Kot Addu Municipal Committee

Energy Audit Report

June 2023

History of the Document

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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 Kot Addu Municipal Committee representatives for their support extended during the field study.

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ABBREVIATIONS

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

UNITS OF MEASUREMENTS

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

CONVERSION FACTORS

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

BASELINE PARAMETERS

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

1 Summary

1.1 Background

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

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

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

1.2 Scope of work

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

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

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

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

1.4 Kot Addu MC Background

Kot Addu is the capital city of Kot Addu District situated in the south east region in the Punjab province of Pakistan. It is located at 29.9927 N 73.2536 E and has a population of approximately 161,033. It is the 34th biggest city of Pakistan by population.

Municipal Committee Kot Addu came into existence on the 1st of January, 2017 consequent upon the promulgation of Punjab Local Government Act, 2013. It is presently subdivided into 32 Electoral Wards. The city is headquarter of Kot Addu Tehsil of Muzaffargarh District in the Punjab province of Pakistan. It is located in the southern part of the Punjab province at about 90 K.M. It has a population of over 130,000 persons as per Census 2017. Kot Addu city is renowned for power generation. Kot Addu Power Plant having a generation capacity of 1,638 MW.

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 Kot Addu MC has the following management.

Sr. No.	Name of Officer	Designation
1	Mr. Muhammad Asghar Iqbal	Administrator
2	Mr. Ch. Arshad Ali	Chief Officer
3	Mr. Taha Hussain*	Municipal Officer (Infrastructure)
4	Ms. Shabana Rasheed	Municipal Officer (Regulation)
5	Mr. Ch. Khalid Mehmood	Municipal Officer (Finance)
6	Mr. Malik Mehboob Alam	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Kot Addu

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Wastewater Disposal[1]	kWh/year	206,614
Electrical energy used in Buildings[2]	kWh/year	8,817
Electrical energy used by Streetlights[3]	kWh/year	100,290
Diesel used by Vehicles	liter/year	83,070
Petrol used by Vehicles	liter/year	14,916

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 Wastewater Disposal	(kWh/m^3)	0.02
2	Energy Density of Wastewater Treatment	(kWh/m^3) – if applicable	No wastewater treatment is carried out
3	Energy Cost on Wastewater Disposal	(PKR/m^3)	1.10
4	Energy Cost on Wastewater Treatment	(PKR/m^3) – if applicable	No wastewater treatment is carried out

1.5.2 Streetlights

Table 3: KPIs for Streetlights

Sr. No.	Description	Unit	KPI
1	Average electricity consumed per kilometer of lit roads	(kWh/km)	2,934
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	77
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	46,275
		PKR/Lighting Equipment	37,193
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

Sr. No.	Description	Unit	KPI
		PKR/Lighting Equipment	370
5	Average annual maintenance costs	(PKR)	223,978
6	Average daily duration of operation	(Hour)	11.9
7	Average energy costs per kilometer of lit roads	(PKR/km)	132,037
8	Average energy costs per light pole/fixture	(PKR/ fixture)	3,472
9	Number and percentage of failed public lights		57%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	16.27
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.19
3	Average Energy Cost of Heating	(PKR/m^2)	8
4	Average Energy Cost of Cooling	(PKR/m^2)	147
5	Average Energy Cost of Lighting	(PKR/m^2)	52

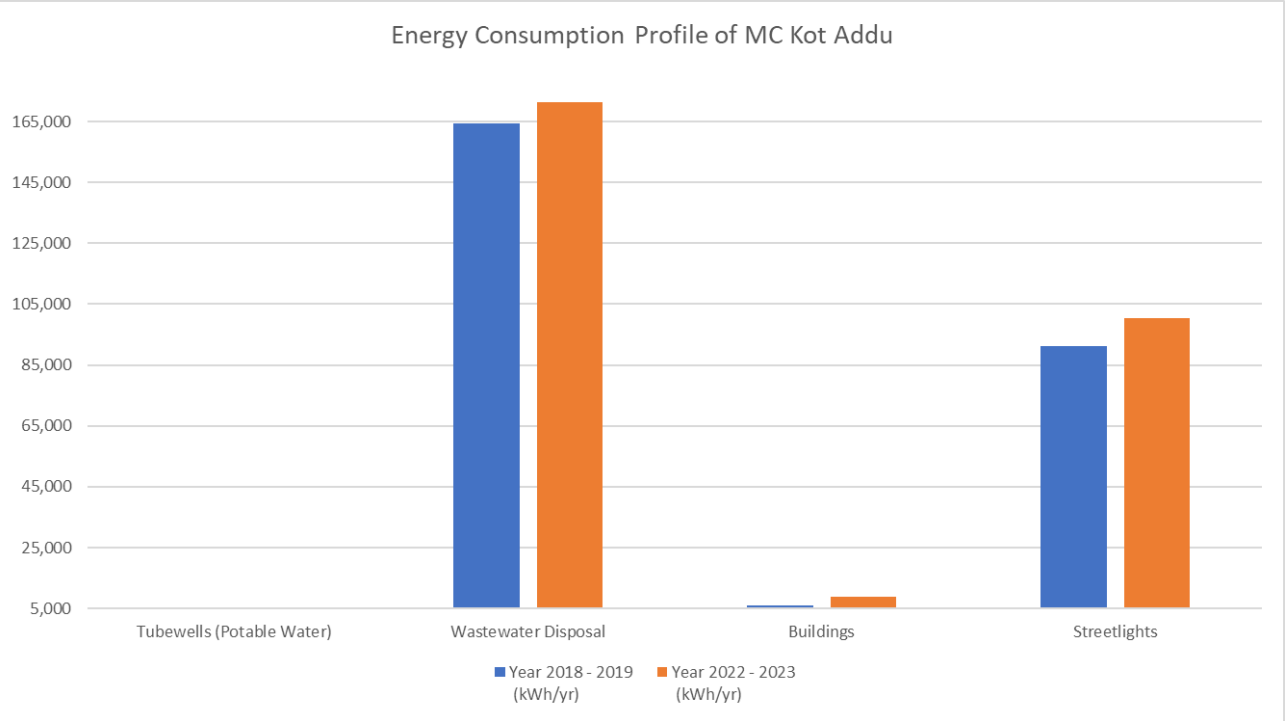
1.5.4 Vehicles

Table 5: KPIs for Vehicles

Sr. No	Description	Unit	KPI
1	Fuel consumption for staff transport vehicles	Liter/hour/vehicle	Cannot be determined
2	Fuel consumption for solid/liquid waste transport	Liter/hour/vehicle	6.28
3	Expenditure on fuel for staff transport vehicles	PKR/hour/vehicle	Cannot be determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/hour/vehicle	47

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)	0	0	0	0	0	N/A	N/A	No performance could be carried out on pump stations as these sites were non-operational during both audits.
2	Wastewater Disposal	6	6	164,295	171,359	-7,064	0.02 kWh/m3	0.02 kWh/m3	No recommendation for the replacement of assets was proposed in the previous assessment. However, the Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal is same. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has remained unchanged.
3	Buildings	5	6	6,048	8,817	-2,769	11.15 kWh/m2	16.26 kWh/m2	MC Camp Office building was not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Furthermore, MC Main Office building and Mosque Building have shared electricity meter with disposal station, and Slaughter House building and Library building have shared electricity meters with streetlights. Therefore, the Consultant has not included these energy consumptions in the overall energy consumption and KPI calculations.

		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
4	Streetlights	227	606	91,125	100,290	-9,165	4,608 kWh/km	2,934 kWh/km	Based on the previous assessment, there were only 227 MC owned operational lights with an average consumption of 401 kWh/light/annum, whereas currently there are 606 operational lights with average energy consumption of 165 kWh/light/annum. The total number of light fixtures in the MC has increased due to which the overall electricity consumption for streetlights has increased from the baseline value. The MC has significantly improved its energy consumption per light fixture.

1.7 Energy Efficiency Recommendations Matrix

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

1.7.1 Energy Efficiency Recommendations Matrix

Table 6: High Priority Measures

High Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Replacement/Installation of Capacitors	Not Quantifiable	450	126,090	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	146,892	41,159,166	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	2,626	387	108,330	422	118,161	11	1
Total:	**2,626**	**147,729**	**41,393,586**	**422**	**118,161**		**1**

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	1,498	4,920	1,378,647	241	67,411	245	1
Total:	**1,498**	**4,920**	**1,378,647**	**241**	**67,411**	**245**	**1**

2 Water Pumps and Disposals

Kot Addu MC has does not have any MC operated tubewells for water supply.

The MC has five (5) disposal station having fifteen (15) pumps. Out of these 6 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are fifteen (15) 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 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) Undertake assessment of the following disposal pumpsets as they were under maintenance

1. Patal Road (Unique ID: 31306471-C)
2. Patal Road (Unique ID: 31306471-D)
3. Patal Road (Unique ID: 31306471-E)
4. Bukhari road (Unique ID: 31306473-B)
5. Bukhari road (Unique ID: 31306473-C)
6. Maweshi Mandi (Unique ID: 31306477-B)
7. Maweshi Mandi (Unique ID: 31306477-C)
8. Noor Shah (Unique ID: 31306478-B)
9. Noor Shah (Unique ID: 31306478-C)

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/Water Pumps

As per information provided by MC Kot Addu, the MC does not have any pumpsets for water supply.

SUMMARY OF WATER SUPPLY IN MUNICIPAL COMMITTEE KOT ADDU

Name of Division			Water Supply		
	Name of District	Name of LGs	Functional	Non Functional	% age Population served
1	2	3	4	5	6
Dera Ghazi Khan	Muzaffargarh	Municipal Committee Kot Addu	Nil	Nil	Nil

Sub Engineer
Municipal Committee
Kot Addu

Figure 1: Letter from Kot Addu MC

2.1.2 Disposal Works

Table 8: 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	31306477-A	Maweshi Mandi	27-15722-4600900	Centrifugal	KSB	2	Siemens	60	30.460051	70.971503
2	31306477-B	Maweshi Mandi	27-15722-4600900	Submersible	KSB	4	KSB	25	30.460051	70.971503
3	31306477-C	Maweshi Mandi	27-15722-4600900	Submersible	KSB	4	KSB	25	30.460051	70.971503
4	31306471-A	Patal Road	27-15722-4617000	Submersible	KSB	4	KSB	25	30.480486	70.968777
5	31306471-B	Patal Road	27-15722-4617000	Submersible	KSB	4	KSB	25	30.480486	70.968777
6	31306471-C	Patal Road	27-15722-4617000	Submersible	KSB	4	KSB	25	30.480486	70.968777
7	31306471-D	Patal Road	27-15722-4617000	Submersible	KSB	4	KSB	25	30.480486	70.968777
8	31306471-E	Patal Road	27-15722-4617000	Submersible	KSB	4	KSB	25	30.480486	70.968777
9	31307771	Muhalla Churkal wala	20-15721-2624900	Centrifugal	KSB	1	Siemens	10	30.469254	70.96302
10	31306473-A	Bukhari road	27-15721-4514000	Centrifugal	KSB	2	Siemens	15	30.462538	70.960808
11	31306473-B	Bukhari road	27-15721-4514000	Centrifugal	KSB	2	Siemens	20	30.462538	70.960808
12	31306473-C	Bukhari road	27-15721-4514000	Centrifugal	KSB	1	Siemens	15	30.462538	70.960808
13	31306478-A	Noor Shah	27-15722-4601100	Centrifugal	KSB	4	Siemens	30	30.466831	70.968403
14	31306478-B	Noor Shah	27-15722-4601100	Submersible	KSB	2	Siemens	15	30.466831	70.968403
15	31306478-C	Noor Shah	27-15722-4601100	Submersible	KSB	4	Siemens	30	30.466831	70.968403

2.1.3 Dewatering Sets

Table 9: Inventory of Dewatering Sets

Sr. No.	Unique Id	Location	Quantity	Latitude	Longitude
1	31806573-1	MC Building Ware House	7	30.469542	70.963665
2	31806573-2	Noor Shah Road	1	30.46668	70.96716
3	31806573-3	G.T Road	2	30.465368	70.964916
4	31806573-4	Madni Road	1	30.45836	70.96672
5	31806573-5	Gaman Shah	1	30.465368	70.964916
6	31806573-6	Sherazi Wali Galli	1	30.465368	70.964916
7	31806573-7	Purani Sabzi Mandhi	1	30.47341	70.96441
8	31806573-8	Near Fish Fam & Disposal	1	30.48000	70.96991

2.1.4 Filtration Units

Table 10: Inventory of Filtration Units

Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East
1	31306476	Rabia Park	Centrifugal	1			Imported Motor	30.460186	70.966061
2	31306479-1	Iqbal Park	Centrifugal	1	Master Pump		Master Motor	30.466603	70.96514
3	31306481	Koray Khan School	Centrifugal	1	Gohar Pump		Gohar Motor	30.47205	70.970439

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

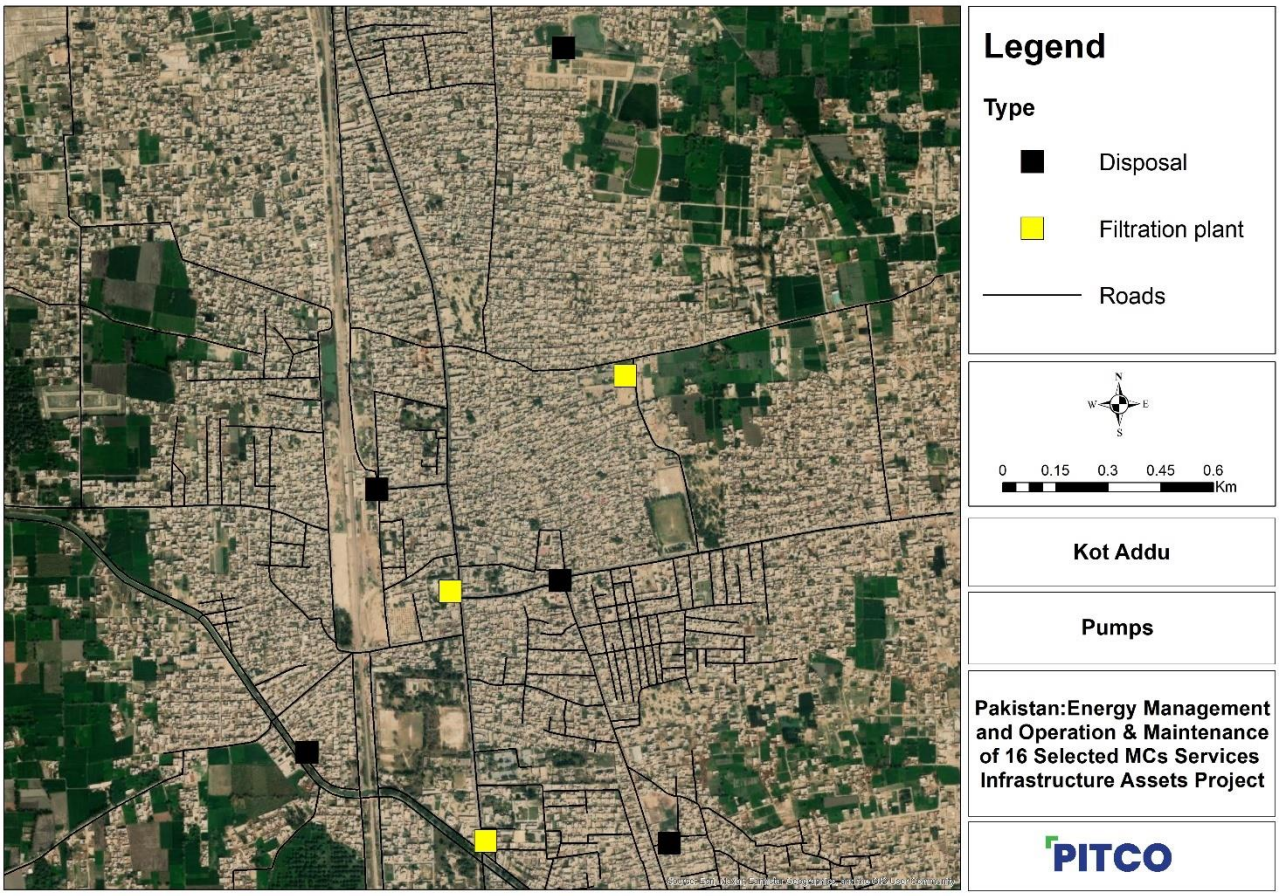


Figure 2: Map for Pumps and Disposal at MC Kot Addu

2.3 Baseline Energy Consumption Trend

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

Table 11: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	0
Electrical energy used by Wastewater Disposal	kWh/y	171,359
Electrical energy used (Total)	kWh/y	171,359

2.4 Observations and Recommendations

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

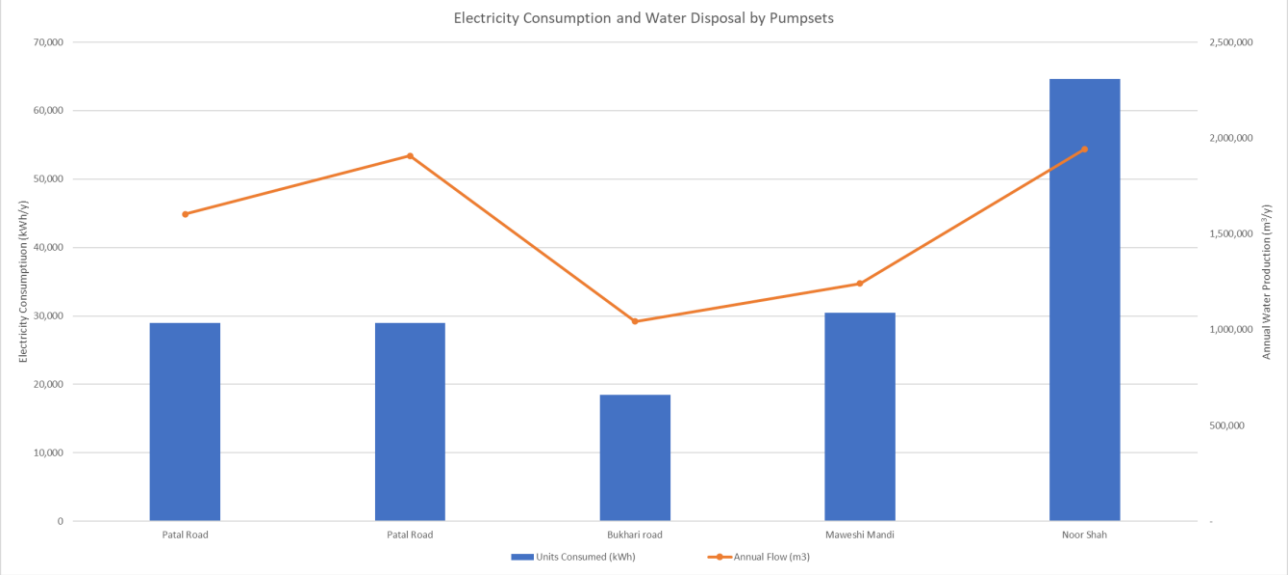
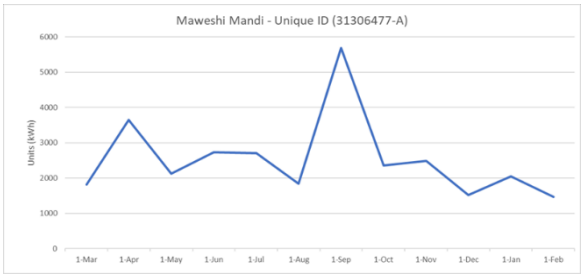


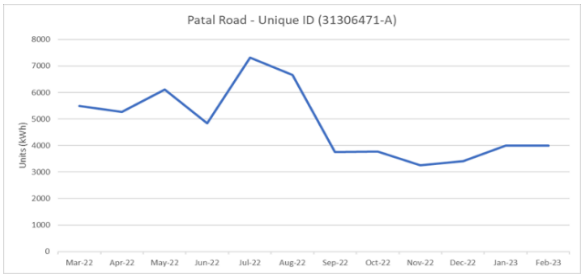
Figure 3: Electricity Consumption and Water Production by Pumpsets

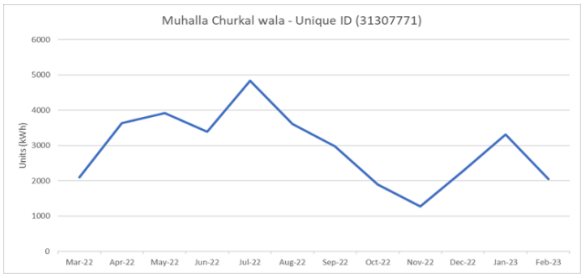
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

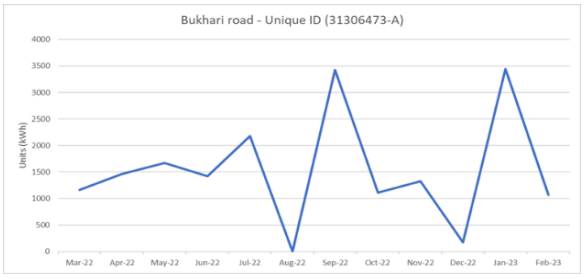
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

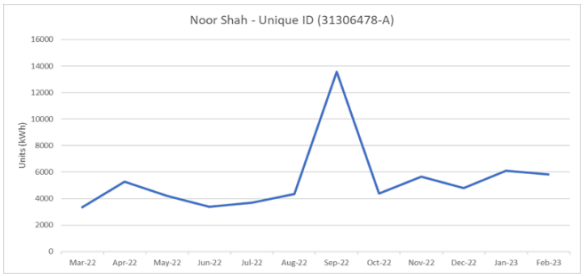
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

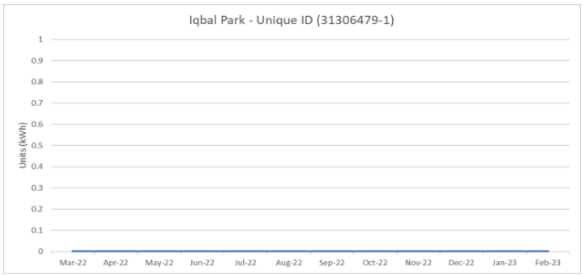












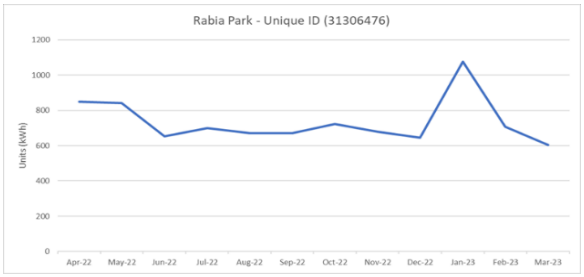


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Wastewater Disposal System

The MC has five (5) disposal station having fifteen (15) 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 12: Disposal Performance Parameters

Sr No	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	PITCO Comments
1	31307771	Muhalla Churkal wala	101.9	64.8	7.62	3.75	42%	Efficiency of the pumpset is satisfactory.
2	31306471-A	Patal Road	407.8	303.4	5.49	14.10	38%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, there was very low water available in well due to which flow could not be measured.
3	31306471-B	Patal Road	407.8	361.0	5.49	15.31	41%	Efficiency of the pumpset is satisfactory. Previously, the pumpset was non-functional.
4	31306473-A	Bukhari road	203.9	225.7	9.14	16.60	40%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 39%.
5	31306477-A	Maweshi Mandi	203.9	289.1	9.14	20.21	42%	Efficiency of the pumpset is satisfactory. Previously, the pumpset was non-functional.
6	31306478-A	Noor Shah	407.8	346.2	9.14	23.05	44%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 42%.

Figure 5: Wastewater Disposal

2.4.3 Dewatering Sets

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

Figure 6: 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 13: Water Pumps and Wastewater Disposal System: Recommendations for improvement

Sr No.	Unique ID	Location	Comments	Recommendation
Pumps				
1	31307771	Muhalla Churkal wala	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
2	31306471-B	Patal Road	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.
3	31306477-A	Maweshi Mandi	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
General Observations				
4	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

Sr No.	Unique ID	Location	Comments	Recommendation
				Government of Punjab intends to do so in future
5	General	Operating Time	Pumps should not be run during Peak electricity consumption hours.	Operational hours of pump should be scheduled keeping in mind the varying peak hours across the year to avoid peak charges. Peak hours for MEPCO during the entire year are given in Annexure 1.
6	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.
7	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 Kot Addu 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 14: Inventory Detail of Streetlights

	Streetlights	MC Operated	Privately Operated
Operational Street Lights	606	606	
Non-Operational Street Lights	806	806	
Total	1,412	1,412	**0**

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

Out of the total streetlights operated by MC, there are 196 light fixtures installed on PC, 107 fixtures are installed on steel structure, 33 fixtures are installed on tubular structure, 269 fixtures are installed on wires and 695 fixtures are installed on walls. The streetlights' structural classification is tabulated below.

Table 15: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Wire	Wall	Grand Total
MC	196	107	33	269	695	1,300
Private						0

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

Table 16: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Near Arbi Master	455	28-15721-4507200	9.968
2	Careem Chowk	439	28-15722-4612000	7.784
3	Thana Chowk	121	28-15721-4510000	3.751
4	Tiba Karbla	397	28-15721-4523200	12.678

Out of the 1,412 surveyed lights in the MC, 606 lights were found to be operational. Details are given in the following table:

Table 17: Details of Operational Streetlights

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	12	16		11.9	831	0
LED	18	382		11.9	29,770	0
LED	30	73		11.9	9,482	0
LED	50	3		11.9	649	0
LED	120	105		11.9	54,552	0
CFl	24	19		11.9	1,974	0
CFL	50	2		11.9	433	0
ILB	100	6		11.9	2,598	0
Total					**100,290**	

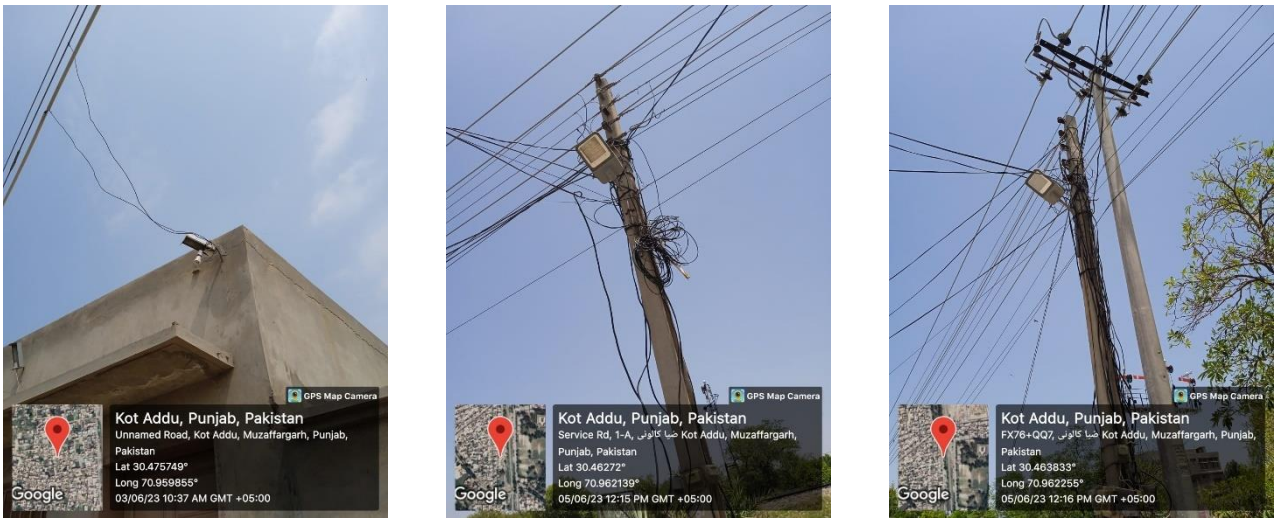


Figure 7: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

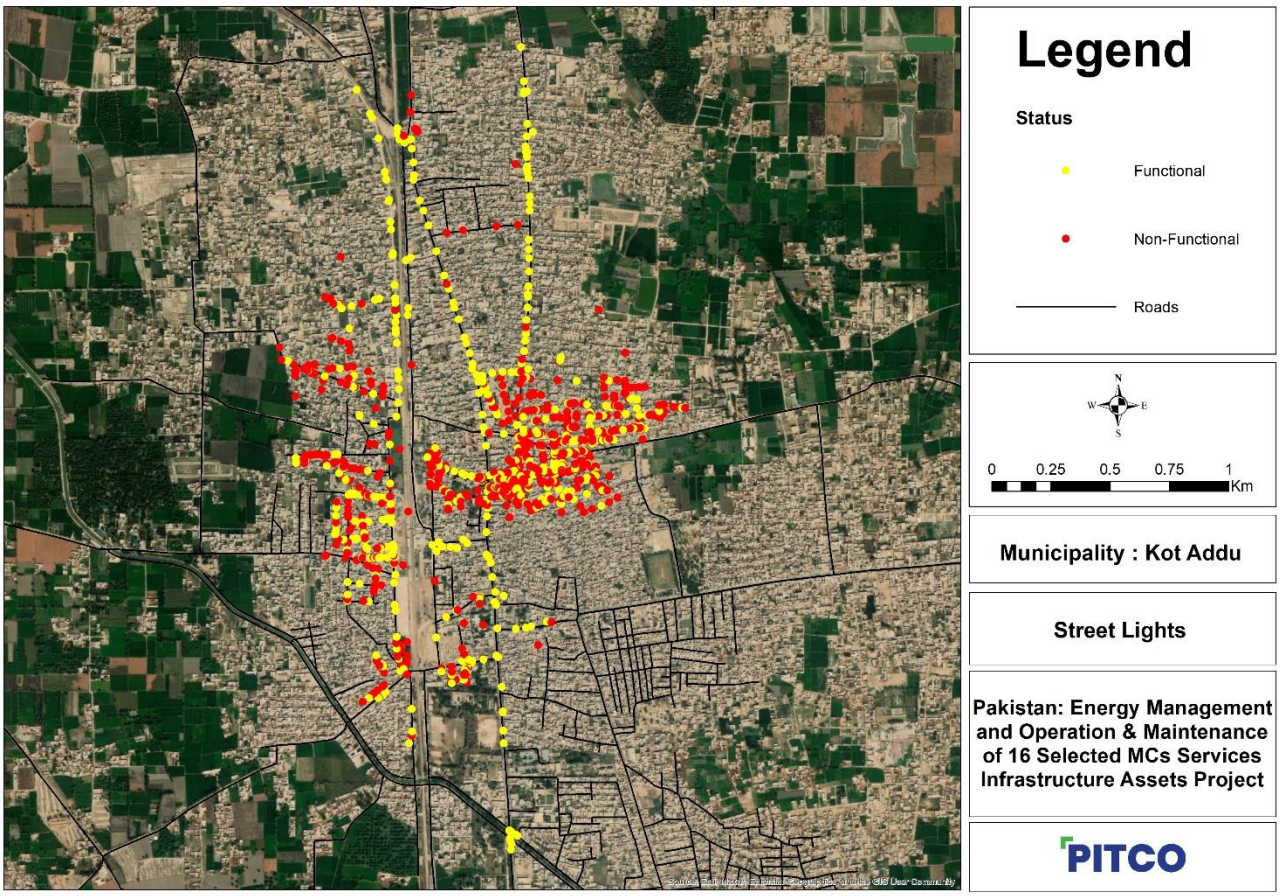


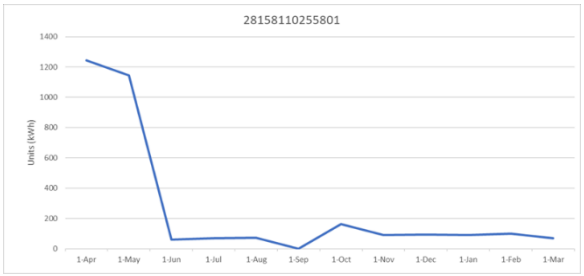
Figure 8: GIS Mapping of street lights in Kot Addu MC

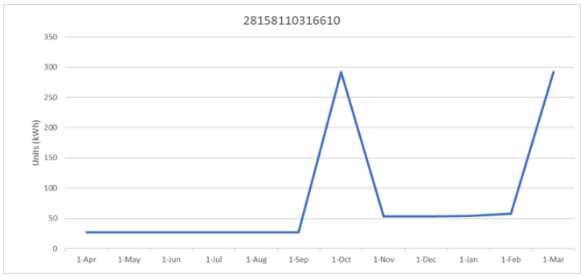
3.3 Baseline Energy Consumption Trend

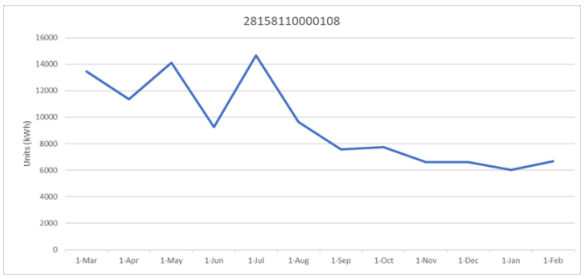
Details of energy consumption by the streetlights in the MC are given below.

Table 18: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy consumed	kWh/y	100,290
Total number of operational lights	No.	606



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Units (kWh)
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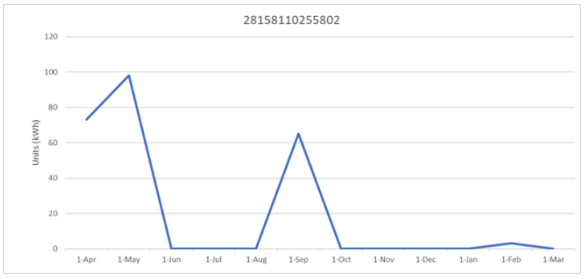
14000
12000
10000
8000
6000
4000
2000
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb


28158130010624
Units (kWh)
8000
7000
6000
5000
4000
3000
2000
1000
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


28158130010625
Units (kWh)
3000
2500
2000
1500
1000
500
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


28158130010613
Units (kWh)
3000
2500
2000
1500
1000
500
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


28158110247302
Units (kWh)
120
100
80
60
40
20
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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60
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1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


14158111276705
Units (kWh)
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400
350
300
250
200
150
100
50
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb


28158111316801
Units (kWh)
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100
80
60
40
20
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


28158111317801
Units (kWh)
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30
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20
15
10
5
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1-Jul
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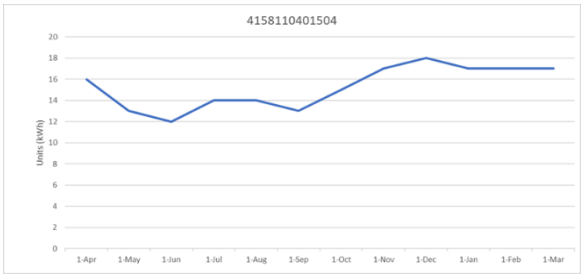
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar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Units (kWh)
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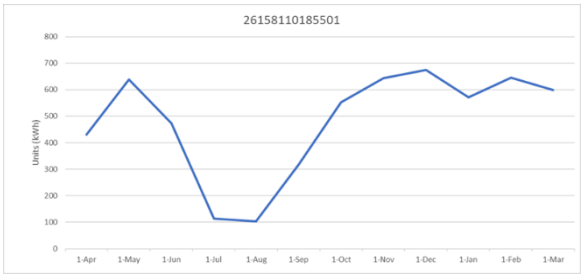
18
16
14
12
10
8
6
4
2
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


26158110185501
Units (kWh)
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600
500
400
300
200
100
0
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar


28158130090601
Units (kWh)
40
35
30
25
20
15
10
5
0
1-Apr
1-May
1-Jun
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1-Sep
1-Oct
1-Nov
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1-Feb
1-Mar

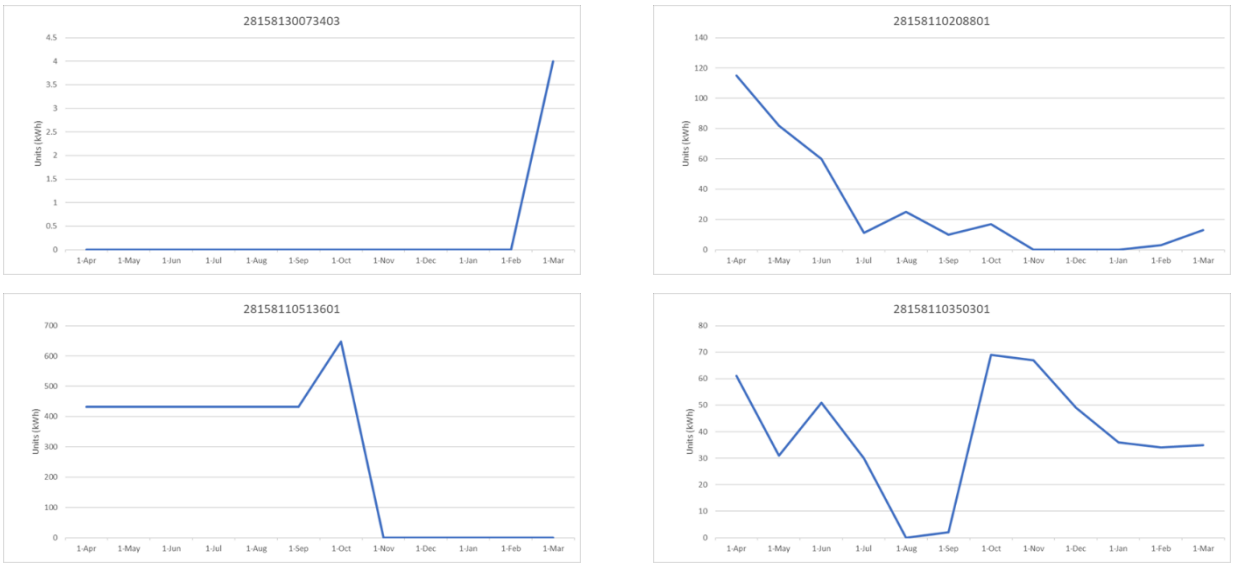

Figure 9: Energy Consumption trend of Streetlights

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	227	606	91,125	100,290	-9,165	4,608 kWh/km	2,934 kWh/km	Based on the previous assessment, there were only 227 MC owned operational lights with an average consumption of 401 kWh/light/annum, whereas, currently there are 606 operational lights with average energy consumption of 165 kWh/light/annum. The total number of light fixtures in the MC has increased due to which the overall electricity consumption for streetlights has increased from the baseline value. The MC has significantly improved its energy consumption per light fixture.

3.4 Maintenance & Replacement of Streetlights

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

3.5 Observations

- All Streetlights in Kot Addu MC are operated by MC.
  Most of the operational streetlights are LEDs.
- Approximately 18% of the LED streetlights have a rating of more than 120 Watts.
- Kot Addu 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 19: Streetlights - recommendations for improvement

Sr. No.	Area	Observations	Recommendations/ Remarks
1	Inventory	• All of the streetlights in Kot Addu are MC operated. • Almost all of the operational streetlights are LEDs • Most of the streetlights are of low wattage	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	Kot Addu 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 Kot Addu MC is tabulated below.

Table 20: 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	MH 5266	Tractor	Millat	MF-240	1980	2WD	Transport of Solid Waste	3711157013	MTL/029/1	50 HP
2	Unregistered Vehicle 1	Tractor	Millat	MF-240	1993	2WD	Transport of Solid Waste	CE97065V502402X	MTL/340/19	50 HP
3	MHD 2566	Tractor	Millat	MF-240	2006	2WD	Front blade	CE97065V627003	1601/13	50 HP
4	MHD 2565	Tractor	Millat	MF-240	2006	2WD	Mechanical Sweeper	CE9065V627082M	1601/13	50 HP
5	MHD 2564	Tractor	Millat	MF-240	2006	2WD	Transport of Solid Waste	CE97065V627039M	1601/63	50 HP
6	MHD 2563	Tractor	Millat	MF-385	2006	4WD	Transport of Solid Waste	500541-M	0038/06	85 HP
7	Unregistered Vehicle 2	Tractor	SNH	SNH-304	2006	2WD	Transport of Solid Waste	650906993D	S50/06	50 HP
8	CHC-3828	Tractor	John Deere	JDT-720	2010	4WD	Back Hoe	N/A	W007479	85 HP
9	CHC 3802	Tractor	John Deere	JDT-720	2010	4WD	No Task Assigned	6020653	W007458	85 HP
10	Unregistered Vehicle 3	Tractor	Millat	MF-385	2022	4WD	Front loader	LM9B572V50733H	85534/01/22	85 HP
11	Unregistered Vehicle 4	Tractor	Millat	MF-385	2022	4WD	Front blade	LM9B572V507307H	85529/01/22	85 HP
12	Unregistered Vehicle 5	Truck	Isuzu	NPR-300	2009	4WD	Sucker Machine	03252P	JAANPR66P7-7104070	3490
13	Unregistered Vehicle 6	Truck	Isuzu	NPR-300	2009	4WD	Jetting Machine	03275P	JAANPR66P7-7104795	3490
14	Unregistered Vehicle 7	Bike	Honda	CD-70	2001	2WD	Transport of Staff	N/A	N/A	70
15	MHE 5534	Truck	Hino	NR-300	2008	4WD	Firefighting	JO8C18776	FG/JKPB-14780	4009
16	MC-1212	Car	Suzuki	Cultus	2006	2WD	Transport of Staff	N/A	N/A	1000
17	Unregistered Vehicle 8	Jeep	Suzuki	Potohar	N/A	4WD	No Task Assigned	N/A	N/A	1000
18	Unregistered Vehicle 9	Jeep	Suzuki	Potohar	N/A	4WD	No Task Assigned	N/A	N/A	1000
19	Unregistered Vehicle 10	Pickup Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	388231	PK492898	796
20	Unregistered Vehicle 11	Pickup Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	388233	PK492897	796
21	Unregistered Vehicle 12	Pickup Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	388227	492866	796
22	Unregistered Vehicle 13	Pickup Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	388220	PK492896	796
23	Unregistered Vehicle 14	Truck	Hino	NR-300	2022	4WD	Water Bowser	WGM50126	90460013	4009
24	Unregistered Vehicle 15	Truck	Hino	NR-300	2022	4WD	Water Bowser	WGM50127	4600113	4009
25	Unregistered Vehicle 16	Rickshaw	Qingqi	CNE-100	2018	2WD	Transport of Solid Waste	24452	N/A	100
26	Unregistered Vehicle 17	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	U724821	N/A	100
27	Unregistered Vehicle 18	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	U589063	N/A	100
28	Unregistered Vehicle 19	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	U585932	N/A	100
29	Unregistered Vehicle 20	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	U724723	N/A	100
30	Unregistered Vehicle 21	Rickshaw	Road Prince	RP-150	2018	2WD	Transport of Solid Waste	8GC06227	N/A	150

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
31	Unregistered Vehicle 22	Rickshaw	Road Prince	RP-100	2018	2WD	Transport of Solid Waste	U583368	N/A	100
32	Unregistered Vehicle 23	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	U583366	N/A	100
33	Unregistered Vehicle 24	Rickshaw	Road Prince	RP-150	2018	2WD	Transport of Solid Waste	8GC06170	N/A	150
34	Unregistered Vehicle 25	Rickshaw	Road Prince	RP-150	2018	2WD	Transport of Solid Waste	8H2085	N/A	150
35	Unregistered Vehicle 26	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	U589076	N/A	100
36	Unregistered Vehicle 27	Rickshaw	Qingqi	CNE-100	2018	2WD	Transport of Solid Waste	8264703	N/A	100
37	Unregistered Vehicle 28	Rickshaw	Qingqi	CNE-100	2018	2WD	Transport of Solid Waste	8264408	N/A	100
38	Unregistered Vehicle 29	Rickshaw	Road Prince	RP-150	2018	2WD	Transport of Solid Waste	N/A	N/A	150
39	Unregistered Vehicle 30	Rickshaw	Qingqi	CNE-100	2018	2WD	Transport of Solid Waste	FML297016	N/A	100
40	Unregistered Vehicle 31	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	U70002	N/A	100
41	Unregistered Vehicle 32	Rickshaw	Qingqi	CNE-100	2018	2WD	Transport of Solid Waste	U70089	N/A	100
42	Unregistered Vehicle 33	Rickshaw	United	US-100	2018	2WD	No Task Assigned	N/A	N/A	100
43	Unregistered Vehicle 34	Rickshaw	Road Prince	RP-150	2018	2WD	Transport of Solid Waste	8GC06225	N/A	150
44	Unregistered Vehicle 35	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	U584649	N/A	100
45	Unregistered Vehicle 36	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	S97098	N/A	100
46	Unregistered Vehicle 37	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	U586089	N/A	100
47	Unregistered Vehicle 38	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	N/A	N/A	100
48	Unregistered Vehicle 39	Rickshaw	United	US-100	2018	2WD	Transport of Solid Waste	N/A	N/A	100
49	Unregistered Vehicle 40	Truck	Hino	NR-300	2022	4WD	No Task Assigned	M50125	7046600112	4009
50	Unregistered Vehicle 41	Truck	Hino	NR-300	2022	4WD	No Task Assigned	M50126	904600113	4009
51	Unregistered Vehicle 42	Truck	Hino	NR-300	2022	4WD	No Task Assigned	50134	804600121	4009
52	Unregistered Vehicle 43	Truck	Hino	NR-300	2022	4WD	No Task Assigned	50126	204600115	4009
53	Unregistered Vehicle 44	Truck	Hino	NR-300	2022	4WD	No Task Assigned	50131	804600118	4009
54	Unregistered Vehicle 45	Truck	Hino	NR-300	2022	4-Wheeler	No Task Assigned	50127	4600114	4009

4.2 Baseline Fuel Consumption Trend

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

Table 21: On-field fuel Consumption analysis of MC vehicles

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)				
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption
1	MHD 2564	1:33 AM	2:33 AM	0.53	0.53 Liters/hr	12:10 PM	1:33 AM		3.27	0.24 Liters/hr
2	Unregistered Vehicle 2	12:58 PM	1:58 AM	1.68	0.13 Liters/hr	11:42 AM	12:58 PM		3.26	2.57 Liters/hr
3	CHC-3828	2:15 AM	3:15 AM	1.92	1.92 Liters/hr	12:16 PM	2:15 AM		6.66	0.48 Liters/hr
4	Unregistered Vehicle 3	1:32 AM	2:32 AM	0.82	0.82 Liters/hr	12:10 PM	1:32 AM		2.47	0.18 Liters/hr
5	Unregistered Vehicle 4	1:29 AM	2:29 AM	1	1 Liters/hr	12:03 PM	1:29 AM		6	0.45 Liters/hr
6	Unregistered Vehicle 5	12:50 PM	1:50 AM	0.26	0.02 Liters/hr	11:40 AM	12:50 PM		3.69	3.16 Liters/hr
7	Unregistered Vehicle 6	3:55 AM	4:55 AM	1.2	1.2 Liters/hr	2:30 AM	3:55 AM		3.7	2.61 Liters/hr
8	Unregistered Vehicle 12	1:10 AM	2:10 AM	0.45	0.45 Liters/hr	11:45 AM	1:10 AM	17	2.02	0.12 Liters/km

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)				
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption
9	Unregistered Vehicle 14	1:35 AM	2:35 AM	1.3	1.3 Liters/hr	11:55 AM	1:35 AM	12	4.39	0.37 Liters/km
10	Unregistered Vehicle 25	1:00 AM	2:00 AM	0.55	0.55 Liters/hr	11:43 AM	1:00 AM		1.81	0.14 Liters/hr

Table 22: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (liter/hr)
1	MH 5266	5.00
2	Unregistered Vehicle 1	5.00
3	MHD 2566	5.00
4	MHD 2565	5.00
5	MHD 2564	5.00
6	MHD 2563	8.50
7	Unregistered Vehicle 2	5.00
8	CHC-3828	5.00
9	CHC 3802	5.09
10	Unregistered Vehicle 3	8.50
11	Unregistered Vehicle 4	8.50
12	Unregistered Vehicle 5	7.51
13	Unregistered Vehicle 10	3.00
14	Unregistered Vehicle 11	3.12
15	Unregistered Vehicle 12	3.00
16	Unregistered Vehicle 13	3.00
17	Unregistered Vehicle 14	4.13
18	Unregistered Vehicle 15	4.00

The logbooks of remaining vehicles are not available in MC.

The MC made 16 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 0.79 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 1.032 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 23: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	83,070
Annual Cost of Fuel (Diesel)	PKR/y	24,339,510
Annual Consumption of Fuel (Petrol)	Liter/y	14,916
Annual Cost of Fuel (Petrol)	PKR/y	4,057,152

4.3 Maintenance Log of Vehicles

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

Figure 10: MC Vehicles

4.4 Observations and Recommendations

All non-registered vehicles must be registered immediately to avoid any misuse.

MC Kot Addu 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 six 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.

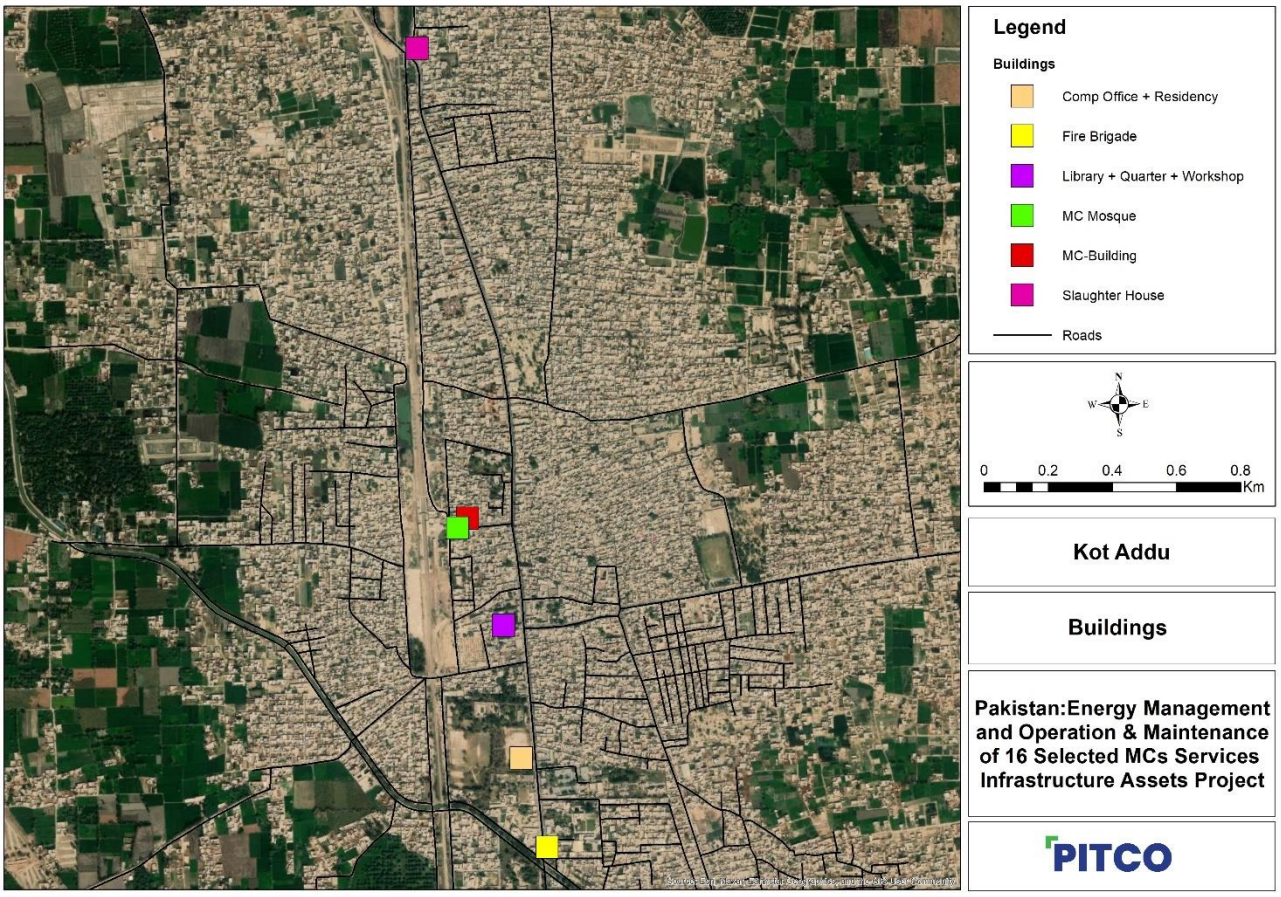

Figure 11: Map for Buildings

5.2 Building Details

Details of the MC buildings are given below.

Table 24: 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	Fire Brigade	N: 30.460276 E:70.966054	31605477	MC	14	Satisfactory	759	No Proper Insulation	1
2	Comp Office + Residency	N:30.462798 E: 70.965268	31605475-1	MC	N/A	Un-Satisfactory	252.9	No Proper Insulation	1
3	Slaughter House	N:30.482741 E:70.962298	32105831	MC	N/A	Un-Satisfactory	505.8	No Proper Insulation	1
4	MC-Building	N:30.469542 E:70.963665	31605475	MC	60	Un-Satisfactory	2,529	No Proper Insulation	1
5	Library + Quarter + Workshop	N:30.466527 E:70.964772	32205861	MC	N/A	Un-Satisfactory	506	No Proper Insulation	1
6	MC Mosque	N:30.469273 E:70.963345	32105832	MC	60	Un-Satisfactory	632	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 25: Number of Heating Units in MC Buildings

Sr. No.	Name of Room	Type of Heating Equipment	Equipment Count	Capacity in Watts	Daily operating hours[4]	No. of months used per year	Operating days per year	Annual Energy consumption (kWh/year)
Comp Office + Residency								
1	**Washroom**	Electric Geyser	1	1500	4	4	104	624
MC-Building								
1	**Finance Branch**	Electric Heater	1	500	5	4	104	260
MC Mosque								
1	**Inside Hall**	Electric Geyser	1	2000	1	4	104	208
	Total							**1,092**

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

Table 26: 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[5]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
MC-Building								
1	**Sanitary Operation**	Ceiling Fan	3	80	8	8	208	399
2	**Sanitary Operation**	Exhaust Fan	1	30	8	8	208	50
3	**Sanitary Operation**	Exhaust Fan	1	30	0	0	0	0
4	**Planning Branch**	Ceiling Fan	2	80	8	8	208	266
5	**Planning Branch**	Inverter AC	1	1452	6	8	208	1,812
6	**Regulation Branch**	Ceiling Fan	1	80	8	8	208	133
7	**Administrator office**	Ceiling Fan	2	80	2	8	208	67
8	**Administrator office**	Inverter AC	1	1452	2	8	208	604
9	**Kitchen**	Ceiling Fan	1	80	2	8	208	33
10	**Co-office**	Ceiling Fan	2	80	5	8	208	166
11	**Co-office**	Inverter AC	1	1452	5	8	208	1,510
12	**Gallery 1**	Pedestal Fan	1	125	8	8	208	208
13	**Encroachment office**	Ceiling Fan	1	80	8	8	208	133
14	**Head Clerk office**	Ceiling Fan	1	80	8	8	208	133
15	**Head Clerk office**	Bracket fan	1	50	8	8	208	83
16	**Head Clerk MOI**	Ceiling Fan	2	80	8	8	208	266
17	**Meeting Hall**	Bracket Fan	4	50	1	8	208	42
18	**Meeting Hall**	Window AC	2	0	0	0	0	0
19	**Finance Branch**	Ceiling Fan	1	80	8	8	208	133
20	**Regulation office 2**	Ceiling Fan	2	80	8	8	208	266
21	**Finance Branch Room 2**	Ceiling Fan	2	80	8	8	208	266
22	**MOF office**	Ceiling Fan	1	80	8	8	208	133
23	**MOF office**	Inverter AC	1	1452	8	8	208	2,416
24	**Registration office**	Ceiling Fan	1	80	8	8	208	133
25	**Registration office**	Air Cooler	1	125	8	8	208	208
26	**Accountant office**	Ceiling Fan	1	80	8	8	208	133
27	**Accountant office**	Air Cooler	1	125	8	8	208	208
28	**Accountant office**	Bracket fan	1	50	8	8	208	83
29	**MOI office**	Ceiling Fan	1	80	8	8	208	133
30	**Warehouse**	Ceiling Fan	3	80	8	8	208	399
31	**Audit office**	Ceiling Fan	1	80	2	8	208	33
32	**Audit office**	Inverter AC	1	1452	2	8	208	604
Fire Brigade								
1	**Room 1**	Ceiling Fan	2	80	24	8	208	799
2	**Kitchen**	Ceiling Fan	1	80	2	8	208	33
3	**Kitchen**	Pedestal Fan	1	125	24	8	208	624
Comp Office + Residency								

[5] 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[5]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
1	**Room**	Ceiling Fan	2	80	8	8	208	266
2	**Room**	Split AC	1	2700	8	8	208	4,493
Library + Quarter + Workshop								
1	**Library**	Ceiling Fan	1	80	8	8	208	133
2	**Quarter**	Ceiling Fan	1	80	5	8	208	83
3	**Quarter**	Air Cooler	1	125	5	8	208	130
4	**Quarter**	Exhaust Fan	1	30	5	8	208	31
MC Mosque								
1	**Inside Hall**	Ceiling Fan	14	80	2	8	208	466
2	**Inside Hall**	Inverter AC	1	1452	4	2	52	302
4	**Inside Hall**	Bracket fan	1	50	2	8	208	21
5	**Inside Hall**	Split AC	1	1800	4	2	52	374
6	**Inside Hall**	Ceiling Fan	2	80	2	8	208	67
7	**Outside Hall**	Ceiling Fan	7	80	2	8	208	233
	Total Annual kWh							**19,112**

Table 27: 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[6]	Operating days per year	Annual Energy consumption (kWh/year)
MC-Building							
1	**Sanitary officer Room**	ILB	1	60	8	312	150
2	**Sanitary officer Room**	LED	1	12	8	312	30
3	**Sanitary officer Room**	LED	2	18	8	312	90
4	**Planning Branch**	LED	3	18	8	312	135
5	**Planning Branch**	LED	3	12	8	312	90
6	**Regulation Branch**	Tube Light	1	40	8	312	100
7	**Regulation Branch**	LED	1	18	8	312	45
8	**Administrator office**	LED	1	18	2	312	11
9	**Administrator office**	Tube Light	3	40	2	312	75
10	**Administrator office**	LED	1	28	2	312	17
11	**Kitchen**	Tube Light	1	40	0	312	0
12	**Kitchen**	LED	2	12	2	312	15
13	**Co-office**	LED	7	18	5	312	197
14	**Gallery 1**	LED	2	18	12	312	135
15	**Encroachment office**	Tube Light	1	40	0	312	0
16	**Encroachment office**	LED	2	12	8	312	60
17	**Encroachment office**	LED	2	18	8	312	90
18	**Head clerk office**	Tube Light	1	40	0	312	0
19	**Head clerk office**	LED	1	12	8	312	30

[6] "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[6]	Operating days per year	Annual Energy consumption (kWh/year)
20	**Head clerk office**	LED	2	18	8	312	90
21	**Head clerk office**	Tube Light	3	40	0	312	0
22	**Head clerk office**	LED	2	18	8	312	90
23	**Meeting Hall**	Tube Light	10	40	1	312	125
24	**Meeting Hall**	Halogen Light	2	500	1	312	312
25	**Finance Branch**	LED	2	24	8	312	120
26	**Finance Branch**	LED	1	18	8	312	45
27	**Regulation Branch 2**	LED	3	18	8	312	135
28	**Regulation Branch 2**	LED	2	12	2	312	15
29	**Finance Branch Room 2**	LED	4	12	8	312	120
30	**Finance Branch Room 2**	LED	1	18	8	312	45
31	**MOF office**	LED	3	18	8	312	135
32	**MOF office**	LED	2	12	8	312	60
33	**Registration office**	Tube Light	2	40	8	312	200
34	**Registration office**	LED	2	18	8	312	90
35	**Registration office**	LED	2	12	8	312	60
36	**Accountant office**	Tube Light	2	40	0	312	0
37	**Accountant office**	LED	1	18	8	312	45
38	**Accountant office**	LED	1	12	8	312	30
39	**MOI office**	LED	4	18	8	312	180
40	**MOI office**	LED	1	12	8	312	30
41	**Warehouse**	Tube Light	1	40	8	312	100
42	**Warehouse**	LED	3	18	8	312	135
43	**Audit office**	LED	4	18	2	312	45
44	**Audit office**	LED	2	12	2	312	15
45	**Outside Area**	LED	8	18	12	312	539
46	**Outside Area**	LED	2	120	12	312	899
Fire Brigade							
1	**Room**	LED	1	18	12	312	67
2	**Room**	LED	1	12	12	312	45
3	**Kitchen**	LED	2	12	12	312	90
4	**Garage**	Tube Light	4	40	0	312	0
Comp Office + Residency							
1	**Washroom**	LED	1	12	8	312	30
2	**Room**	LED	2	45	8	312	225
3	**Room**	LED	5	12	8	312	150
4	**Outside Area**	LED	3	12	12	312	135
Slaughter House							
1	**Hall**	LED	2	12	3	312	22
2	**Room**	LED	3	18	3	312	51
Library + Quarter + Workshop							
1	**Library**	LED	1	18	8	312	45
2	**Quarter**	LED	1	18	5	312	28

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[6]	Operating days per year	Annual Energy consumption (kWh/year)
3	**Workshop**	LED	8	18	12	312	539
MC Mosque							
1	**Inside Hall**	LED	19	18	2	312	213
2	**Inside Hall**	LED	5	12	2	312	37
3	**Inside Hall**	LED	1	18	1	312	6
4	**Outside Hall**	Tube Light	2	40	1	312	25
5	**Outside Hall**	LED	1	18	1	312	6
6	**Outside Hall**	Tube Light	1	40	0	312	0
7	**Outside Hall**	LED	2	12	1	312	7
8	**Outside Area**	Tube Light	1	40	12	312	150
						Total Annual kWh	**6,796**

5.3 Baseline Energy Consumption Trend

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

Table 28: Energy consumption in Office Buildings

SI No.	Description	Unit	Value[7]
1	Annual Electricity Consumption	kWh	100,108
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[7] 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	5	6	6,048	8,817	-2,769	11.15 kWh/m2	16.26 kWh/m2	MC Camp Office building was not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Furthermore, MC Main Office building and Mosque Building have shared electricity meter with disposal station, and Slaughter House building and Library building have shared electricity meters with streetlights. Therefore, the Consultant has not included these energy consumptions in the overall energy consumption and KPI calculations.

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

Table 29: Cooling Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
Fire Brigade	Ceiling Fan	3	0	3
Fire Brigade	Exhaust Fan	1	0	0
Fire Brigade	Pedestal Fan	-	-	1

Table 30: Lighting Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
Fire Brigade	Incandescent Light Bulbs	1	1	0
Fire Brigade	Tube Light	1	1	4
Fire Brigade	LED	1	0	4
Fire Brigade	CFL	5	5	0

Table 31: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh	Comments
Fire Brigade Building	6,048	8,817	MC Camp Office building was not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Furthermore, MC Main Office building and Mosque Building have shared electricity meter with disposal station and Slaughter House building and Library building have shared electricity meters with streetlights so, for the purpose of this comparison, their energy consumptions are also not considered in the overall energy consumption and KPI calculations.

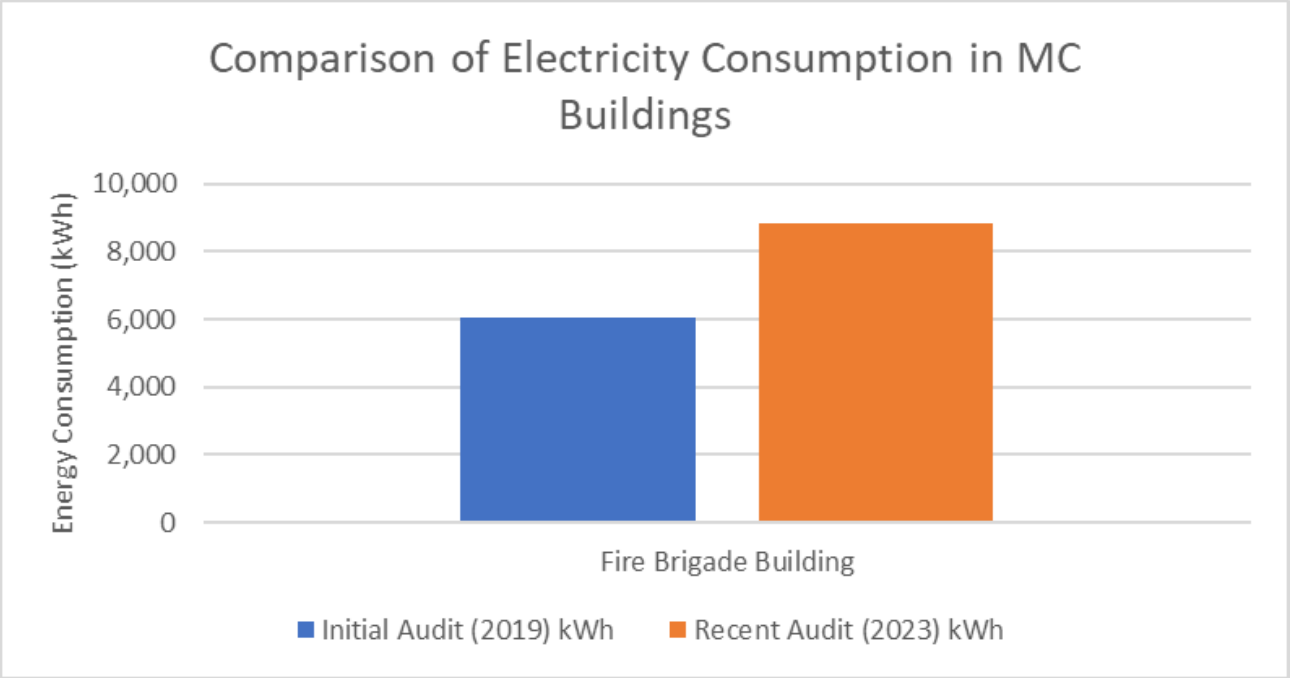

Figure 12:Comparison of Electricity Consumption in MC Buildings

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 Kot Addu

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

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

Slaughter House Building has a Three Phase 400V electrical connection whereas, MC Main Office, Library & Quarter & Workshop, Fire Brigade, MC Mosque, Comp Office & Residency 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 32: Metering details at MC Kot Addu

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Fire Brigade	31605477	16157212080800 (1ϕ)	1	A-3a (66)
2	Comp Office & Residency	31605475-1	19157212560515 (1ϕ)	2	A-1a (01)
3	Slaughter House	32105831	28157214507200 (3ϕ)	15	G-1 (72)
4	MC-Building	31605475	20157212624900 (1ϕ)	4	A-3a (66)
5	Library & Quarter & Workshop	32205861	19157212581000 (1ϕ)	1	A-3a (66)
6	MC Mosque	32105832	20157212624900 (1ϕ)	4	A-3a (66)

6.1 Main MC Building

The project site i.e Main Office Building is Located near Ward Number 14-E Kot Addu, Muzaffargarh, Punjab, Pakistan while the geographical co-ordinates of location are 30.46913°N (latitude) and 70.96354°E (longitude).

Figure 13: Front view of MC Office Building

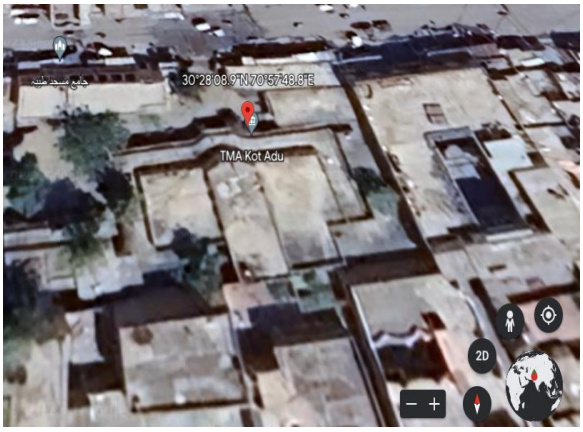

Figure 14: Aerial view of MC Office Buildings

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 MC Office Building is 34,405 kWh with the peak electricity consumption of 4,838 kWh in July 2022. The annual energy consumption for Main MC building cannot be accurately determined as this meter is shared with MC Mosque and disposal pumpset. Based on the historical billing, the Consultant has estimated the solar system requirement of this electrical connection, which is presented below in the following table.

Table 33:Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	20157212624900	34,405	2,867	4,838	25

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Building is 27,221 ft^2 whereas, the total area of rooftop available for the solar installation is 11,543 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 15: Top View of complete building

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.

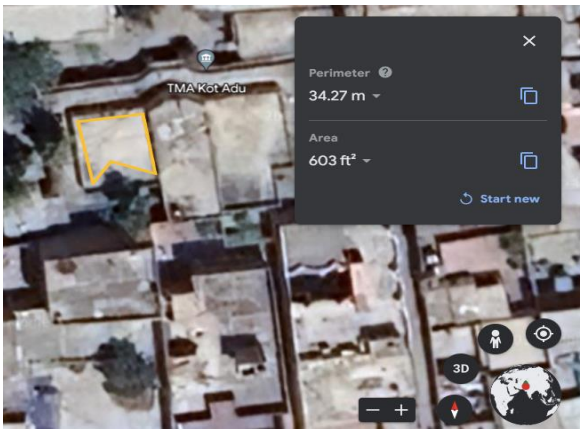

Figure 16: Location for Solar Installation - A

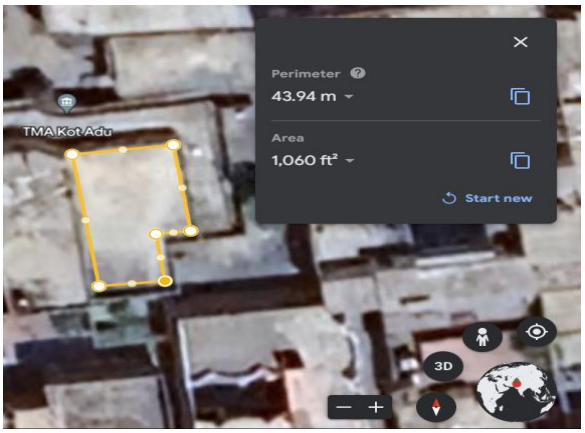

Figure 17: Location for Solar Installation – B

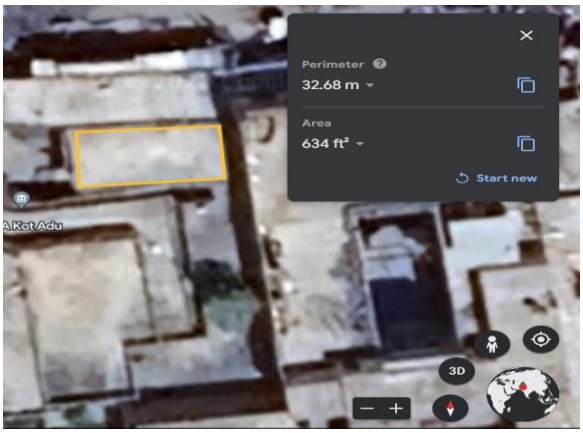

Figure 18: Location for Solar Installation-C

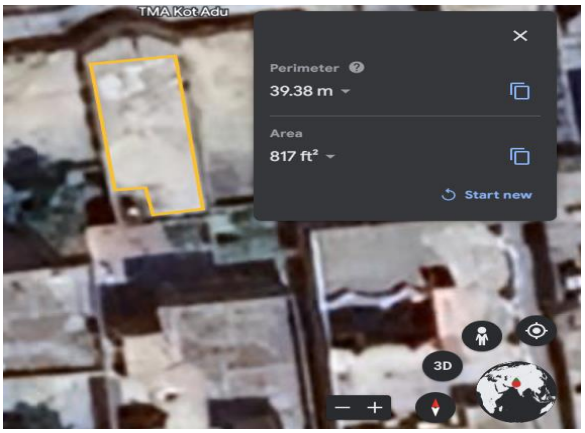

Figure 19: Location for Solar Installation-D

Table 34: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Location – D	Total
Area availability (ft²)	603	1,060	634	817	3,114

Parameters	Location – A	Location – B	Location – C	Location – D	Total
Solar System capacity (kW)	6	11	6	8	31

Note: Based on the analysis of the historical billings it is identified that the total system requirement for this electrical connection is 25 kW. It is highly recommended to replace this single-phase connection with three-phase connection before the installation of solar system as estimated by the Consultant.

6.2 MC Mosque

The project site i.e. MC Mosque Building is Located near Ward Number 14E Kot Addu, Muzaffargarh, Punjab, Pakistan while the geographical co-ordinates of location are 30.46913°N (latitude) and 70.96354°E (longitude).

Figure 20: Front view of MC Mosque

Figure 21: Aerial view of MC Mosque

6.2.1 Solar System Requirement

As discussed in the previous section, Main MC Building, Mosque and disposal station have common electrical connection, therefore it is not possible to determine accurate energy consumption of MC Mosque based on the historical billing however, the Consultant has estimated the installation capacity of the MC Mosque.

6.2.2 Roof Assessment

As per the Consultant's assessment, the total area of the MC Mosque 2,723 ft^2 whereas, the total area of rooftop available for the solar installation is 2,458 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

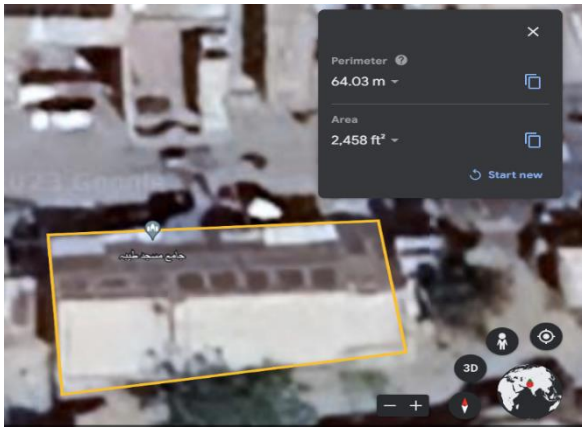

Figure 22: Top View of complete building

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

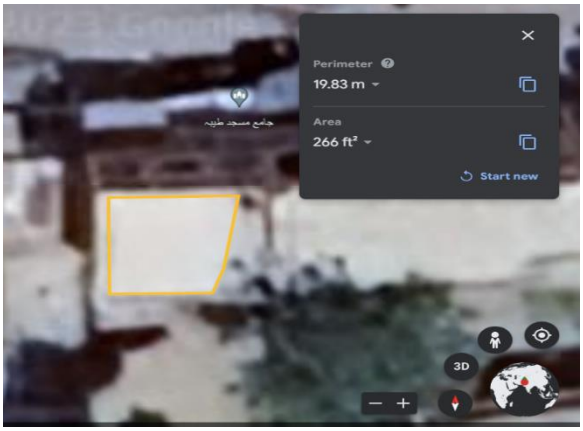

Figure 23: Location for Solar Installation-A

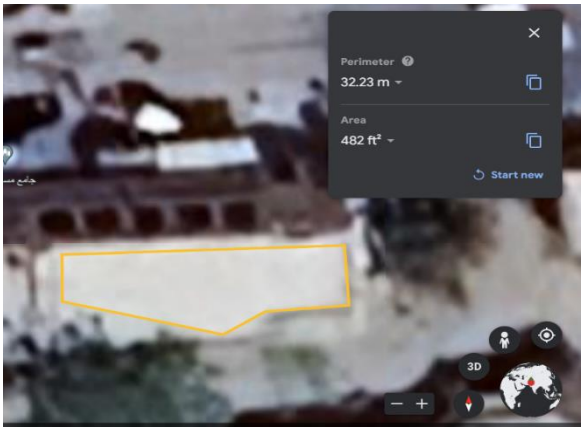

Figure 24: Location for Solar Installation-B

Table 35: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Total
Area availability (ft²)	266	482	748
Solar System capacity (kW)	3	5	7

6.3 Comp Office & Residency

The project site i.e. Comp Office & Residency is located near Lower Kot Sultan, Kot Addu, Muzaffargarh, Punjab, Pakistan while the geographical co-ordinates of location are 30.4602°N (latitude) and 70.96565°E (longitude).

Figure 25: Front view of Camp office & residency

Figure 26: Aerial view Camp office & residency

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 4,839 kWh with the peak electricity consumption of 730 kWh in July 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 36:Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	19157212560515	4,839	403	730	4

Note: Based on the analysis of the historical billings it is identified that the system requirement for this site is **4kW** 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, Quarter and Workshop

The project site i.e. Library is located Ward Number 14E Kot Addu, Muzaffargarh, Punjab, Pakistan while the geographical co-ordinates of location are 30.466527°N (latitude) and 70.96477°E (longitude).

Figure 27: Front view of Library & Quarter & Workshop

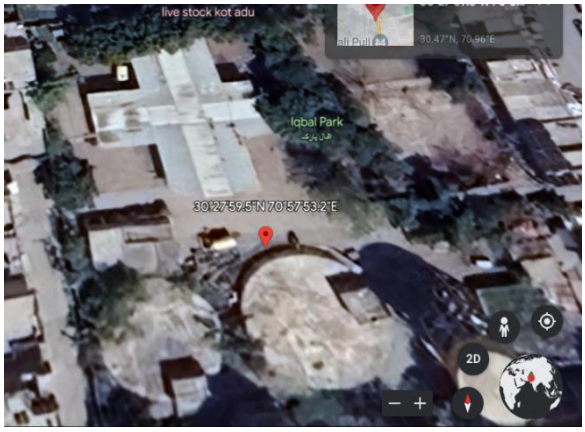

Figure 28: Aerial view of Library & Quarter & Workshop

6.4.1 Solar System Requirement

Based on the analysis of energy bills from April 2022 to March 2023, it is identified that currently, MC is not receiving the bills against this electrical connection therefore, it is not possible for the Consultant to calculate the solar system requirement based on the historical billing. Furthermore, based on the site visit it was identified that condition of library building, Quarter and Workshop is unsatisfactory and therefore, it is not recommended to install solar system at these sites.

6.5 Slaughterhouse

The project site i.e. Slaughter House is located near Kot Addu, Muzaffargarh, Punjab, Pakistan while the geographical co-ordinates of location are 30.482741°N (latitude) 70.962298°E (longitude).

Figure 29: Front view of Slaughter House

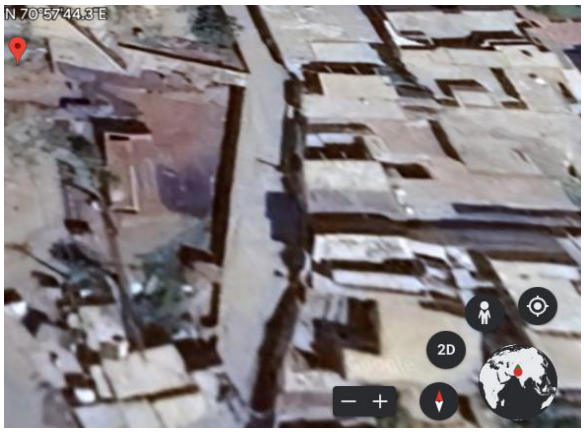

Figure 30: Aerial view of Slaughter House

6.5.1 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 this electrical connection is 52,047 kWh with the peak electricity consumption of 5,901 kWh in January 2023. The annual energy consumption for Slaughterhouse building cannot be accurately determined as this meter is shared with streetlight. Based on the historical billing, the Consultant has estimated the solar system requirement of this electrical connection, which is presented below in the following table.

Table 37:Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	28157214507200	52,047	4,337	5,901	38

Note: Based on the analysis of the historical billings, it is identified that the total system requirement for this electrical connection is 38 kW including Street Lights. However, during the assessment it was identified that the condition of Slaughterhouse building is unsatisfactory. Therefore, it is not recommended to install the solar system at this site.

6.6 Fire Brigade

The project site i.e. Fire Brigade is located near circular road ,Kot Addu, Muzaffargarh, Punjab, Pakistan while the geographical co-ordinates of location are 30.4598°N (latitude) and 70.96615°E (longitude).

Figure 31: Front view of Fire Brigade

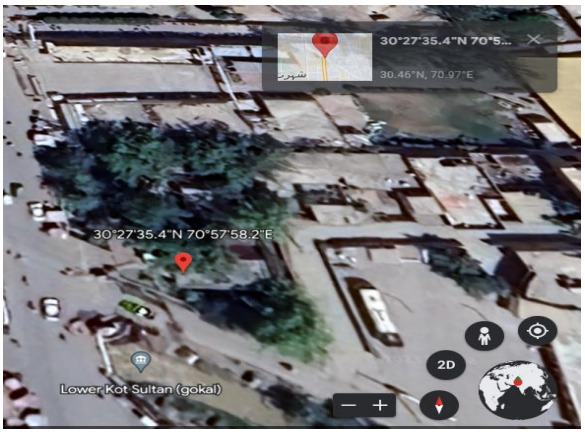

Figure 32: Aerial view of Fire Brigade

6.6.1 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 Fire Brigade 8,817 kWh with the peak electricity consumption of 1075 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 38:Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	16157212080800	8,817	734	1075	6

6.6.2 Roof Assessment

As per the Consultant's assessment, the total area of the Fire Brigade is 5834 ft^2 whereas, there is no clear roof space area available due to obstructions of trees.

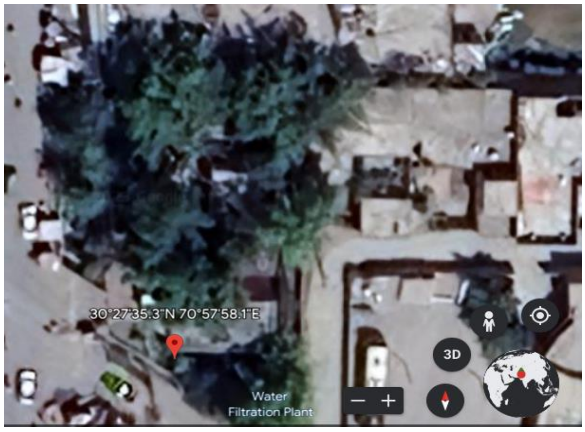

Figure 33: View of complete building

6.7 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.

6.7.1 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.

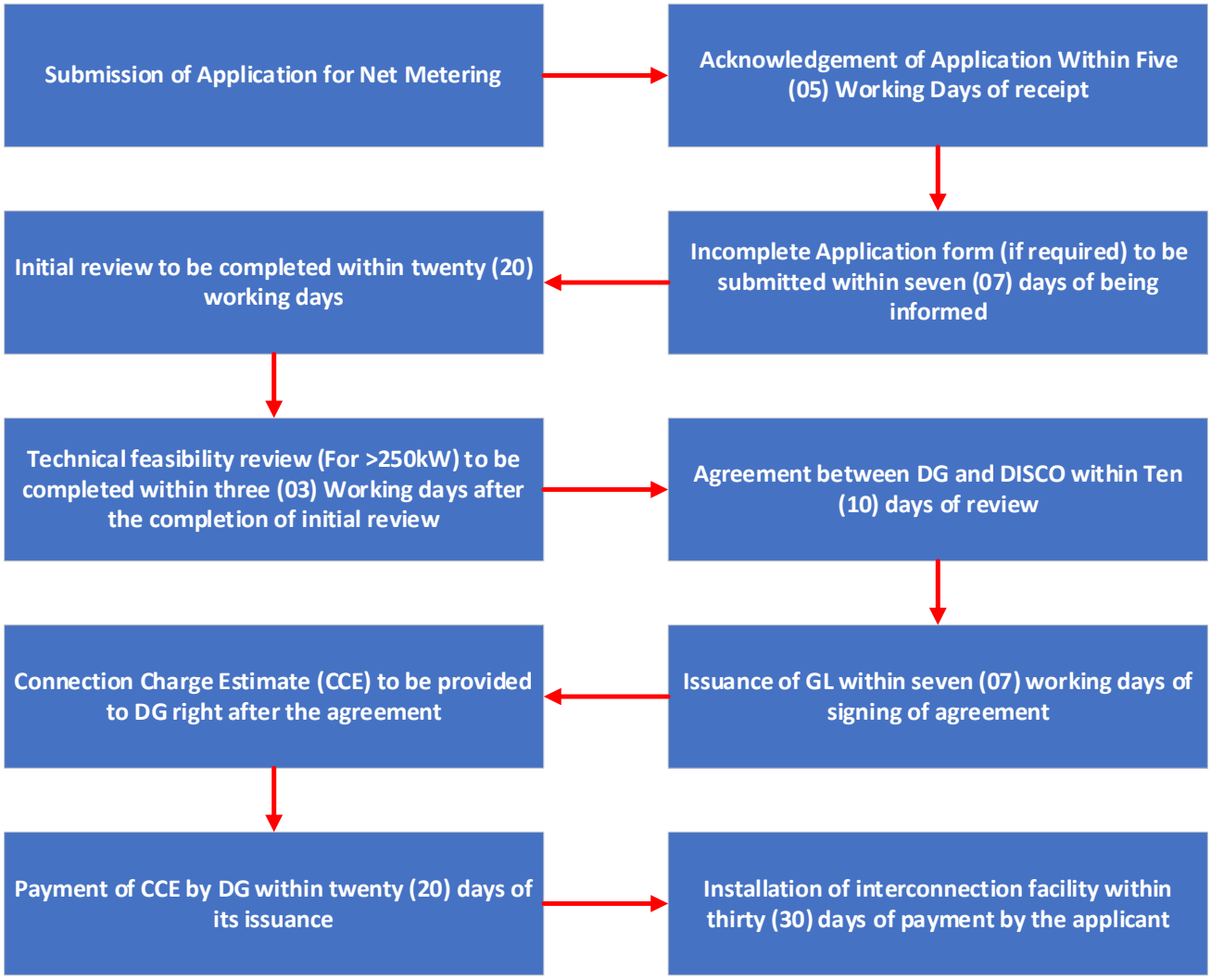

Figure 34:Pakistan Net Metering Application Process

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

7 Recommended Energy Efficiency Measures

Recommended EE measures are categorized into high, medium and low priority measures. High priority EE measures are those which shall be implemented immediately (within 1-2 years' time) to meet the baseline demand, medium term measures may be implemented in the near future (within 3-7 years' time) and low priority measures may be implemented in the remote future (within 7-10 years' time).

7.1 Energy Efficiency Measures for Streetlights

7.1.1 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 1,412 streetlights are being operated by the municipality. Out of these, 806were 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 35: 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 39: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	806
Number of non-functional streetlights (>20 feet)	#	0
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	806

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	41,155,166
Proposed number of photocell switches	#	4
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	4,000
Upfront investment cost	PKR	41,159,166
Upfront investment cost	US$	146,892
Annual Operating Electricity unit	kWh/yr	104,689
Annual Operating Cost	PKR/yr	4,710,998
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	512,583
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

7.1.2 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 1,412 streetlights operated by municipality out of which 606 are operational. 579 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 40: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	27
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)	#	27

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Upfront investment cost	PKR	1,378,647
Upfront investment cost	US$	4,920
Annual Operating Electricity unit	kWh/yr	3,507
Annual Electricity Consumption of Existing Lights	kWh/yr	5,005
Financial Savings	US$/yr	241
Payback	months	245

7.2 Energy Efficiency Measures for Buildings

7.2.1 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 41: 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
MC-Building											
1	ILB	1	60	60	150	LED Bulb 8 Watts	8	8	20	330	330
2	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
3	Tube Light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
4	Tube Light	10	40	400	998	LED Rod 20 Watts	20	200	499	2,900	29,000
5	Halogen Light	2	500	1000	2,496	Flood LED 200 Watts	200	400	998	25,000	50,000
6	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
7	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
Slaughter House											
8	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
9	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
	Total										**108,330**

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 42: Saving & cost benefit analysis

Parameters	Unit	Value
Average Operational Days for Building Lighting Equipment	days/year	312
Average Operational Hours for Building Lighting Equipment	Hours/day	8
Energy consumption of inefficient Equipment	kWh/yr	4,643
Energy consumption of Proposed Equipment	kWh/yr	2,017

Parameters	Unit	Value
Energy Savings	kWh/yr	2,626
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	422
Upfront Investment (including change in fixtures)	USD	387
Payback Period	Months	11

8 Investment Estimate (including Material Specification/Quantities)

8.1 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.

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	806	51,061	41,155,166
2	Accessories	Photocell switch				4	1,000	4,000
Lumpsum Price (PKR)								**41,159,166**
Lumpsum Price (USD)								**146,892**

8.1.2 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	30	51,061	1,378,647
Lumpsum Price (PKR)								**1,378,647**
Lumpsum Price (USD)								**4,920**

8.2 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.

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

Sr. No	Proposed Equipment	Wattage of Proposed Equipment	Equipment Count	Overall Wattage of Proposed Equipment	Individual Cost of Proposed Equipment (PKR)	Cost of Proposed Equipment
1	LED Bulb 8 Watts	8	1	8	330	330
2	LED Rod 20 Watts	20	20	400	2,900	58,000
3	Flood LED 200 Watts	200	2	400	25,000	50,000
Lumpsum Price (PKR)						**108,330**
Lumpsum Price (USD)						**387**

9 Summary of Energy Efficiency Measures

MC Kot Addu's annual energy consumption is 1,387,442 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$ 662** with an estimated investment of **US$ 152,649**
- Reduce electricity consumption by approx. **4,124 kWh**
- Reduce GHG Emissions by **1 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of MEPCO

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