, Gojra, Toba Tek Singh District, Punjab, Pakistan while the geographical co-ordinates of location are 31.148807°N (latitude) and 72.68128°E (longitude).

Figure 22: Front view of the Mosque

Figure 23: Aerial view of the Mosque

6.2.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to February 2023, it is identified that the annual energy consumption of this electrical connection is 33,874 kWh with the peak electricity consumption of 5,034 kWh in June 2022. The annual energy consumption for this electrical connection could not be accurately determined as this meter is shared with Main MC Office Building therefore, the Consultant has only carried out the assessment of installation capacity of solar system.

6.2.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Mosque is 7,145 ft^2 whereas, the total area of rooftop available for the solar installation is 2,735 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

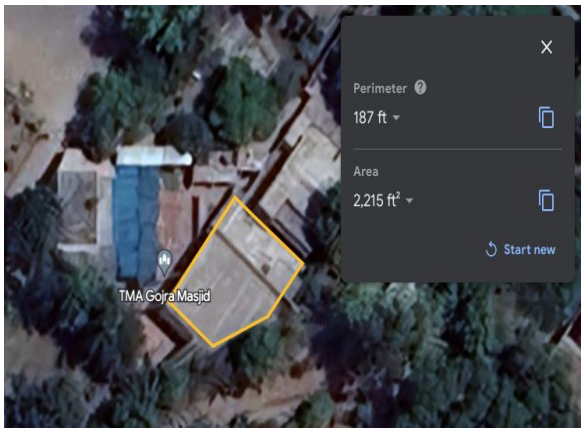


Figure 24: Top view of the building section-A

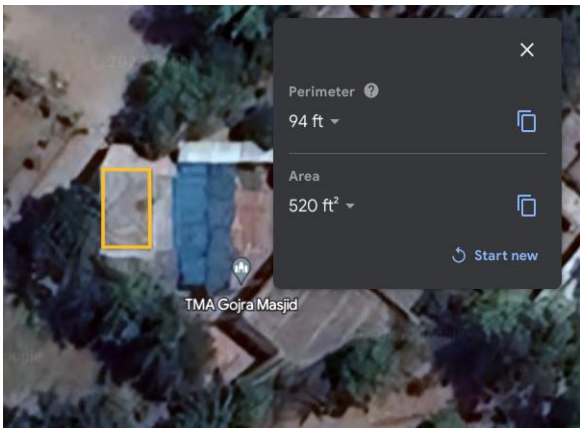


Figure 25: Top view of the building section-B

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

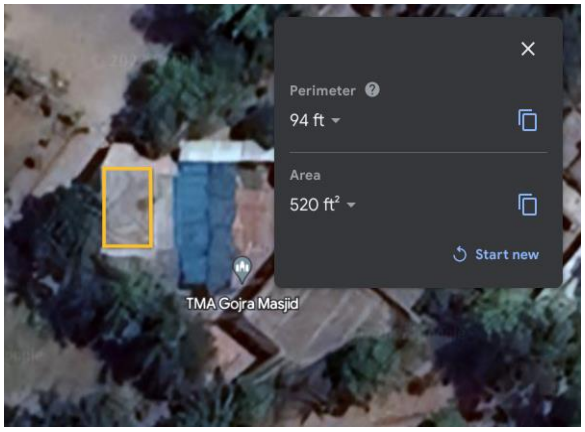


Figure 26: Location for Installation-A

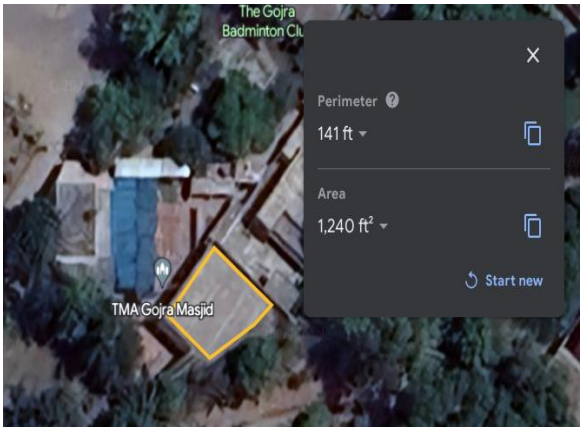


Figure 27: Location for Installation-B

Table 40: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Total
Area availability (ft²)	520	1,240	1,760
Solar system capacity (kW)	5	12	17

6.3 Bus Stand

The project site i.e. Bus Stand is located near Qabristan Wala Road, Gojra, Toba Tek Singh District, Punjab, Pakistan while the geographical co-ordinates of location are 31.148778°N (latitude) and 72.69126°E (longitude).

Figure 28: Front View Of Bus Stand

Figure 29: Aerial View of the Bus Stand

6.3.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption of Bus Stand is 976 kWh with the peak electricity consumption of 112 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 41: Solar System Requirement

Sr. No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	06133310570300	976	81	112	1

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

6.4 Library

The project site i.e. Library is located near City Thana Road, Gojra, Punjab, Pakistan while the geographical co-ordinates of location are 31.148303°N (latitude) and 72.683194°E (longitude).

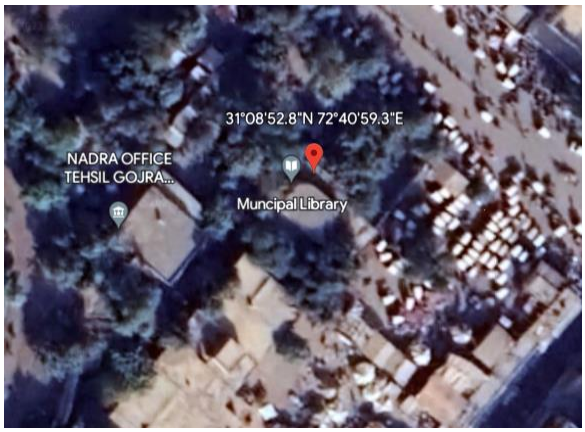


Figure 30: Aerial View of the Library

6.4.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that the annual energy consumption of Library is 1,281 kWh with the peak electricity consumption of 174 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 42: Solar System Requirement

Sr. No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	04133310404200	1,281	107	174	1

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

6.5 Net Metering Consideration

With the rising costs of electricity in Pakistan and owning to unreliable grid supply, an ever increasing number of industries and commercial organizations are turning to captive solar solutions. There has been a strong

surge in domestic installation of rooftop photovoltaic panels in larger cities. For projects under 1 MW, net metering regulations came into effect in September 2015.
The key highlights of net-metering regulation are as follows:

- Any three phase consumers (residential, commercial and industrial) will be considered eligible for the net metering system.
- Only plants installed and commissioned by AEDB registered vendors/consultants shall be eligible for net metering.
- Any empty space on the roof or facades of buildings, car parking, garages, factory or industrial buildings or sheds or similar buildings or at land within own premise of the consumer or any other suitable area where utility meter exists, is acceptable by the utility.
- Interconnection standards shall comply with the interconnection rules and standards set by the Utility or other relevant governing authority.
- 150% on the customer's sanctioned load is specified as the maximum permissible generator size (installed output DC capacity).
- The maximum output DC capacity of the installed RE system for Net Metering cannot be more than 1 MW.
- Load flow study for the facility having capacity up to 250kW is not required.
- The NOC by Electrical Inspector is not required for Net Metering of a system below 250 kW capacity.
    - In case the kWh supplied by Distribution Company exceed the kWh supplied by Distributed Generator, the Distributed Generator shall be billed for the net kWh in accordance with the Applicable Tariff.
    - The tariff payable by the Distribution Company shall only be the off-peak rate of the respective consumer category of the respective month.
- The equipment installed for net metering shall be capable of accurately measuring the flow of electricity in two directions.
- The net meter shall conform to the specifications mentioned in Net metering regulation or approved by relevant authority (Utility or NEPRA).
- A Distributed Generator shall be responsible for all costs associated with Interconnection Facilities up to the Interconnection Point including metering installation
- A variation of ±5%in Voltage and ±1% in frequency is permissible to the nominal voltage and frequency respectively
- The Distributed Generator will furnish and install a manual disconnect device that has a visual break to isolate the Distributed Generation Facility from the Distribution facilities
- The grid connected inverters and generators shall comply with Underwriter Laboratories UL 1741 standard (Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources) which addresses the electrical interconnection design of various forms of generating equipment, IEEE 1547 2003, IEC 61215, EN
- The Distributed Generator shall not have any right to utilize Distribution Company's Interconnection Facilities for the sale of electricity to any other person.

6.5.1 Net-metering application procedure

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

- Any person who meets the requirements of a Distributed Generator as defined under the regulations 2(k) is eligible for submitting application. Regulation 2(k) states the definition of a Distributed Generator as "a Distribution Company's 3 Phase 400V or 11 kV consumer i.e: domestic, commercial or industrial and who owns and/or operates the Distributed Generation **Facility and** is responsible for the rights and regulations related to the agreement and licensed by the Authority under these regulations".
- Application to Distribution Company along with necessary documents shall be submitted by intending Distributed Generator.
- Within five working days of receiving an Application, the Distribution Company shall acknowledge its receipt and inform the Applicant whether the Application is completed in all respect. Provided that in case of any missing information or documents the Applicant shall provide the same to Distribution Company within seven working days of being informed by Distribution Company.
- Upon being satisfied that the Application is complete in all respect, the Distribution Company shall perform an initial review (20 days) to determine whether the Applicant qualifies for Interconnection Facility or may qualify subject to additional requirements.
- In case the initial review reveals that the proposed facility is not technically feasible, the Distribution Company shall return the Application and communicate the reasons to the Applicant within three working days after the completion of initial review.
- For connections up to 250 kW, no technical feasibility study is needed. Power Ministry, GOP has directed DISCOs to carry out relevant technical studies and approve the connections at sub-division level. If the DISCO is satisfied that the Applicant qualifies as a DG, then the DISCO and DG will enter into an agreement.
- The DISCO office will send the copy of the Agreement between DISCO and DG to NEPRA along with application for issuance of Generation License (GL). NEPRA will issue GL within forty (40) hours of submission of application by DISCOs.
- After the Agreement. DISCO will issue the Connection Charge Estimate, if any, to the Applicant for the proposed interconnection facility up to the interconnection point including net metering installation (it is the Applicant's choice to purchase Net Meter from DISCO or open market)
- The Applicant shall make the payment of Connection Charge Estimate within twenty days of its issuance.
- Within Thirty (30) days of payment by Applicant, the DISCO office will install and commission the proposed interconnection facility after the confirmation of GL license to the DG by NEPRA.

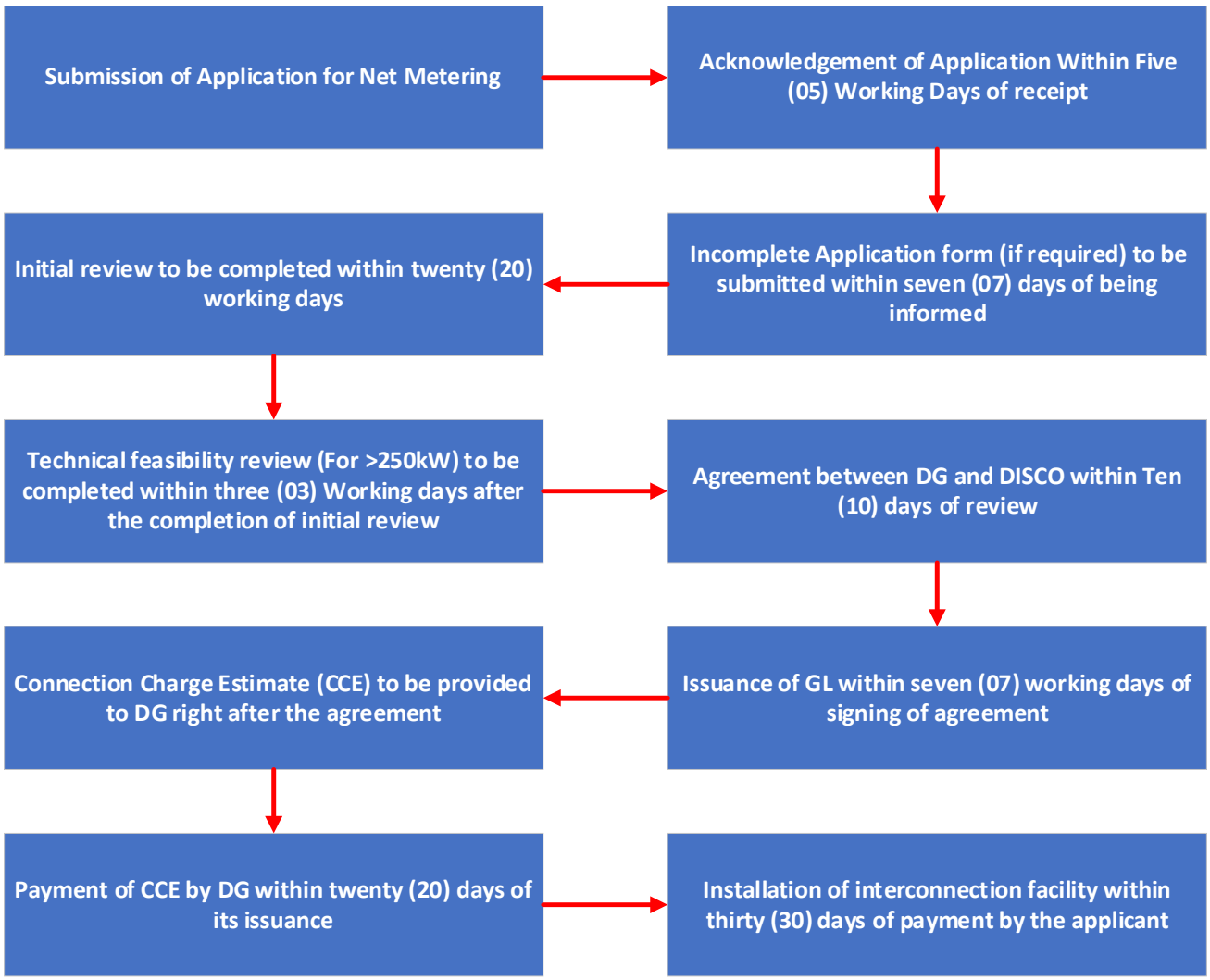


Figure 31: Pakistan Net Metering Application Process

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

7 Recommended Energy Efficiency Measures

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

7.1 Energy Efficiency Measures for Water Pumps & Wastewater Disposal System

7.1.1 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Mochi Wala Road # 4 - Unique ID: 52905151)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 35%.

Recommended Action

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

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

Saving Assessment

Table 43: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	76
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	73
Measured Head	m	25.0
Measured Motor Power	kW	16.80
Pump Efficiency	%	35%
Existing Operational Hours	h	18.0
Proposed Pump Flow	m^3/h	76
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	17.2
Pump Operational Days	days	330
Efficiency	%	80%
Energy Required by Existing Pump	kWh/y	99,792
Energy Required by Proposed Pump	kWh/y	76,231
Saving Potential	kWh/y	23,561
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,784
Investment	US $	3,569
Simple Payback Period	months	11

7.1.2 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Sultan Pura Damma Bangla # 05 - Unique ID: 52905162)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 38%.

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 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	250
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	103
Measured Head	m	20.6
Measured Motor Power	kW	18.20
Pump Efficiency	%	38%
Existing Operational Hours	h	14.0
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	14.2
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	84,084
Energy Required by Proposed Pump	kWh/y	62,949
Saving Potential	kWh/y	21,135
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,394
Investment	US $	3,794
Simple Payback Period	months	13

7.1.3 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Dijkot Road water works - Unique ID: 53105182-A)

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 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	19
Measured Flow	m^3/h	112
Measured Head	m	12.5
Measured Motor Power	kW	18.40
Pump Efficiency	%	24%
Existing Operational Hours	h	7.5
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	8.3
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	45,540
Energy Required by Proposed Pump	kWh/y	36,591
Saving Potential	kWh/y	8,949
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,437
Investment	US $	3,794
Simple Payback Period	months	32

7.1.4 High Priority Energy Efficiency Measure: Replacement/installation of Capacitors for Power Factor improvement.

Description

Replacement/installation of capacitors for power Factor (PF) improvement.

Study & Investigation

The power factor (PF) was measured using an energy analyzer during normal pump operation.

Recommended Action

Replacement/Installation of capacitors to improve Power Factor. The recommended capacitor size has been calculated for achieving a PF value of 0.9.

Saving Assessment

Table 46: Financial Analysis of installation of capacitors for improvement of Power Factor

Sr. No.	Location	Unique ID	PF kVAR on each phase	Quantity	Unit Cost (USD)	Total (USD)
1	Mochi Road #2	52905155	2.5	3.0	50	150
2	Damma Bangla # 2	53105177	2.5	3.0	50	150
3	298/JB Balvand Pura	53005172-C	2.5	3.0	50	150
4	298/JB Balvand Pura	53005172-D	2.5	3.0	50	150
5	Model City Phase-2	53005175-A	2.5	3.0	50	150
6	Model City Phase-2	53005175-B	2.5	3.0	50	150
7	Chak No. 371-JB Ganda Singh	35007771-A	5.0	3.0	50	150
8	Chak No. 371-JB Ganda Singh	35007771-B	5.0	3.0	50	150
9	Chak No. 371-JB Ganda Singh	35007771-C	2.5	3.0	50	150
Total						**1350**

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

Description

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

Study & Investigation

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

Recommended Action & Benefits

- It is recommended to install 42 smart water meters on all operational potable water and disposal pumps.
- DCS system will help in water data review, development of KPI, analysis of generation and consumption trends during different seasons and times of year.
- In the long term, the measure will help the GoPb tremendously if it intends to meter the water usage of its commercial and domestic consumers, and determine a water tariff (based on actual consumption).
- Overall reduction in water & corresponding energy consumption

Saving Assessment

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

Table 47: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	3,591,785
Annual Water consumption (post-implementation)	m^3/y	3,555,868
Annual Water saving per year	m^3/y	35,918
Estimate of Investment (including the cost of the server)	US$	42,000

7.2 Energy Efficiency Measures for Streetlights

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

Project

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

Study & Investigation

During the assessment it was observed that there are 1,989 streetlights are being operated by the municipality. Out of these, 1,723 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 32: Picture of proposed LED, Photocell switch and energy meter for streetlights

Saving Assessment

LED lamps will have less maintenance issues as compared to conventional tube lights and energy savers (CFLs), because they have longer operational life.

Automatic photocell switches will optimize the daily operational hours of streetlights resulting in electricity savings and cost of operation (no more dedicated person will be required for operation of streetlights).

Since this measure is for all non-functional lights hence no direct electricity savings could be quantified.

Table 48: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	1723
Number of non-functional streetlights (>20 feet)	#	49
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	1,674

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	88,115,891
Proposed number of photocell switches	#	46
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	46,000
Upfront investment cost	PKR	88,161,891
Upfront investment cost	US$	314,639
Annual Operating Electricity unit	kWh/yr	230,695
Annual Operating Cost	PKR/yr	10,381,257
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	985,105
Monthly diesel cost for operating fork lifter for two days	PKR/month	20,000
Monthly cost of renting Fork Lifter for two days	PKR/month	80,000
Miscellaneous Cost	PKR/month	20,000
Monthly maintenance cost	PKR/month	120,000

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

Project

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

Study & Investigation

During the assessment it was observed that there are 1,989 streetlights operated by municipality out of which 266 are operational. 262 of the operational streetlights were LEDs so they are not recommended for replacement.

Recommended Action

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

Saving Assessment

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

Table 49: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	4
Number of functional streetlights (>20 feet)	#	0
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	4

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Upfront investment cost	PKR	204,244
Upfront investment cost	US$	729
Annual Operating Electricity unit	kWh/yr	526
Annual Electricity Consumption of Existing Lights	kWh/yr	24
Financial Savings	US$/yr	-81
Payback	months	-109

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 50: Replacement of inefficient equipment at office buildings

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
Main MC Building											
1	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
2	CFL	1	85	85	212	LED Bulb 50 Watts	50	50	125	6,800	6,800
3	CFL	1	15	15	37	LED Bulb 8 Watts	8	8	20	330	330
4	Tube light	5	40	200	499	LED Rod 20 Watts	20	100	250	2,900	14,500
5	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
6	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
7	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
8	CFL	4	24	96	240	LED Bulb 13 Watts	13	52	130	350	1,400
9	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
10	Tube light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
11	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
12	CFL	2	30	60	150	LED Bulb 13 Watts	13	26	65	350	700
13	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
14	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
15	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
16	Tube light	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
17	Tube light	5	40	200	499	LED Rod 20 Watts	20	100	250	2,900	14,500

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
18	CFL	1	85	85	212	LED Bulb 50 Watts	50	50	125	6,800	6,800
Mosque											
19	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
Bus Stand											
20	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
21	ILB	5	100	500	1,248	LED Bulb 13 Watts	13	65	162	350	1,750
Library											
22	Tube light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
23	Tube light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
24	CFL	1	15	15	37	LED Bulb 8 Watts	8	8	20	330	330
	Total										**123,210**

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 51: 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	6,040
Average Operational Hours for Building Cooling Equipment	Hours/day	2,508
Energy consumption of inefficient Equipment	kWh/yr	3,532
Energy consumption of Proposed Equipment	kWh/yr	45
Energy Savings	kWh/yr	567
Unit cost of electricity	PKR/kWh	440
Annual cost savings	USD	9
Upfront Investment (including change in fixtures)	USD	312
Payback Period	Months	8

8 Investment Estimate (including Material Specification/Quantities)

8.1 Potable Water Pump

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

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

Pump Size		8 HC /8 Stages			
Capacity		76.46 m3/hr	Max. O.D bowl		7.5 Inches
Speed		1450 rpm	I.D tubewell	-	
Pump Input		25 HP	Length of suction pipe		
Prime Mover (SEM/DE)		25 HP			
			Length of bowl assembly		
			Length of column pipe		
			Length of top pipe		0 Ft
			Total length of column		0 Ft

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

Pump assembly of	8	stages with flow type impellers				
Column assembly of	4	inshces I.D with flanged joins		each 10 ft length	0	Sets
				and one top set	0	feet length
				column shaft dia	0	mm
Electric Motor vertical hollow shaft 25 HP/4 Pole						included
DWT with Discharge Head						included
Mechanical installation within Pump House Only						included

Price of pumping unit as specified above

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

8.1.2 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

8.2 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	49	53,873	2,639,777
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	1,674	51,061	85,476,114
3	Accessories	Photocell switch				46	1,000	46,000
Lumpsum Price (PKR)								**88,161,891**
Lumpsum Price (USD)								**314,639**

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	4	51,061	204,244
Lumpsum Price (PKR)								**204,244**
Lumpsum Price (USD)								**729**

8.3 Investment Estimate (including Material Specification/Quantities) Buildings

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

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

Sr. No	Proposed Equipment	Wattage of Proposed Equipment	Equipment Count	Overall Wattage of Proposed Equipment	Individual Cost of Proposed Equipment (PKR)	Cost of Proposed Equipment
1	LED Rod 20 Watts	20	36	720	2,900	104,400
2	LED Bulb 50 Watts	50	2	100	6,800	13,600
3	LED Bulb 8 Watts	8	2	16	330	660
4	LED Bulb 13 Watts	13	13	169	350	4,550
Lumpsum Price (PKR)						**123,210**
Lumpsum Price (USD)						**440**

9 Summary of Energy Efficiency Measures

MC Gojra's annual energy consumption is 3,014,065 kWh which is mainly in the form of electricity (water supply, buildings & streetlights) and fuel for vehicles. The study has helped in successfully identifying resource and energy efficiency improvement measures which will help:

- Yield annual savings of **US$ 9,102** with an estimated investment of **US$ 370,314**
- Reduce electricity consumption by approx. **56,675 kWh**
- Reduce GHG Emissions by **28 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of FESCO

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

Annexure 2: List of Energy Audit Equipment

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

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