



Jhang Municipal Committee s

Energy Audit Report

June 2023

History of the Document

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Client Name	Punjab Municipal Development Fund Company (PMDFC)	Contract No.	PK-PMDFC-318212-CS-CQS
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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

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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

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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 Jhang MC Background

Jhang 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.

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. Tariq Husaain Bhatti	Administrator
2	Mr. Adil Rahnja	Chief Officer
3	Mr. Faraz Ahwaz*	Municipal Officer (Infrastructure)

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Sr. No.	Name of Officer	Designation
4	Mr. Khalid Mehmood	Municipal Officer (Regulation)
5	Mr. Shakeel Ahmad	Municipal Officer (Finance)
6	Mr. Masroor Tayyab Khan	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Jhang

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells ¹	kWh/year	33,108
Electrical energy used by Wastewater Disposal ²	kWh/year	1,120,078
Electrical energy used in Buildings ³	kWh/year	81,732
Electrical energy used by Streetlights ⁴	kWh/year	337,998
Diesel used by Vehicles	liter/year	70,248

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)	No Operational Tubewells
2	Energy Density of Wastewater Disposal	(kWh/m3)	0.06
3	Energy Density of Wastewater Treatment	(kWh/m3)	No wastewater treatment is carried out
4	Energy Cost for Potable Water Production	(PKR/m3)	No Operational Tubewells
5	Energy Cost for Wastewater Disposal	(PKR/m3)	2.50
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)	1,125
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	49
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	46,905
		PKR/Lighting Equipment	36,213
4	Average cost of installation of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	1,254
		PKR/Lighting Equipment	370
5	Average annual maintenance costs	(PKR)	543,682
6	Average daily duration of operation	(Hour)	12.0

¹Based on 12-month historical billing data

²Based on 12-month historical billing data

³Based on 12-month historical billing data

⁴Based on 12-month historical billing data

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Sr. No.	Description	Unit	KPI
7	Average energy costs per kilometer of lit roads	(PKR/km)	50,645
8	Average energy costs per light pole/fixture	(PKR/ fixture)	2,188
9	Number and percentage of failed public lights		79%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m ²)	4.79
2	Municipal Buildings Heat Consumption	(kWh/m ²)	0.14
3	Average Cost of Heating	(PKR/m ²)	6
4	Average Cost of Cooling	(PKR/m ²)	113
5	Average Cost of Lighting	(PKR/m ²)	41

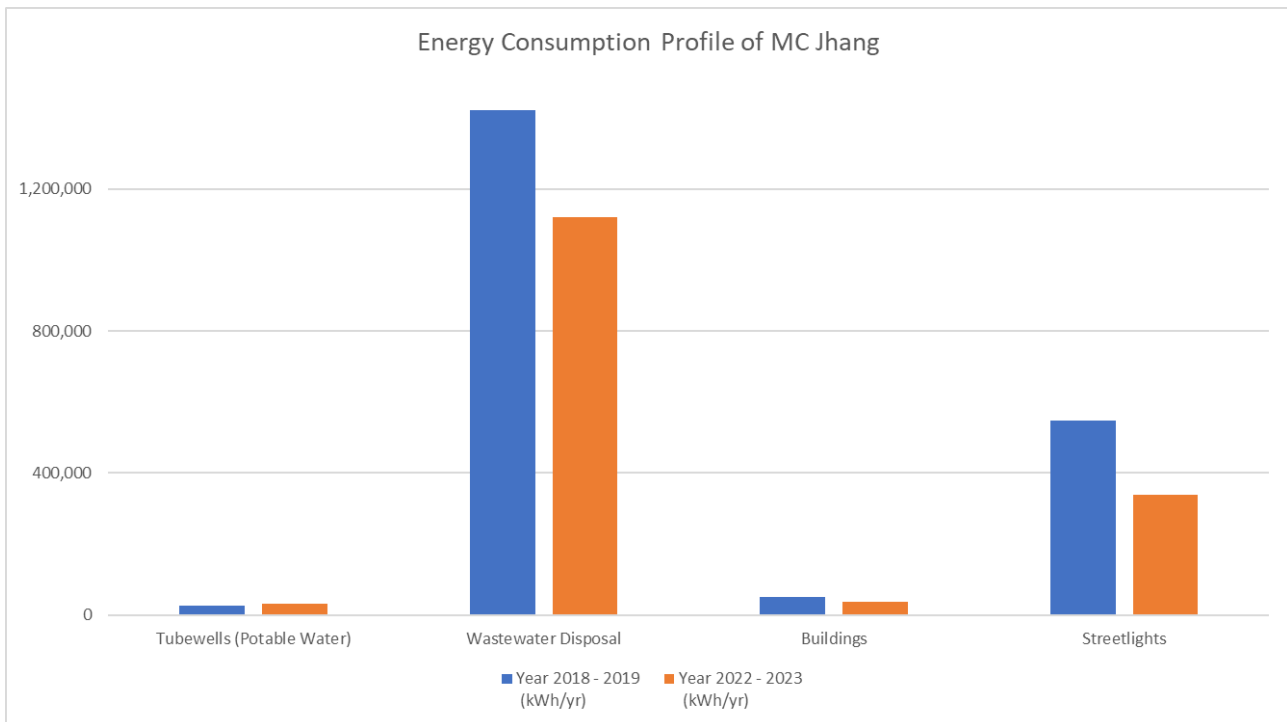
1.5.4 Vehicles

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	3.99
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	73

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.



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		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)	2	0	25,480	33,108	-7,628	0.12 kWh/m3	N/A	No comparison calculations have been presented here as no performance could be carried out on pump stations as all the water supply pumpsets were non-operational during the current audit.
2	Wastewater Disposal	14	15	1,422,305	1,120,078	302,227	0.07 kWh/m3	0.06 kWh/m3	No recommendation for 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. As seen from the KPI, the overall energy consumption per cubic meter of wastewater disposed has decreased.
3	Buildings	6	19	51,434	37,494	13,940	8.22 kWh/m2	5.99 kWh/m2	The energy consumption of Main MC Building, MC Mosque, Tiba Ragistan Slaughter House, Mohallah Bag Wala Slaughter House, Harmal Pur Slaughter House and Fire Brigade building are included for the purpose of this comparison. Furthermore, during the last assessment, the electricity units on bill of the Fire Brigade building are shown as zero so, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Remaining buildings were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption

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		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
									of those buildings have not been considered in the overall energy consumption and KPI calculations.
4	Streetlights	2,896	1456	548,780	337,998	210,782	4,236 kWh/km	1,125 kWh/km	<p>During the 2019 audit, there were 837 LEDs out of 2,896 operational lights and currently there are 1346 LEDs out of 1,456 operational lights. Based on this information, the Consultant has identified that although the MC has undertaken replacement of 509 inefficient streetlights with LEDs, a significant increase of 43 kWh/light/annum in the overall billing for streetlights has been observed.</p> <p>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.</p>

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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	1,350	378,270	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	1,014,286	284,202,966	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	24,448	1,558	436,540	3,926	1,100,174	5	12
Total:	24,448	1,017,194	285,017,776	3,926	1,100,174		12

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	N/A	20,228	5,667,771	N/A	N/A	N/A	N/A
Total:	N/A	20,228	5,667,771	N/A	N/A	N/A	N/A

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2 Water Pumps and Disposals

Jhang MC has three (3) tubewells for groundwater, all of which are manually operated. Out of these, no pumpsets were found to be in working condition.

The MC has eleven (11) disposal station having twenty-six (26) pumps. Out of these, 15 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are thirty (30) dewatering sets in the MC and 16 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) Undertake assessment of the following pumpsets as these were as these under maintenance
 1. MC Jhang (Unique ID: 52405138)
- (iii) Undertake assessment of the following pumpsets as these were non-functional due to damaged delivery lines
 1. Kalma Chowk (Unique ID: 52405139)
 2. Satellite Town (Unique ID: 52405140)
- (iv) Undertake assessment of the following disposal stations as these were non-functional due to damaged delivery lines
 1. Lakhi Wala (Unique ID: 52105112-C)
- (v) Undertake assessment of the following pumpsets as these were as these under maintenance
 1. Noor shah (Unique ID: 52105113-C)
 2. Karmanwala (Unique ID: 52205123-A)
 3. Karmanwala (Unique ID: 52205123-B)
 4. Karmanwala (Unique ID: 52205123-C)
- (vi) Undertake assessment of the following disposal stations because of the non-functional motor
 1. Ghadiyan Wala old (Unique ID: 52105114)
 2. Harmul Pura (Unique ID: 52105110-C)
 3. Lakhi Wala (Unique ID: 52105112-D)
 4. Tibba Raigstan (Unique ID: 52205121-B)
 5. Khokhar Chak (Unique ID: 52205125-B)
 6. Khokhar Chak (Unique ID: 52205125-C)

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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.

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2.1 Inventory for water and wastewater pumping equipment

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

2.1.1 Tubewells

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

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	Year of Motor Manufacturing	Latitude	Longitude
1	52405138	MC Jhang	24-13341-2578500	Turbine	Peco	1976	Beco	1976	31.278992	72.313057
2	52405139	Kalma Chowk	24-13318-1452802	Turbine	KSB	2007	Siemens	2007	31.258562	72.351225
3	52405140	Satellite Town	24-13318-1087200	Turbine	KSB	N/A	Siemens	N/A	31.26665	72.35382

2.1.2 Disposal Works

Table 9: 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	52205125-A	Khokhar Chak	24-13319-5905500	Centrifugal	KSB	6	Siemens	75	31.265226	72.373774	
2	52205125-B	Khokhar Chak		Centrifugal	KSB	6	Siemens	75	31.265226	72.373774	
3	52205125-C	Khokhar Chak		Centrifugal	KSB	6	KSB	60	31.265226	72.373774	
4	52105110-A	Harmul Pura	24-13315-5302003	Turbine	KSB	10	Warszawska Fabryka	100	31.264171	72.293569	
5	52105110-B	Harmul Pura		Turbine	KSB	10	Warszawska Fabryka	100	31.264171	72.293569	
6	52105110-C	Harmul Pura		Centrifugal	KSB	5	KSB	60	31.264171	72.293569	
7	52105111-A	Gharay Band	24-13341-5109803	Centrifugal	KSB	3	Siemens	30	31.277371	72.298905	
8	52105111-B	Gharay Band		Centrifugal	KSB	3	Siemens	30	31.277371	72.298905	
9	52105112-A	Lakhi Wala	24-13341-0519802	Centrifugal	KSB	5	KSB	60	31.283933	72.305317	
10	52105112-B	Lakhi Wala		Centrifugal	KSB	4	KSB	60	31.283933	72.305317	
11	52105112-C	Lakhi Wala		24-13315-5308801	Centrifugal	KSB	5	KSB	60	31.283933	72.305317
12	52105112-D	Lakhi Wala		Centrifugal	KSB	4	Siemens	40	31.283933	72.305317	
13	52105114	Ghadiyan Wala old	24-13341-0590800	Centrifugal	Master Pump		TECHO		31.309382	72.319387	
14	52105115	Ghadiyan Wala New	24-13341-0590801	Centrifugal	Chamber	1.5	Siemens	25	31.30975	72.321333	
15	52205121-A	Tibba Raigstan	24-13317-2401400	Centrifugal	KSB	2	Siemens	15	31.300267	72.328609	
16	52205121-B	Tibba Raigstan		Centrifugal	KSB	2	Siemens	15	31.300267	72.328609	
17	52105113-A	Noor shah	24-13317-2400500	Centrifugal	KSB	5	Siemens	60	31.298713	72.30671	
18	52105113-B	Noor shah		24-13341-0519803	Centrifugal	KSB	5	Siemens	60	31.298713	72.30671
19	52105113-C	Noor shah		Centrifugal	KSB	5	Siemens	60	31.298713	72.30671	
20	52205124	Islam Nagar	24-13319-5900303	Centrifugal	Beco	1.5	Beco	25	31.267515	72.34394	
21	52208881	Jalalanbad	24-13319-5909503	Centrifugal	Local, Lahori	2	MEZ	25	31.287288	72.333918	
22	52205123-A	Karmanwala		Submersible	Grund Fos	3	Grund Fos	30	31.282005	72.333781	
23	52205123-B	Karmanwala		Submersible	Grund Fos	3	Grund Fos	30	31.282005	72.333781	
24	52205123-C	Karmanwala		Submersible	Grund Fos	3	Grund Fos	30	31.282005	72.333781	
25	52205126-A	Farooqabad	24-13318-5801300	Centrifugal	KSB	3	Siemens	40	31.257003	72.348084	

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Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Pump Capacity (Cusec)	Motor Manufacturer	Motor Capacity (Hp)	Latitude	Longitude
26	52205126-B	Farooqabad		Centrifugal	KSB	3	Siemens		31.257003	72.348084

2.1.3 Dewatering Sets

Table 10: Inventory of Dewatering Sets

Sr. No.	Unique Id	Location	Quantity	Latitude	Longitude
1	5180583-1	By-Pass Road	1	31.28599	72.30562
2	5180583-2	Mosa Masjid, Basti Oddan Wali	1	31.29197	72.32952
3	5180583-3	Taqwa Colony, Street # 15	1	31.30483	72.33154
4	5180583-4	Choudhary Colony	2	31.29598	72.32281
5	5180583-5	Basti Rasoolpura	1	31.28703	72.32363
6	5180583-6	Jalalabad Jhang Sadar	1	31.30566	72.33143
7	5180583-7	Naya Shahar	1	31.26509	72.35355
8	5180583-8	Hasnana Mohallah	1	31.26822	72.30196
9	5180583-9	Pindhi Mohallah	1	31.27513	72.30563
10	5180583-10	Amir Town, Choudhary Colony	1	31.29508	72.32214
11	5180583-11	Galli Number # 1, Mohallah Amnabad	1	31.26930	72.31634
12	5180583-12	4 TH Mile, Gojra Road Civil Lines Mohallah Burjhi Wala	1	31.27043	72.31916
13	5180583-13	IDC Jhang	1	31.26295	72.33550
14	5180583-14	Near Ghulshan Colony	1	31.25875	72.31481
15	5180583-15	697 Kacha Kot Road, Madina Colony	13	31.27804	72.31503
16	5180583-16	Plot # 442, Madina Colony	1	31.27866	72.31503
17	518058317	Ghodhay Wala	1	31.31088	72.3261

2.1.4 Filtration Units

Table 11: Inventory of Filtration Units

Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East
1	52305127	Qabristan Rulay Shah	Centrifugal	1	Asli Punjab	N/A	Asli Punjab	31.262454	72.30061
2	52305128	Muhallah Baghwala	Centrifugal	1	Golden Pumps	N/A	Golden Matic	31.267072	72.309379
3	52305130	Abrar Park	Centrifugal	1	IDEAL	N/A		31.270857	72.309673
4	52305131	Basti Mura wali	Centrifugal	1	Punjab Pumps	N/A		31.341643	73.422063
5	52305132	Muhallah Farooqia	Centrifugal	1	Golden Deep Well Pumps	N/A	Golden Motors	31.308041	72.324314
6	52305133	Milad Chowk	Centrifugal	1	Golden Pumps	N/A	Golden Motors	31.304925	72.322057
7	52305134	Larri Adda	Centrifugal	1	Asli Punjab	N/A	Asli Punjab	31.288924	72.324405
8	52305135	Rasheed Chowk	Centrifugal	1	Faisal Pumps	N/A	Faisal Motors	31.290308	72.328756
9	52305136	Shadab Colony	Centrifugal	1	Minister	N/A	Minister	31.272672	72.325622
10	52305137	Sadiqabad	Centrifugal		Asli Punjab	N/A	Asli Punjab	31.24997	72.35371

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Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East	
11	52307771	Jhang	Water is Pumped from main Tanki						31.278858	72.312922
12	52405141	Behari Satellite Town	Centrifugal	1	Golden Pumps	N/A	Golden Motor	31.267395	72.350639	
13	52405142	Jalalabad Yousaf bhatta			Golden Pumps	N/A		31.283956	72.326464	
14	52405144	Faisalabad Jalalabad	Centrifugal	1	Asli Punjab	N/A		31.280298	72.32955	

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

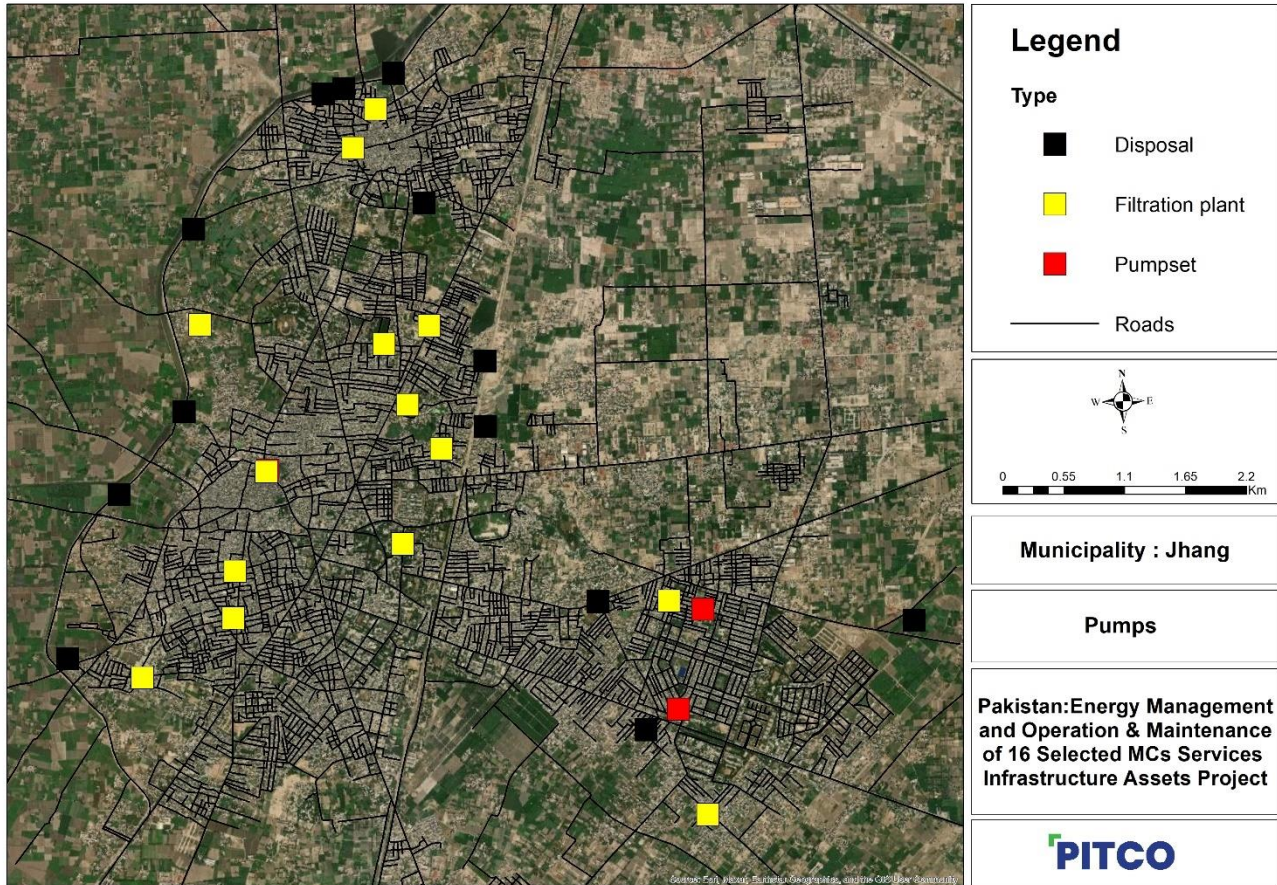


Figure 1: Map for Pumps and Disposal at MC Jhang

2.3 Baseline Energy Consumption Trend

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

Table 12: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	33,108
Electrical energy used by Wastewater Disposal	kWh/y	1,120,078
Electrical energy used (Total)	kWh/y	1,153,186

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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)	2	0	25,480	33,108	-7,628	0.12 kWh/m3	N/A	No comparison calculations have been presented here as no performance could be carried out on pump stations as all the water supply pumpsets were non-operational during the current audit.
2	Wastewater Disposal	14	15	1,422,305	1,120,078	302,227	0.07 kWh/m3	0.06 kWh/m3	No recommendation for 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. As seen from the KPI, the overall energy consumption per cubic meter of wastewater disposed has decreased.

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2.4 Observations and Recommendations

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.

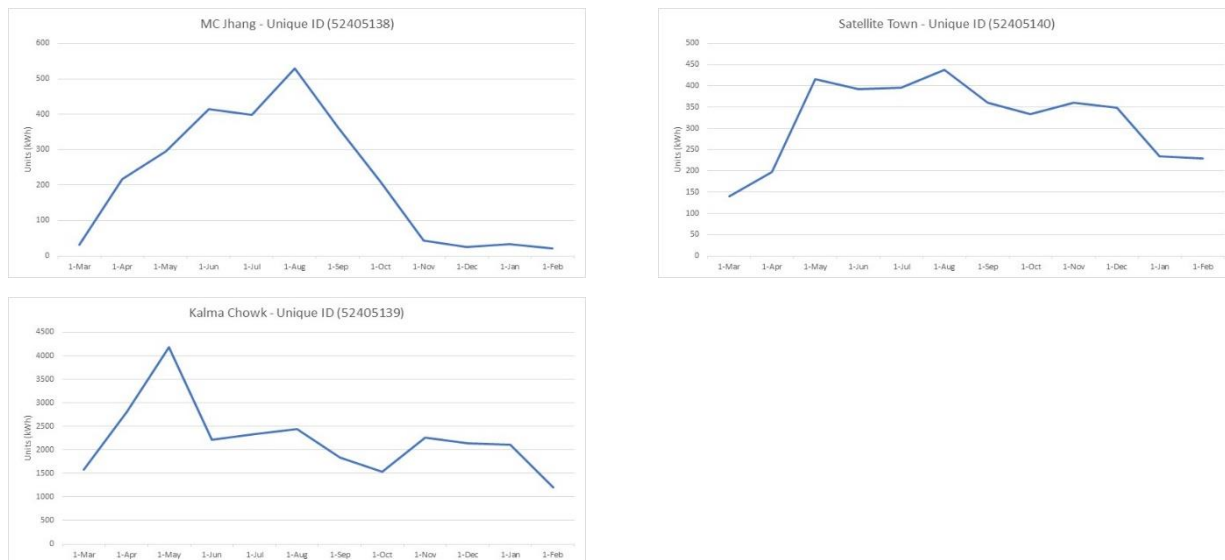
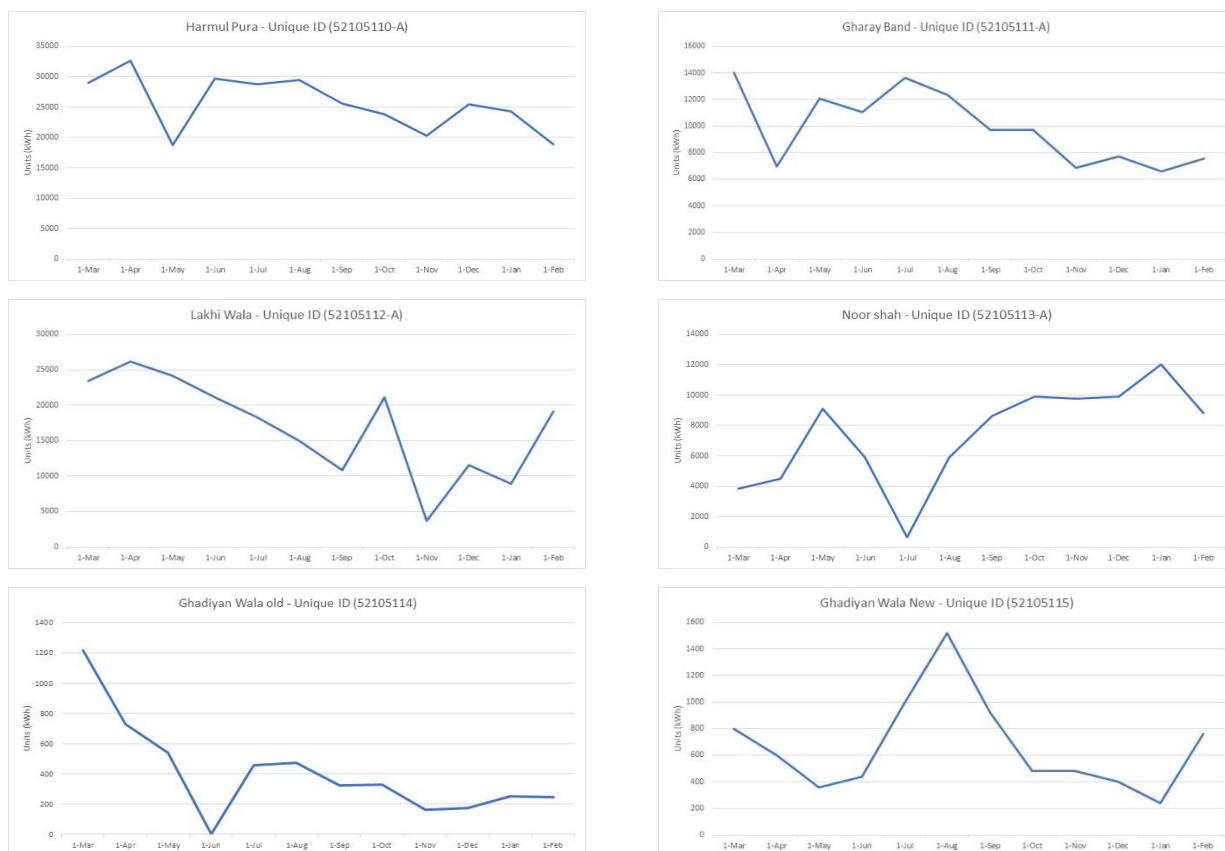


Figure 2: Energy Consumption Trend for Water Pumps



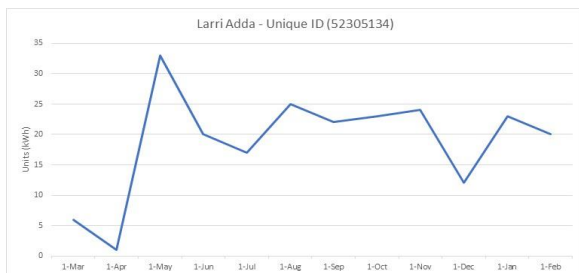
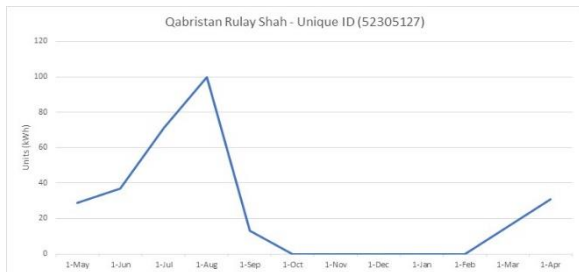
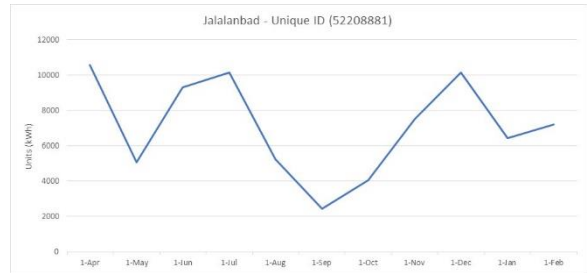
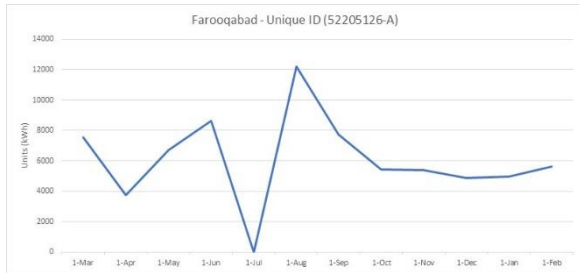
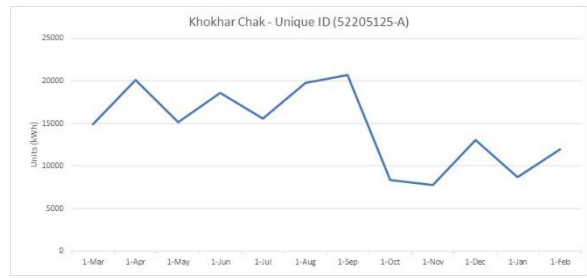
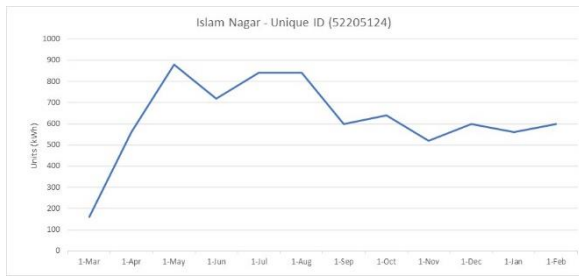


Figure 3: Energy Consumption Trend for Disposal Units

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2.4.2 Performance of Water Pumping System

Jhang MC has three (3) tubewells for groundwater, all of which are manually operated. Out of these, no pumpsets were found to be in working condition.



Figure 4: Sample pictures from field audit of pumpsets

2.4.3 Wastewater Disposal System

The MC has eleven (11) disposal station having twenty-six (26) pumps. Out of these 15 pumps were found to be in working condition. All these pumps are manual and run as per requirement. The list of audit equipment used by the Consultant is attached as Annexure 2.

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 13: Disposal Performance Parameters

Sr No	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	PITCO Comments
1	52105115	Ghadiyan Wala New	152.9	162.1	10.67	13.80	40%	Efficiency of the pumpset is satisfactory. Previously, the pump site was under construction.
2	52205124	Islam Nagar	152.9	257.2	9.14	18.20	41%	Efficiency of the pumpset is satisfactory. Previously, the site was non-functional.
3	52208881	Jalalanbad	203.9	121.6	13.72	14.20	38%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory.
4	52105110-A	Harmul Pura	1,019.4	1,350.8	4.88	44.60	47%	Efficiency of the pumpset is satisfactory. Previously, the motor of the pumpset was not functioning properly so no reliable data was recorded.
5	52105110-B	Harmul Pura	1,019.4	844.8	4.88	32.10	41%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 38%.
6	52105111-B	Gharay Band	305.8	321.4	7.62	19.90	39%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, the delivery line of the pumpset was damaged.

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Sr No	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	PITCO Comments
7	52105112-B	Lakhi Wala	4,077.6	401.1	7.01	22.70	40%	Efficiency of the pumpset is satisfactory. Previously, flow was not detected due to extremely rusty surface of the delivery line.
8	52105113-A	Noor shah	509.7	543.0	7.62	34.20	39%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, the efficiency of the pumpset was 38%.
9	52105113-B	Noor shah	509.7	386.5	7.62	22.30	42%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 49%.
10	52205121-A	Tibba Raigstan	203.9	166.0	9.14	11.80	41%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 41%.
11	52205125-A	Khokhar Chak	611.6	748.4	7.92	46.50	41%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 41%.
12	52205126-A	Farooqabad	305.8	188.7	7.62	10.70	43%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 41%.
13	52205126-B	Farooqabad	305.8	300.0	4.57	8.30	53%	Efficiency of the pumpset is satisfactory.



Figure 5: Wastewater Disposal

2.4.4 Dewatering Sets

There are thirty (30) dewatering sets in the MC and 16 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.

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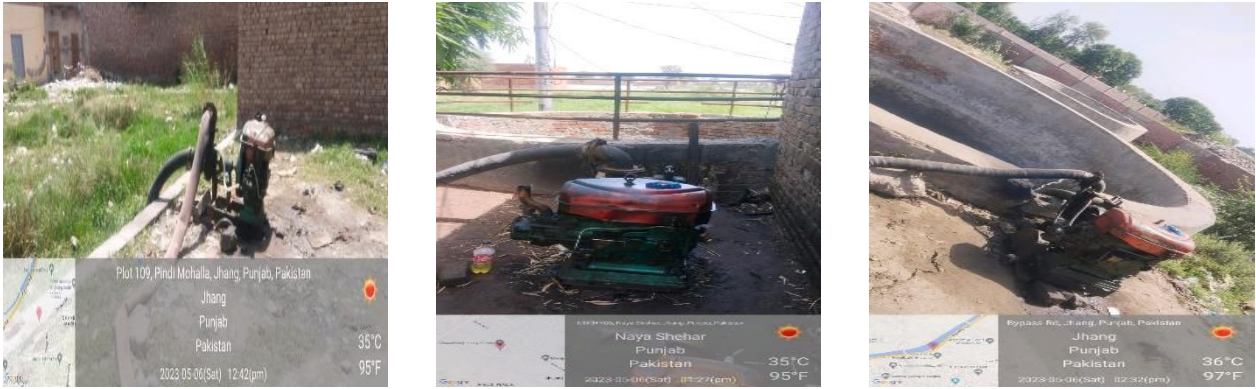


Figure 6: Dewatering Sets

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 14: Water Pumps and Wastewater Disposal System: Recommendations for improvement

Sr No.	Unique ID	Location	Comments	Recommendation
Pumps				
1	52105115	Ghadiyan Wala New	The power factor at the site is below 0.8.	A 2.5 kVAR capacitor should be installed on each phase.
2	52205124	Islam Nagar	The power factor at the site is below 0.8.	A 5 kVAR capacitor should be installed on each phase.
3	52105110-A	Harmul Pura	The power factor at the site is below 0.8.	A 12.5 kVAR capacitor should be installed on each phase.
4	52105110-B	Harmul Pura	The power factor at the site is below 0.8.	A 5 kVAR capacitor should be installed on each phase.
5	52105111-B	Gharay Band	The power factor at the site is below 0.8.	A 2.5 kVAR capacitor should be installed on each phase.
6	52105112-B	Lakhi Wala	The power factor at the site is below 0.8.	A 2.5 kVAR capacitor should be installed on each phase.
7	52105113-B	Noor shah	The power factor at the site is below 0.8.	A 2.5 kVAR capacitor should be installed on each phase.
8	52205121-A	Tibba Raigstan	The power factor at the site is below 0.8.	A 2.5 kVAR capacitor should be installed on each phase.
9	52205126-A	Farooqabad	The power factor at the site is below 0.8.	A 2.5 kVAR capacitor should be installed on each phase.
10	52205126-B	Farooqabad	The power factor at the site is below 0.8.	A 5 kVAR capacitor should be installed on each phase.
General Observations				
11	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
12	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.

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Sr No.	Unique ID	Location	Comments	Recommendation
13	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.
14	General	Water Supply Network	Proper O&M of Air Release Valves	Air release valves installed on the network should be properly maintained.

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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 Jhang 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 15: Inventory Detail of Streetlights

	Streetlights	MC Operated	Privately Operated
Operational Street Lights	1,456	1,456	-
Non-Operational Street Lights	5,562	5,562	-
Total	7,018	7,018	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 1073 light fixtures installed on PC, 1076 fixtures are installed on steel structure, 22 fixtures are installed on tubular structures and 4,779 light fixtures are installed on wires. The streetlights' structural classification is tabulated below.

Table 16: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	On Wire	Grand Total
MC	1,073	1,076	22	4,779	6,950
Private					0

Streetlights of Jhang 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 17: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Jhang Saddar	59	24133415106802 24133415103700	2.611
2	Boarding House	28	24133172406900	2.887
3	Chaudry Colony (Andron)	18	04133172412300	1.430
4	Muhallah Sharifan Wala	81	24133172409400	1.817324
5	Chaudry Colony Malik Younas	64	24133172412300	1.584328
6	Thana Saddar Chowk	24	24133115200901	0.669217
7	Muhallah Burji wala	15	24133115202407	0.467172
8	Gali Burji Wali	30	24133115202408	1.306096
9	Toba Road Near Dr. Habibullah	42	24133115202402	1.390422
10	Station Chowk	39	24133115202200 24-13311-520600	3.806992
11	Nazir Colony Civil Line	36	24-13311-520201	4.142529
12	Basti Haseen Abad	30	24-73311-5202300	1.079413
13	Basti Mallah Wali	22	24133115202301	2.535479
14	Milad Chowk Janaza Gah Road	15	24133172409700	0.574348
15	Muhallah Gulab Wala	112	24133172411500	4.222071
16	Muhallah Hathiwan	32	24133172410700	0.94123

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Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
17	Muhallah Haideri	25	24133172411700 24133172406800	2.170
18	Gali Mulazim hussian wali	21	24133172410500	1.792
19	Chungi No. 22	11	24133172410000	0.936
20	Mohallah Purana Bagh	36	24-13317-5109600	2.301
21	Qadri Colony Basti Ali	43	24133115202302	0.986
22	Aqib SP House	24	24133115202303	1.509
23	Tuba Road Near Chairman Kothi	13	24133115202401	1.245
24	Haseena High School Road	12	24133115204501	0.476
25	Muhallah Samnabad	26	24133115202403	2.016
26	Galli Master Naseer Wali	28	24133115202406	2.140
27	Basti Aata Wali	39	24133115202405 24133115202404	4.642
28	Adda Maduki Toba Road	14	24133115202404	0.656
29	Milad Chowk Chak Shumali	34	24133172409800	1.728
30	Mohalla Kuharan Wala	16	24133172411600	0.830
31	Mohalla New Eid Gah	19	24133172409100	1.036
32	Mohallan Qazian Wala	39	24133172412500	5.545
33	Hakeem Chawani Wala	19	24133172411300	2.060
34	Gulshan Colony	26	24-13311-5202408	0.774
35	New Eid-Gah Road	29	24-13311-5202409	0.782
36	Millat College Road	10	24-13311-5202411	0.422
37	Doctor Niggat Hospital Road	20	24-13311-5202412	2.712
38	Chah Nishan Wala	53	24-13317-2412400	1.544
39	Mohallah Dawood Shah	63	24-13317-2407900	2.524
40	Sheikh Colony	73	24-13311-5202401	7.542
41	Lakar Mandi Kapi Court Road	25	24-13311-5202413	2.156
42	Muhallah Jogian Wala	30	24-13311-5203100	1.610
43	Chah Tiwana	42	24-13317-2412000	1.164
44	Police Chowki Rail Bazar	47	24-13317-2407600	1.446
45	Chah Kalwara	21	24-13317-2407500	1.285
46	Millat Colony Andron	15	24-13317-2408400	0.634
47	Woolen Center	31	24-13317-2411800	1.202
48	Wapda Complaint Center	92	24-13317-2411900	2.909
49	Mohallah Tauhid Abad	17	24-13317-2408600	2.825
50	Muhallah Budah Wala	127	24-13311-5203300	8.661
51	Muhallah Khawajgan	67	24-13311-5203201	1.688
52	Amir Town Near Baab-e-Ali	27	24-13317-2411000	1.255
53	Amir Town Near Sargoda Road	28	24-13317-2410600	0.482
54	basti Gohar Shah	32	24-13317-2410200	0.834
55	Mohallah Sarafan Wala	85	24-13317-2410400	3.378
56	Kacha Court Road	30	24-13311-5206400	0.757
57	Chowk Rail Bazar	147	24-13311-5203700	7.438
58	Shaheed Road	7	24-13311-5203702	0.533
59	Tehsil Road Near Imam Bargah	5	24-13311-5203703	1.289
60	Muhallah Court Akbar	40	24-13311-5203801	0.916
61	Civil Hospital Road	92	24-13317-2412100	2.837
62	Noor Shah Bazar	66	24-13317-2410000	2.968
63	Mamna Bazar	91	24-13317-2411400	1.695
64	Babe-e-Umar	84	24-13317-2407700	1.678
65	Abshar Nawaz Chowk	22	24-13311-5204302	1.263
66	Abida Bashir Road	10	24-13311-5204303	0.545
67	Nawaz Chowk	15	24-13311-5204300	5.586
68	Girls College Chowk	42	24-13311-5204400	2.454
69	Chah Farid Wala	45	24-13311-5204401	1.795
70	Mohallah Burji Wala G-H-R	13	24-13311-5204402	0.522
71	Sacred Hard School Road	18	24-13311-5204404	0.577
72	Ganda Nala Road Chowk	92	24-13317-2407000	3.198
73	Gali Hakeem Ashraf Wali	22	24-13317-2408700	1.053

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74	Mohallah Sultan wala T-M	60	24-13311-5204801	1.502
75	Mohallah Sultan wala P-C	73	24-13311-5204900	1.809
76	Basti Shehni Wali	38	24-13317-2407800	1.785
77	Mohallah Madan Shah	40	24-13317-2411100	2.615
78	Basti Tahri Abad	23	24-13317-2411200	1.032
79	Gali Jear Semi Wali	13	24-13311-5204901	0.341
80	Inhar Colony	43	24-13311-5204304	1.136
81	Mohallah Sultan wala near H-S	49	24-13311-5204903	0.924
82	Rafiq Chowk	23	24-13317-2408100	0.852
83	Rafiq Chowk Ward No. 7	11	24-13317-2408200	1.732
84	Barny Wala	28	24-13317-2407300	0.571
85	Abdullah Pur	23	24-13317-2408300	0.725
86	Faridia Colony	27	24-13317-2408500	0.950
87	Mohallah Sultan wala Masjid AH	36	24-13311-5204904	0.620
88	Mohallah Sultan Wala	25	24-13311-5204902	0.719
89	kotwali Road	65	24-13311-5205000	1.759
90	Basti Loharan Wali (Andron)	19	24-13317-2408900	1.039
91	Basti Loharan Wali	18	24-13317-2409000	0.406
92	Muhallah Islamabad	31	24-13317-2409200	0.917
93	Pathan Colony	29	24-13317-2410900	1.609
94	Aimanabad (Andron)	32	24-13317-2410100	1.254
95	Bahkar Chowk	45	24-13311-5205100	1.867
96	Dabhi Road	69	24-13311-5205200	3.446
97	Christian Colony Outside	20	24-13317-2410800	0.665
98	Christian Colony Inside	19	24-13317-2409600	1.076
99	Aimanabad # 2	32	24-13317-2409500	1.199
100	Muhallah Kuhran wala # 2	25	24-13317-2408800	1.043
101	Chaudry Colony (Masjid Mustafa)	24	24-13317-2410300	1.175
102	Chah Shadi Wala	18	24-13341-5106900	0.698
103	Chaudhry Colony Near Masjid AH	0	24-13341-5104000	1.052
104	Naqad Pura	95	24-13341-5308000	2.817
105	Anarkali Bazar	70	24-13311-5205201	1.135
106	Yousaf Shah Road	10	24-13311-5205901	0.463
107	Mohallah Qapaya	24	24-13311-5206002	0.639
108	Dana Mandi Chowk	34	24-13311-5205300	1.107
109	Mohallah Yousaf Abad	25	24-13311-5206001	1.116
110	Pakka Court Road	15	24-13311-5206301	1.023
111	Mohallah Gohar Shah	30	24-13311-5206005	3.526
112	Ilahi Baksh Colony	27	24-13311-5206302	0.820
113	Basti Mochain Wali	16	24-13317-2406700	0.475
114	Basti Abbas Pur	19	24-13341-0519817	0.576
115	Abbas Town	25	24-13341-0519824	0.949
116	Rehman Colony	37	24-13341-0519819	1.242
117	Gali Bank Wali Jhang Bazar	131	24-13311-5302100	2.831
118	Sargodha Road Near G-S	22	24-13341-5308002	0.822
119	Ali Town	37	24-13341-5307200	1.302
120	General Bus Stand	52	24-13341-5103000	1.213
121	Lory Adda	33	24-13341-5103003	2.010
122	Chaudry Colony	47	24133415104100	1.899
123	Basti Diwan, Masjid Norani	35	24-13341-5107404	1.558
124	Main Bazar (Andron)	22	24-13311-5206303	0.790
125	Main Bazar	33	24-13311-5206300	1.311
126	Wiki Hotel Ayoob Chowk	30	24-13311-5206004	1.065
127	Amir Colony	28	24-13311-5206100	0.820
128	Galli Chaki Atta Wali Kapi CR	15	24-13311-5206401	0.344
129	MPA Road MC Jhang	15	24-13311-5206402	0.576
130	Near Mosque Mallah Kapi CR	10	24-13311-5206403	0.841
131	Kacha Court Road Raees Abbas	12	24-13311-5206404	0.408
132	Tasveer Mahal Cinema Road	39	24-13311-5207100	4.095

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Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
133	Basti Diwan Wali	29	24-13341-5100804	1.347
134	Main Gali Basti Diwan	32	24-13341-5107403	1.264
135	Mohallah Zafarabad	18	24-13341-5100802	0.832
136	Chiniot Road Basti Diwan	52	24-13341-5107405	1.862
137	Rasool Pura Chiniot Road	42	24-13341-5107406	1.713
138	Marzi Pura Sharqi	121	24-13341-5107000	3.026
139	District Kacheri	30	24-13311-5207101	1.916
140	Highway office	15	24-13311-5207200	0.707
141	Mohallah Kapayan Wala (Androon)	45	24-13311-5207201	1.849
142	Link Jail Road	22	24-13311-5207202	1.172
143	Near Janaz Gah Sultan Shah	13	24-13315-5302004	1.034
144	New Abadi Ali Arayyen	20	24-13315-5302002	1.052
145	Akbar Pura	57	24-13315-5302402	2.236
146	Yosafabad	15	24-13341-5100803	1.139
147	Christian Graveyard Jalalabad	164	24-13341-5103500	5.230
148	Bashir Colony	25	24-13315-5302400	0.700
149	Street Gujar Soap Bashir Colony	30	24-13315-5302403	0.816
150	Street Hanif Colony Mai Chalian	11	24-13315-5302404	0.985
151	Street K Hussain Bakhar Road	28	24-13315-5302405	2.450
152	Laila Majnoo Gate	22	24-13315-5304100	1.151
153	Muhallah Jalalabad	31	24-13341-5107502	1.141
154	Main Gali Jalalabad	44	24-13341-5107500	1.625
155	Mohallah Sheikh Lahori	111	24-13315-5303803	2.999
156	Masjid Qamar Islam Jalalabad	41	24-13341-5107402	1.320
157	Muhallah Kumharan Wala	65	24-13341-5108702	1.776
158	Mohallah Dhup Sari	71	24-13315-5303804	2.272
159	Street Saeed Soap Factory	53	24-13315-5303805	1.659
160	Kachi Abadi Jalalabad	45	24-13341-5107400	2.091
161	Imam Bargah Jalalabad	15	24-13341-5107300	0.892
162	Sargodha Road	55	24-13341-5103100	1.910
163	Khaki Shah Road	83	24-13315-5304400	2.294
164	Govt. Higher School	47	24-13341-5107002	1.151
165	Basti Kal wali	53	24-1334-5305502	2.613
166	Gali Markaz Nabina Wali	70	24-13315-5304000	1.235
167	Mohallah Piplian Wala	33	24-13315-5304700	1.651
168	Gali Munshi Nawaz Basti KalWali	39	24-13341-5308300	1.456
169	Ahmad Nagar Hussain Abad	74	24-13341-5108703	2.295
170	Taqwa Masjid	41	24-13317-2407100	1.513802
171	Pak Railway Road Chungi # 17	20	24-13317-2407200	0.813711
172	Channu Mori	21	24-13317-2408000	0.629449
173	Basti Shehni Wali # 2	24	24-13317-2409300	0.71806
174	Madni Colony	89	24-13341-5107501	3.540338
175	Basti Noor Pura	88	24-13311-5204602	1.663644
176	Muhallah Sultan Wala (Tandoor Wala)	42	24-13311-5204800	0.544073
177	Faisalabad Road	90	24-13311-5207300	4.630532
178	Street Tarkhan Wali	25	24-13315-5302001	0.651906

Out of the 7,018 surveyed lights in the MC, 1,456 lights were found to be operational. Details are given in the following table:

Table 18: Details of Operational Streetlights

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	8	4		12.0	140	0
LED	12	693		12.0	36,424	0
LED	18	429		12.0	33,822	0

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Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	24	1		12.0	105	0
LED	25	6		12.0	657	0
LED	27	27		12.0	3,193	0
LED	28	1		12.0	123	0
LED	40	12		12.0	2,102	0
LED	50	89		12.0	19,491	0
LED	75	1		12.0	329	0
LED	100	64		12.0	28,032	0
LED	120	17		12.0	8,935	0
LED	257	1		12.0	1,126	0
CFL	18	4		12.0	315	0
CFL	23	1		12.0	101	0
CFL	24	14		12.0	1,472	0
CFL	25	16		12.0	1,752	0
CFL	45	1		12.0	197	0
Tube Light	40	53		12.0	9,286	0
Sodium light	40	1		12.0	175	0
Sodium light	220	1		12.0	964	0
Sodium light	250	2		12.0	2,190	0
ILB	100	18		12.0	7,884	0
ILB	200	15		12.0	13,140	0
Total					171,954	

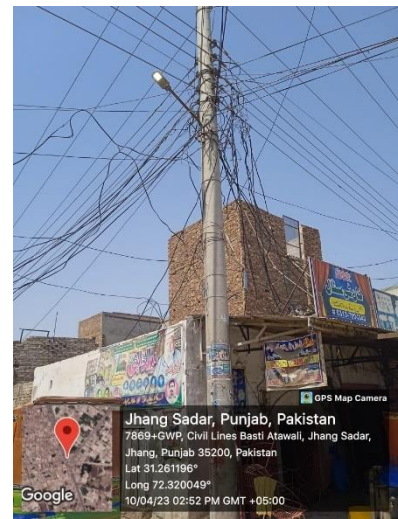
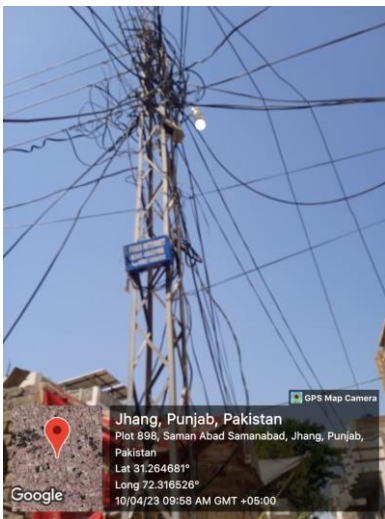


Figure 7: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

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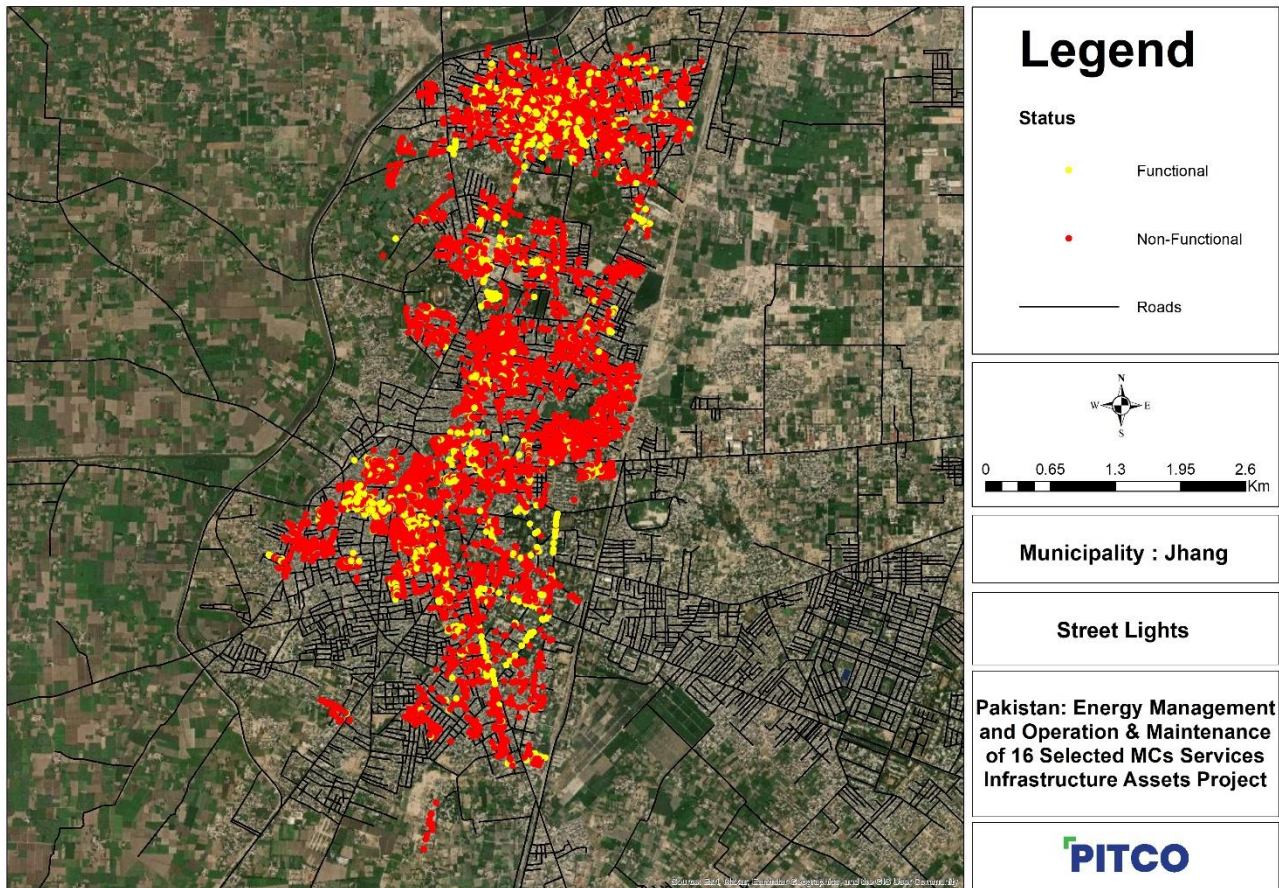


Figure 8: GIS Mapping of street lights in Jhang MC

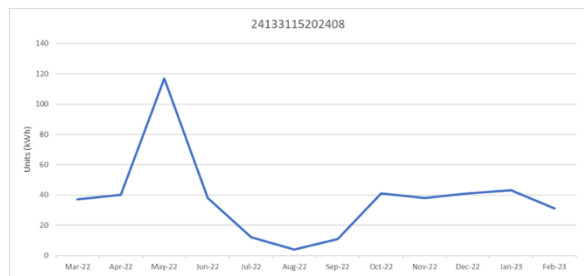
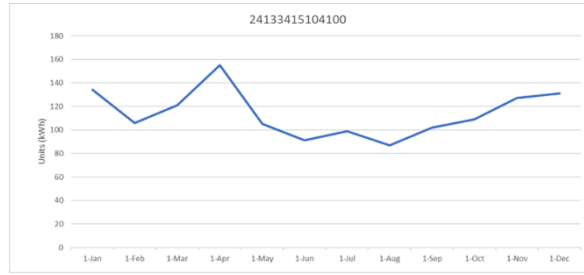
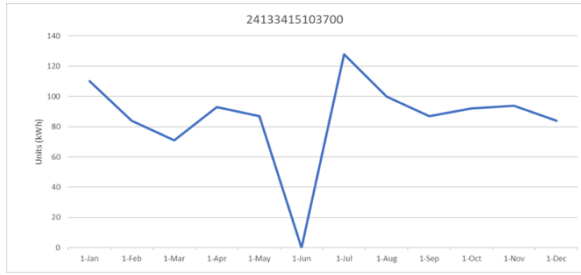
3.3 Baseline Energy Consumption Trend

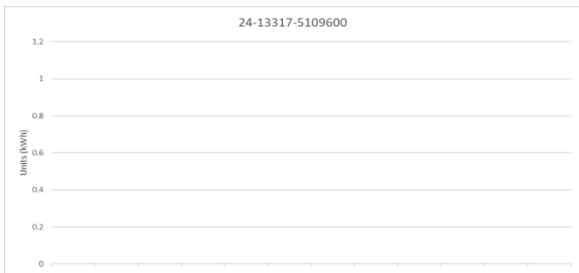
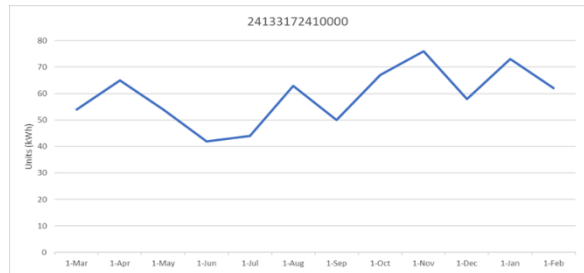
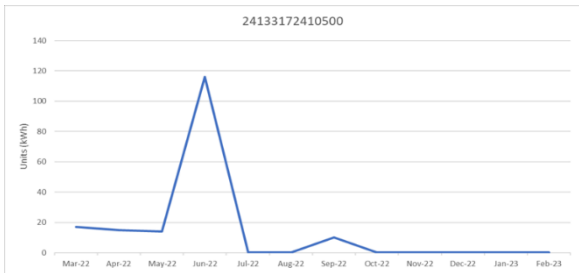
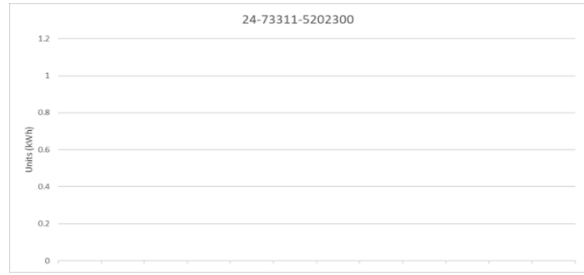
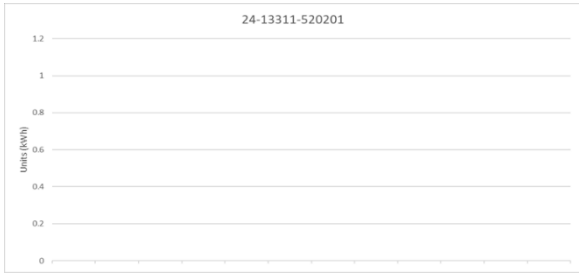
Details of energy consumption by the streetlights in the MC are given below.

Table 19: Baseline Energy Consumption Trend

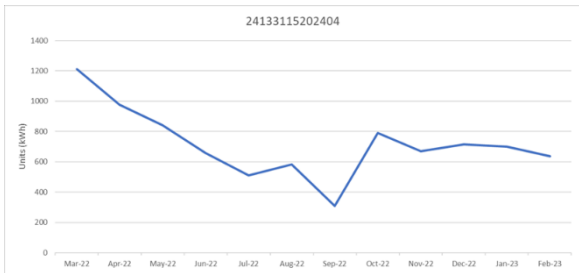
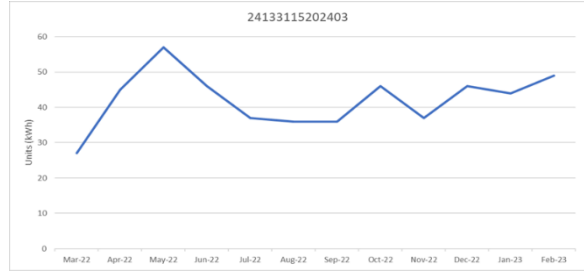
Particulars	Unit	Value
Electrical energy consumed	kWh/y	337,998
Total number of operational lights	No.	1,456

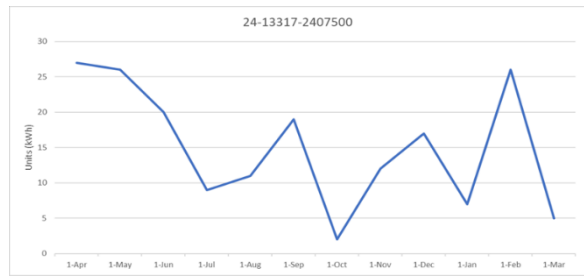
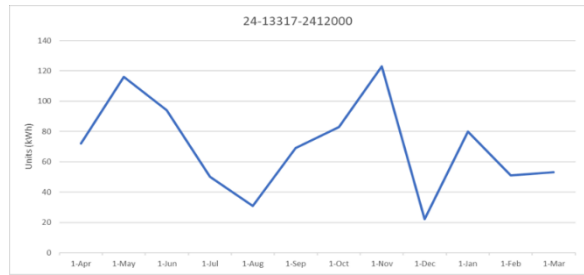
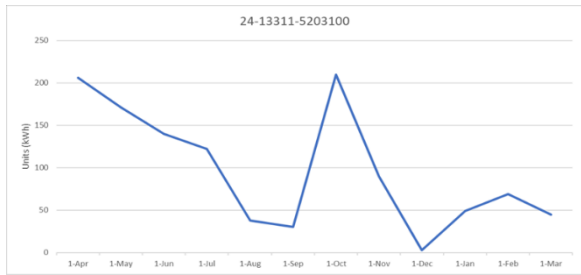
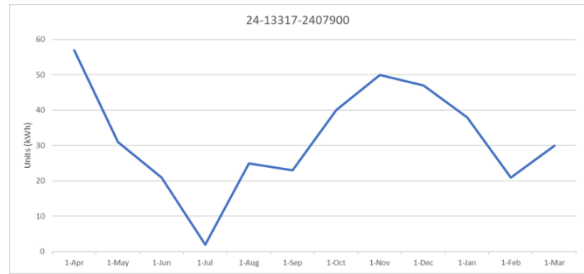
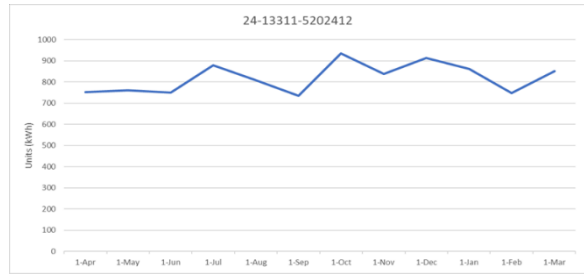
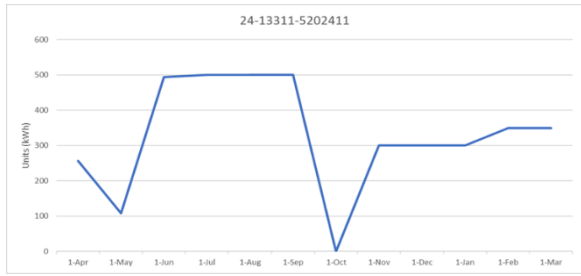
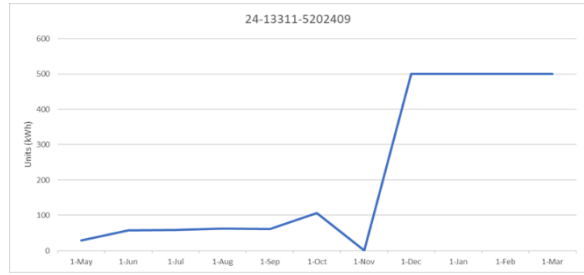
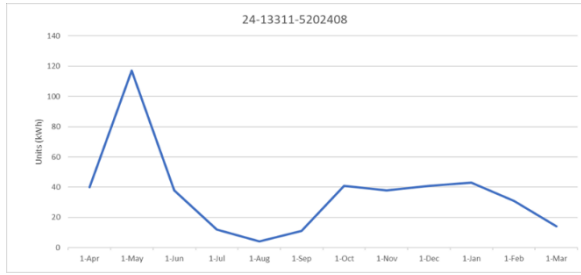




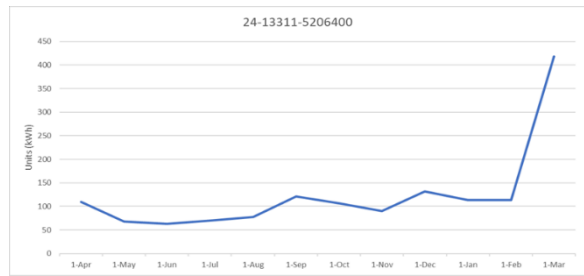
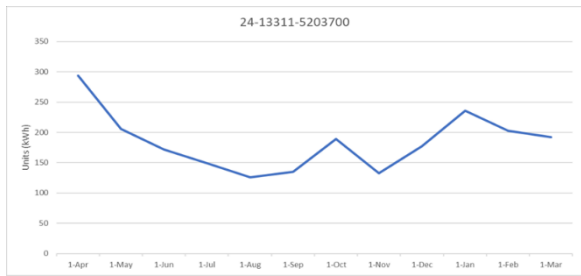
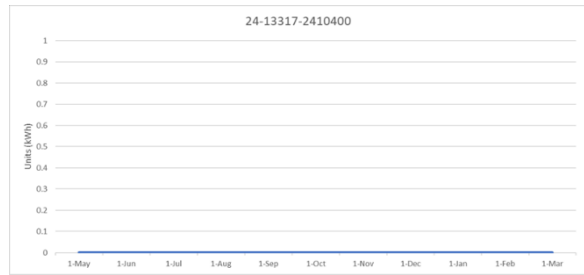
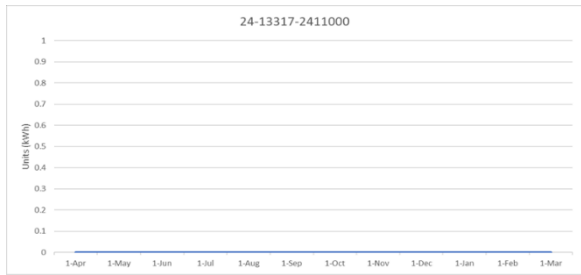
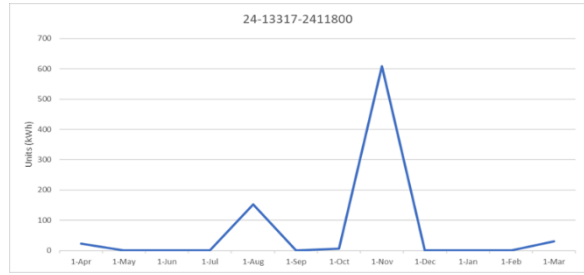


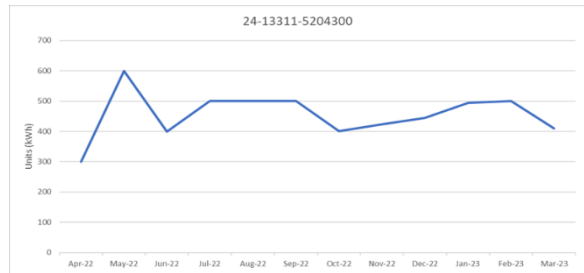
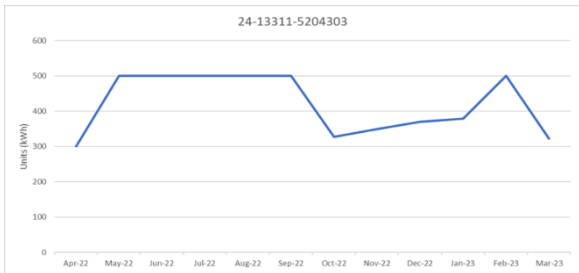
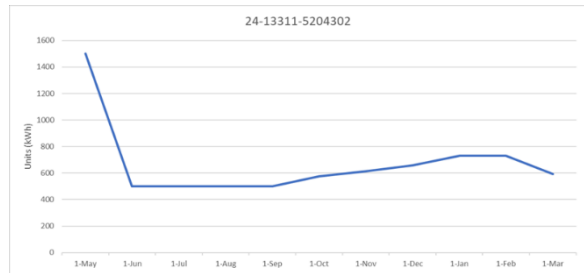
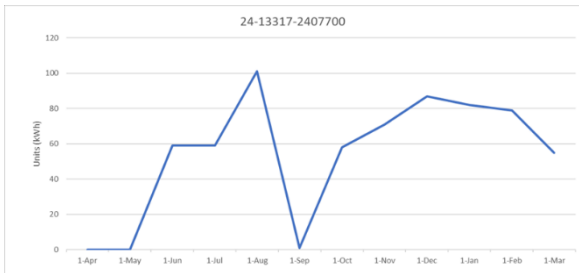
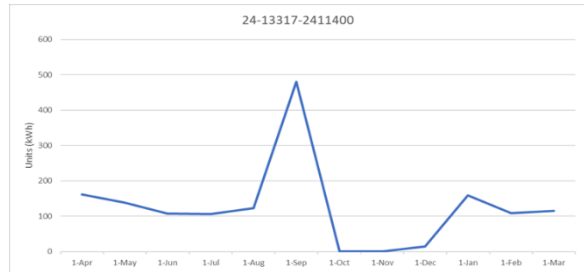
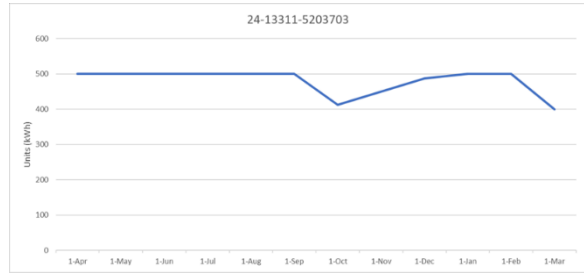
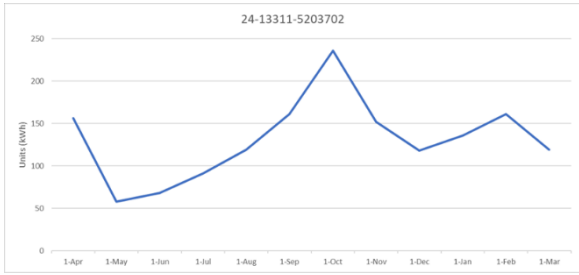
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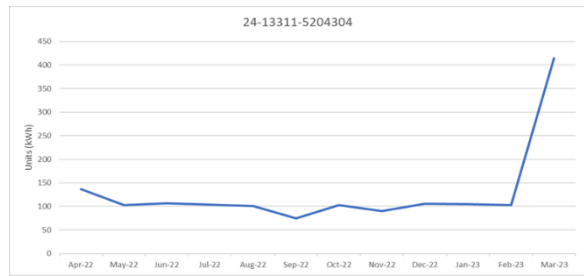
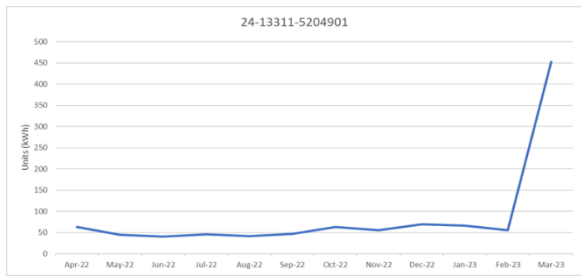
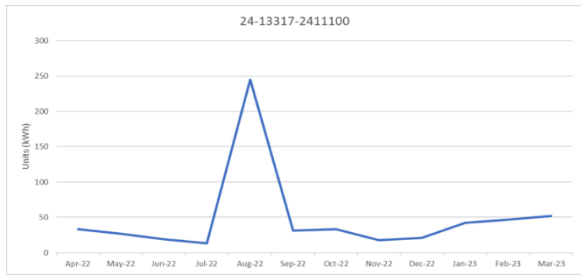
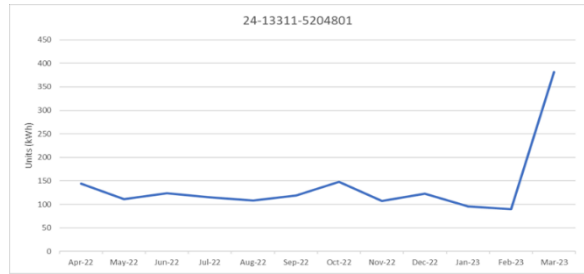
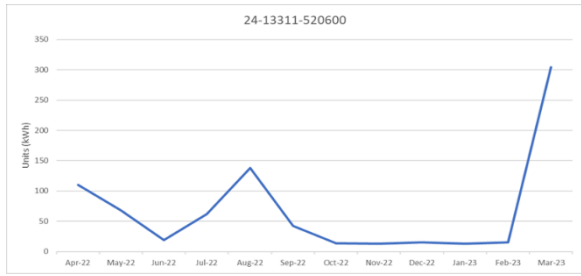
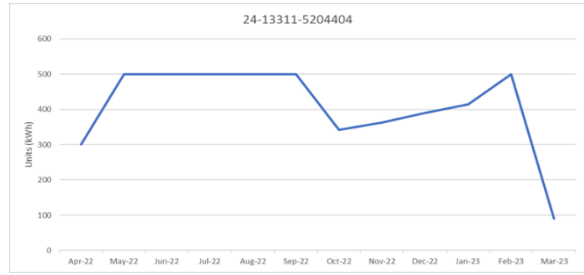
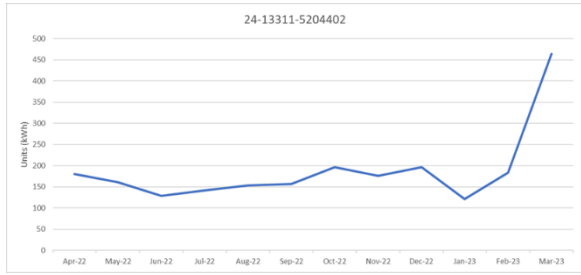




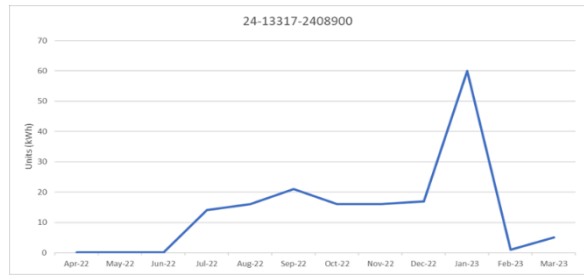
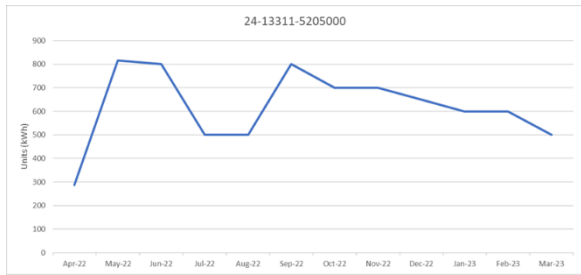
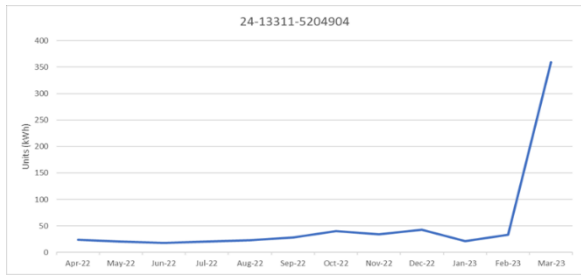
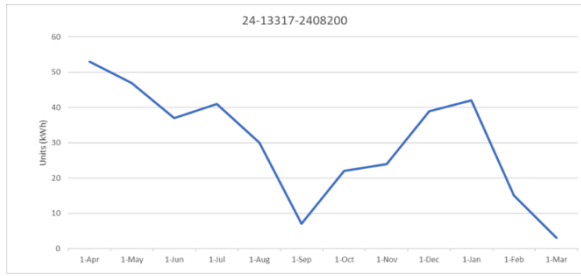
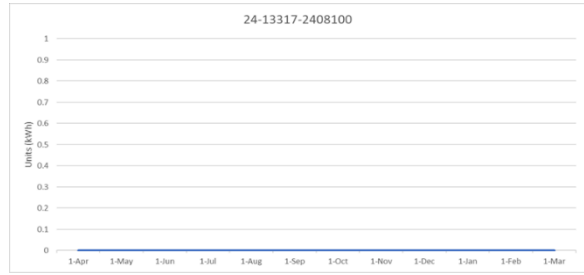
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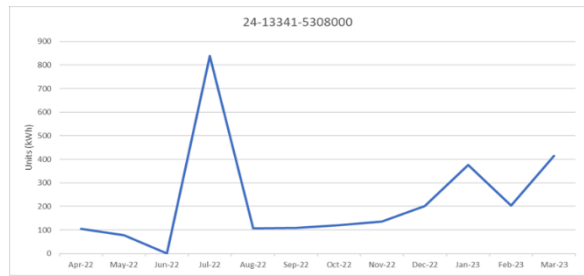
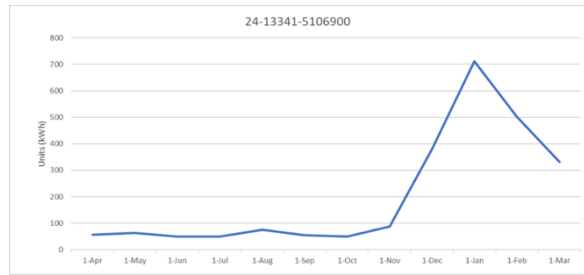
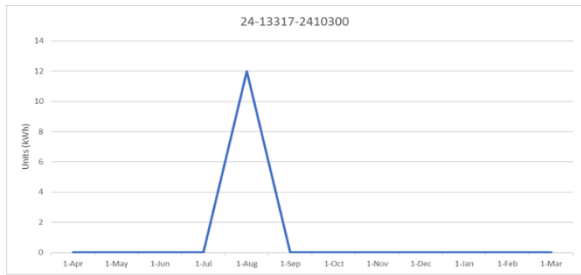
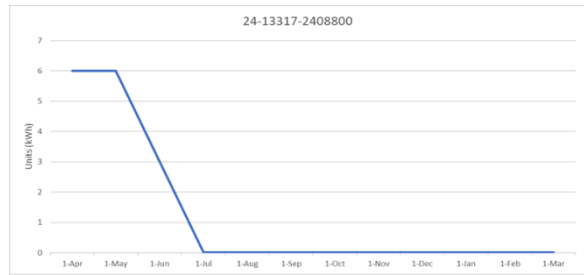
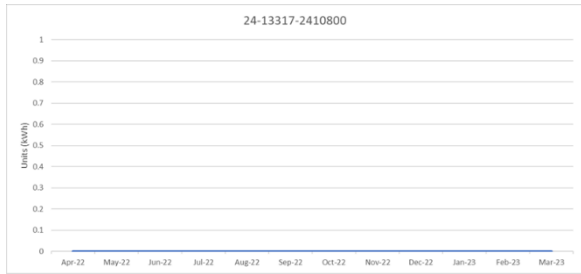
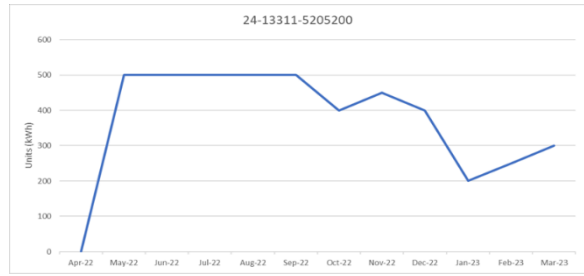
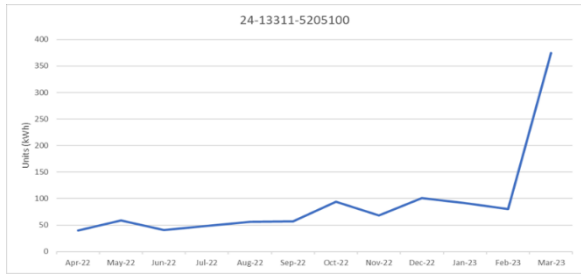
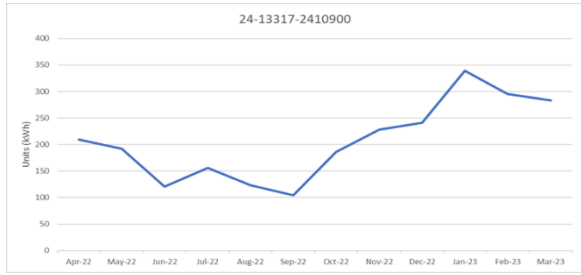




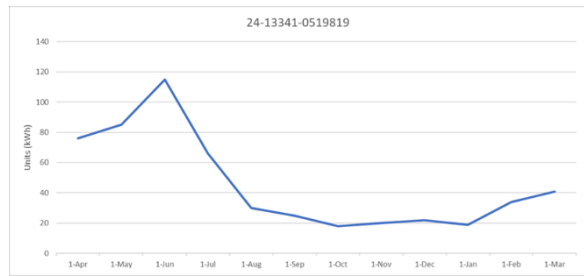
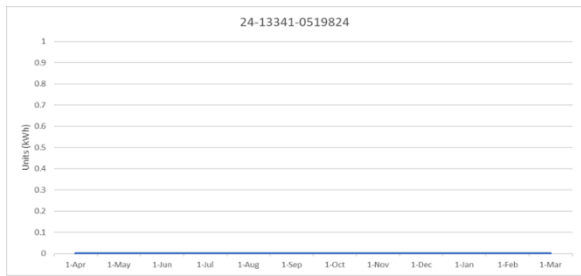
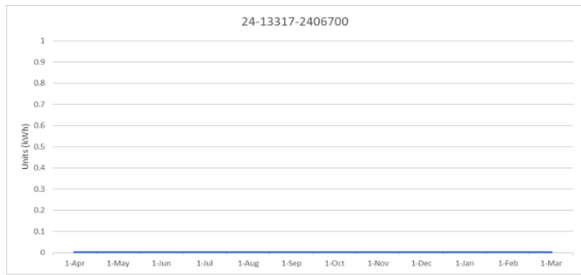
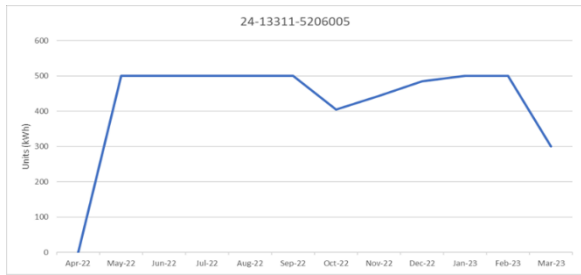
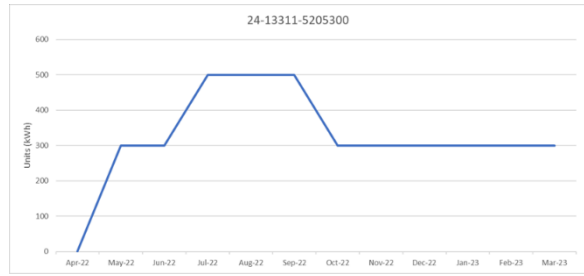
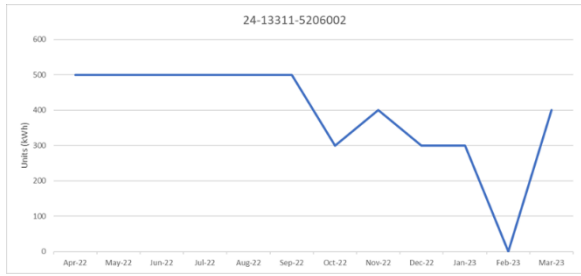
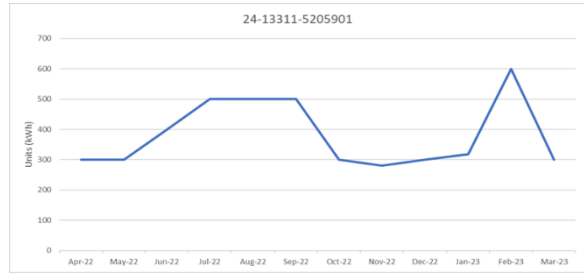
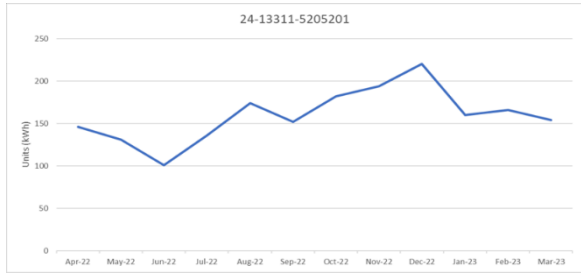
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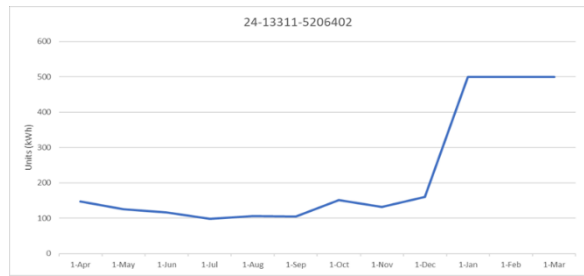
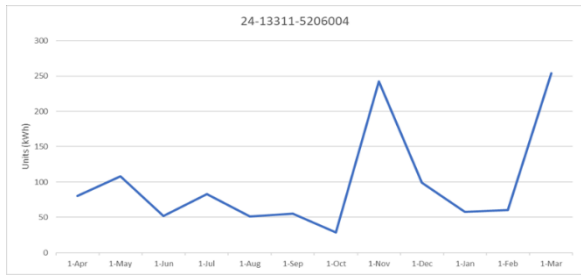
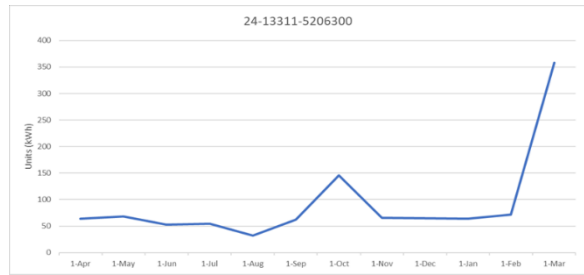
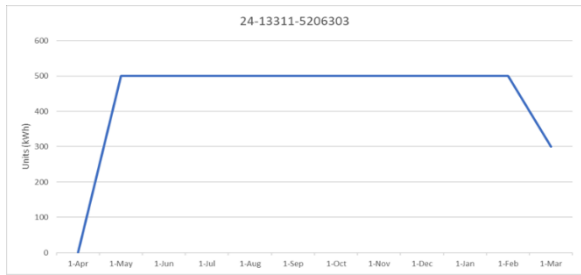
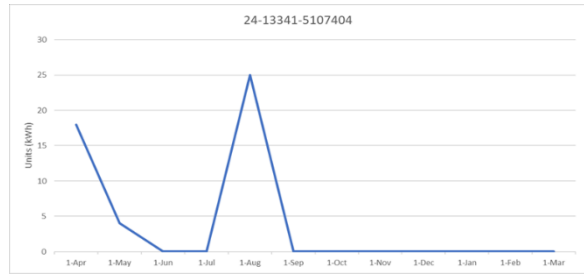
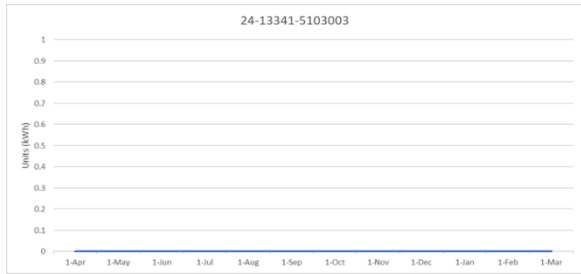
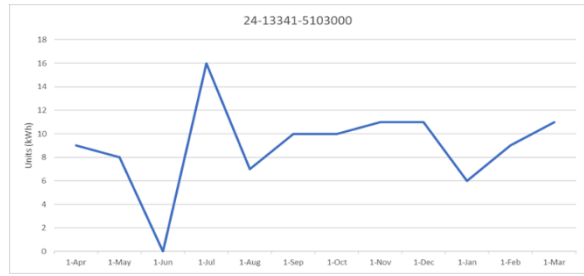
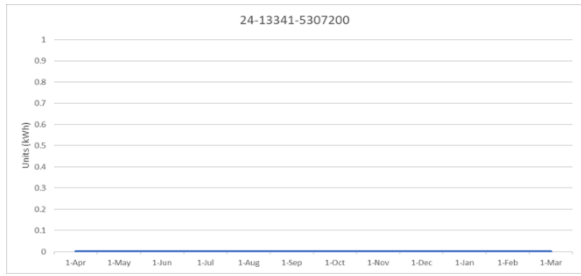
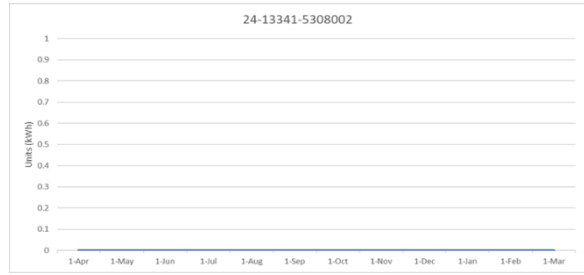
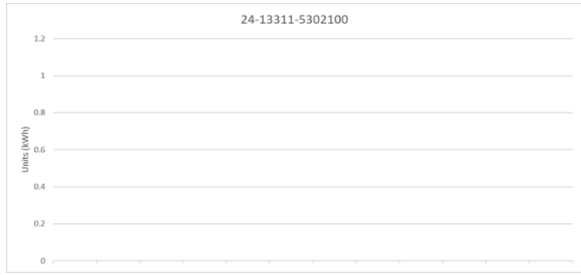


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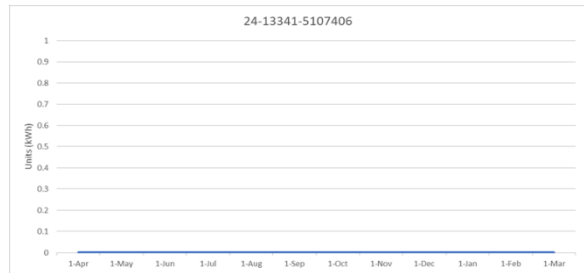
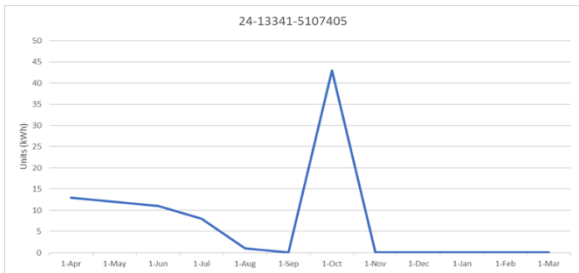
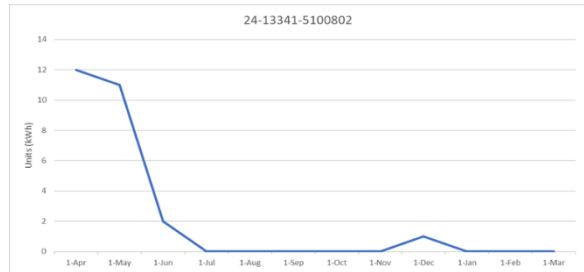
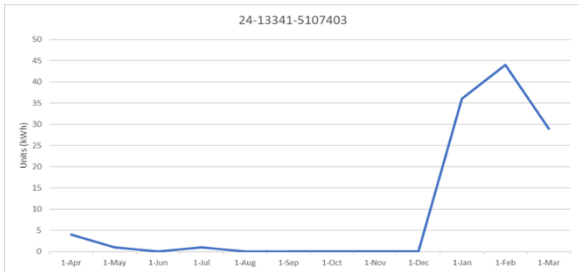
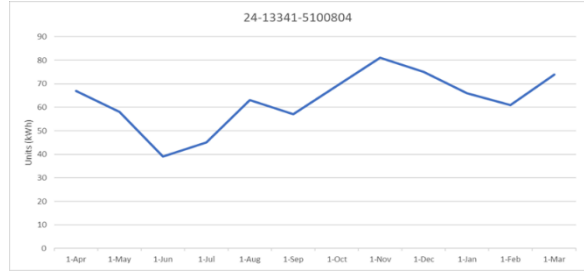
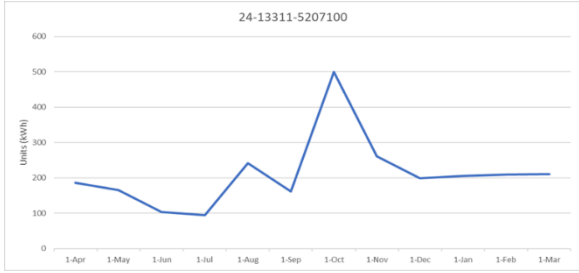
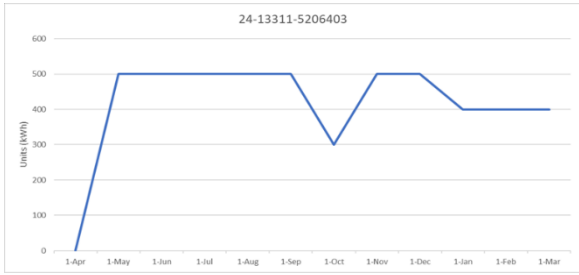


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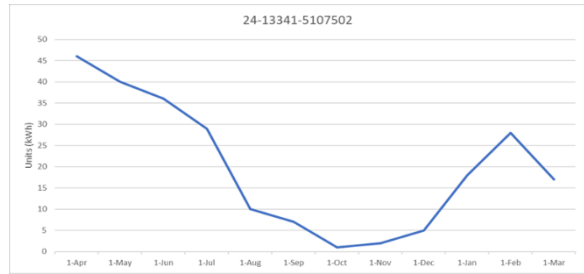
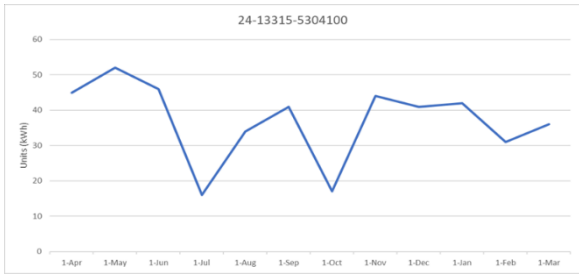
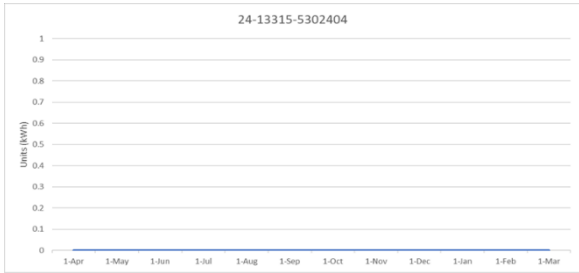
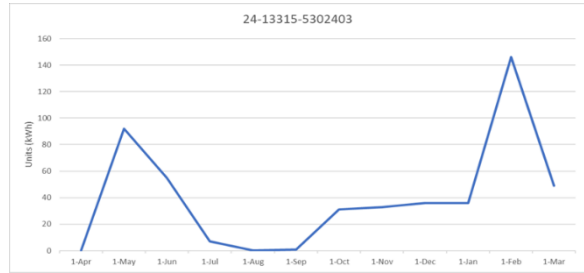
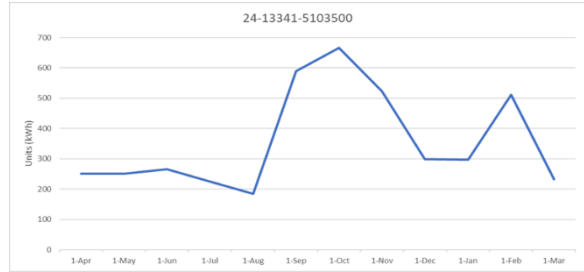
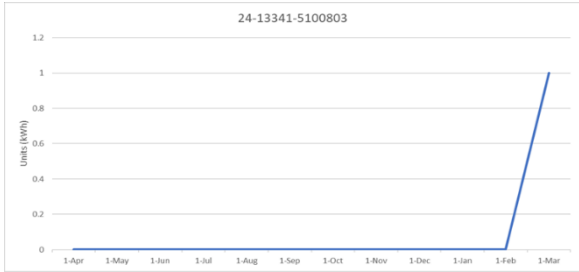
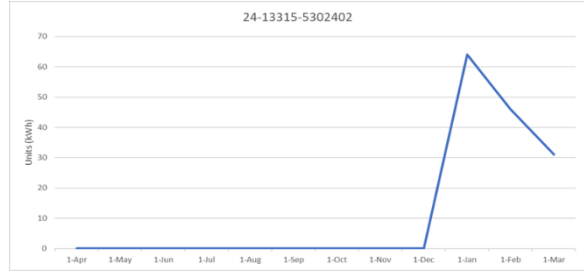
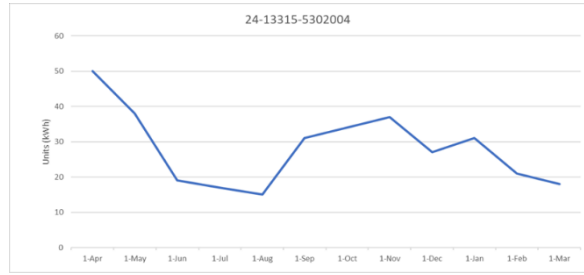




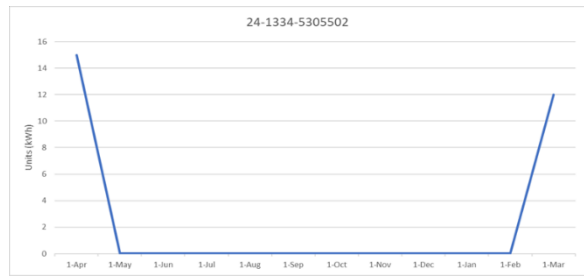
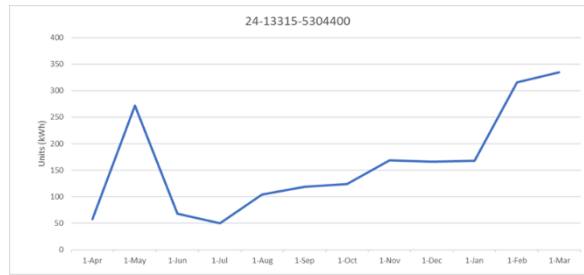
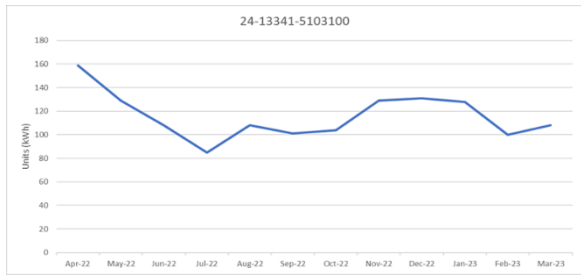
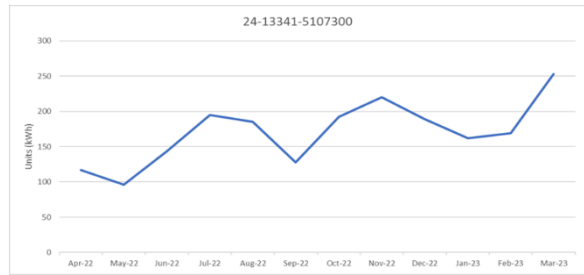
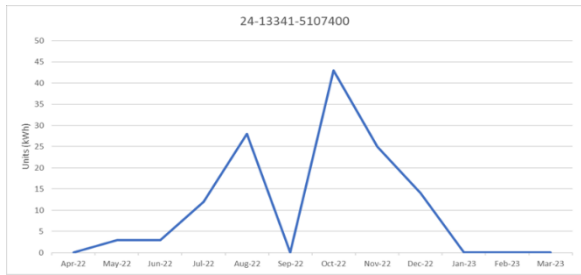
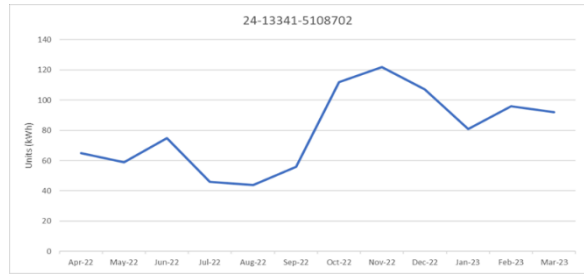
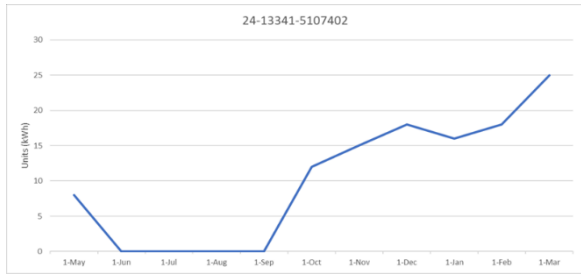
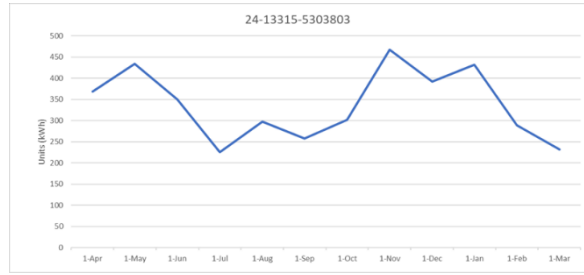
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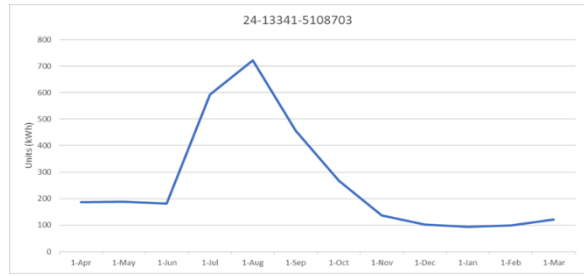
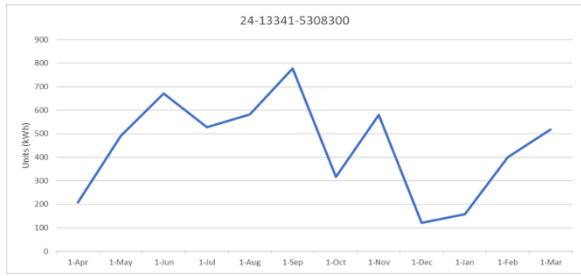
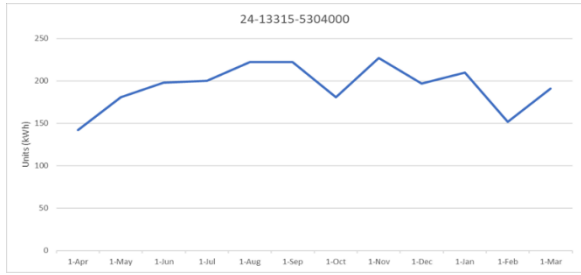


Figure 9: Energy Consumption trend of Streetlights

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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	2,896	1456	548,780	337,998	210,782	4,236 kWh/km	1,125 kWh/km	<p>During the 2019 audit, there were 837 LEDs out of 2,896 operational lights and currently there are 1346 LEDs out of 1,456 operational lights. Based on this information, the Consultant has identified that although the MC has undertaken replacement of 509 inefficient streetlights with LEDs, a significant increase of 43 kWh/light/annum in the overall billing for streetlights has been observed.</p> <p>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.</p>

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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 Jhang.

3.5 Observations

- All Streetlights in Jhang MC are operated by MC.
Most of the operational streetlights are LEDs.
- Approximately 6% of the LED streetlights have a rating of more than 120 Watts.
- Jhang 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 20: Streetlights - recommendations for improvement

Sr. No.	Area	Observations	Recommendations/ Remarks
1	Inventory	<ul style="list-style-type: none"> • All of the streetlights in Jhang are MC operated. • Most of the operational streetlights are LEDs • Most of the streetlights are of low wattage 	<p>All non-operational streetlights should be repaired to make them functional.</p> <p>As per illuminating engineering society (IES) and Committee for European Standardization (CEN) public areas with dark surroundings should have illumination (lux or lumen/m²) between 20-50.</p> <p>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.</p> <p>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.</p>
2	Maintenance & Replacement Log	Jhang MC has no records and database of streetlights despite the fact they are operated and managed by them.	<p>A database shall be developed to record all operation and maintenance related activities of the streetlights.</p> <p>Every streetlight pole should have a unique identification</p>

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Sr. No.	Area	Observations	Recommendations/ Remarks
			<p>number. This number should be printed/painted on the streetlight pole.</p> <p>Photo-electric switches are recommended to be installed at each streetlight pole.</p> <p>It is recommended to conduct group maintenance practice to save money.</p>

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4 Vehicles

4.1 Inventory

The detailed inventory for vehicles in Jhang MC is tabulated below.

Table 21: 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	JGJ-14-10	Tractor Trolley	Millat	MF-375	2011	2WD	Transport of Solid Waste	L79900120512430	K75984/03/11	75 HP
2	JGJ-14-11	Tractor Trolley	Millat	MF-375	2013	2WD	Transport of Solid Waste	LM9B602V507033X	71553/02/13	75 HP
3	JGJ-14-12	Tractor Front loader	Millat	MF-375	2011	2WD	Transport of Solid Waste	L79900120515049U	75969-12-11	75 HP
4	JGJ-14-13	Tractor	Millat	MF-375	2012	2WD	Mechanical Sweeper	LM9B602V502850W	71207-01-12	75 HP
5	Unregistered Vehicle 1	Tractor	Millat	MF-385	2012	4WD	Back hoe	LM9B572V503107B	84539-03/16	85 HP
6	JGJ-14-14	Tractor	Millat	MF-375	2012	2WD	Water Bowser	LM9B602V506407W	71501-12/12	75 HP
7	JGJ-15	Tractor Front loader	Millat	MF-385	2012	4WD	Transport of Solid Waste	LM9B572V503102B	84539/01/16	85 HP
8	JGJ-17-41	Tractor Front loader	Millat	MF-385	2017	4WD	Transport of Solid Waste	LM9B57220503333C	84632/03/17	85 HP
9	JGJ-17-42	Tractor Front loader	Millat	MF-385	2017	4WD	Transport of Solid Waste	LM9B572205033760	84641-01	85 HP
10	JG-754	Tractor Trolley	Millat	MF-375	2003	2WD	Transport of Solid Waste	LM9B60V5004535	09B	75 HP
11	JG-757	Tractor Trolley	Millat	MF-240	2003	2WD	Transport of Solid Waste	CE97065V604215J	1377-54	50 HP
12	JG-1051	Tractor Trolley	Fiat	Fiat-640	2006	4WD	Transport of Solid Waste	AGS 4814	004839/06/H8	85 HP
13	JG-1052	Tractor Trolley	Fiat	Fiat-640	2006	4WD	Transport of Solid Waste	4780881	4842	85 HP
14	JG-1053	Tractor	Fiat	Fiat-640	2006	4WD	No Task Assigned	0047F406H8	187379	85 HP
15	JG-1054	Tractor	Fiat	Fiat-640	2006	4WD	Jetting Machine	004674 06G8	804505	85 HP
16	JGA-4765	Tractor Trolley	Millat	MF-240	1998	2WD	Transport of Solid Waste	3711164A/1	N/A	50 HP
17	JGA-4768	Tractor	Millat	MF-240	1980	2WD	Shifting of Dewatering Sets	8540R	056-53	50 HP
18	JG-5659	Tractor	Millat	MF-240	1980	2WD	No Task Assigned	CE22488U638887-G	MLT/134/15	50 HP
19	JG-5660	Tractor Trolley	Millat	MF-240	1980	2WD	Transport of Solid Waste	CE22488U-036991	MLT/13/24	50 HP
20	JGB-7108	Tractor Front loader	Millat	MF-375	1998	2WD	Transport of Solid Waste	LD97041V508848D	624/17	75 HP
21	JGB-7148	Tractor Trolley	Millat	MF-240	1993	2WD	Transport of Solid Waste	504444-X	MIL/361/44	50 HP
22	Unregistered Vehicle 2	Tractor	Millat	MF-375	2011	2WD	No Task Assigned	LM9B602V501411V	K7100/05/11	75 HP
23	Unregistered Vehicle 3	Tractor Trolley	Millat	MF-240	2011	2WD	Transport of Solid Waste	LM9B602V501730U	K71121/08/11	50 HP
24	Unregistered Vehicle 4	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H403923	LZSHCKZJ4H8002282	150
25	Unregistered Vehicle 5	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H403804	LZSHCKZJ3H8002368	150
26	Unregistered Vehicle 6	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H312830	LZSHCKZJ0H8002425	150
27	Unregistered Vehicle 7	Rickshaw	Road Prince	RP-150	2017	2WD	No Task Assigned	8H403589	LZSHCK25H8002369	150
28	Unregistered Vehicle 8	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H403544	LZSHCKZJ0H8002375	150
29	Unregistered Vehicle 9	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H309986	LZSHCKZJ2H8002359	150
30	Unregistered Vehicle 10	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H403653	LZSHCKZJXH8002383	150
31	Unregistered Vehicle 11	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H403579	LZSHCKZJ2H8002443	150
32	Unregistered Vehicle 12	Rickshaw	Road Prince	RP-150	2017	2WD	No Task Assigned	8H403769	LZSHCKZJ6H8002283	150
33	Unregistered Vehicle 13	Rickshaw	Road Prince	RP-150	2017	2WD	No Task Assigned	8H403502	LZSHCKZJ8H8002382	150

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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)
34	Unregistered Vehicle 14	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H403796	LZSHCKZJ6H8002381	150
35	Unregistered Vehicle 15	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H403914	LZSHCKZJ9H8002374	150
36	Unregistered Vehicle 16	Rickshaw	Road Prince	RP-150	2017	2WD	No Task Assigned	8HC05969	LZSHCKZJ6H8002364	150
37	Unregistered Vehicle 17	Rickshaw	Road Prince	RP-150	2017	2WD	Transport of Solid Waste	8H309946	LZSHCKZJ2H8002362	150
38	Unregistered Vehicle 18	Rickshaw	Road Prince	RP-150	2017	2WD	No Task Assigned	8H312706	LZSHCKZJ6H8002445	150
39	JG-15	Truck/ Jetting	Nissan	PKB-211	2007	4WD	No Task Assigned	97519	622	4400
40	JGJ-14-16	Truck	Nissan	PKB-211	2009	4WD	Suction Sucker Machine	97545	648	4400
41	Unregistered Vehicle 19	Bike	Honda	CD-70	N/A	2WD	No Task Assigned	N/A	N/A	70
42	Unregistered Vehicle 20	Bike	Yamaha	YB-110	N/A	2WD	No Task Assigned	N/A	N/A	110
43	JGF-5729	Bike	Honda	CD-70	1990	2WD	Transport of Staff	N/A	N/A	70
44	JGA-5752	Mini Truck	Mazda	Titan-3500	1990	4WD	No Task Assigned	N/A	N/A	3500
45	Unregistered Vehicle 21	Truck/ Suction	Hino	NR-300	N/A	4WD	No Task Assigned	N/A	N/A	4009
46	JGJ-4242	Car	Suzuki	Cultus	2003	2WD	Transport of Staff	33178D	SF310PK95792	1000
47	JGA-4077	Jeep	Suzuki	Potohar	N/A	4WD	Transport of Staff	F10A	300034	1000
48	JG-40	Truck	Hino	NR-300	2014	4WD	Light Lifter	JM 13547	JHHYFJOH202000273	4009
49	JGJ-12-51	Truck	Isuzu	FTR	2011	4WD	Fire-fighting	N/A	JALFIR33K97000243	4334
50	JGJ-12-52	Truck	Isuzu	FTR	2011	4WD	Fire-fighting	N/A	N/A	4334
51	JGJ-18-11	Bike	Honda	CD-70	2018	2WD	Transport of Staff	8356867	N/A	70
52	JGJ-18-12	Bike	Honda	CD-70	2018	2WD	Transport of Staff	B356902	N/A	70
53	JGJ-18-13	Bike	Honda	CD-70	2018	2WD	Transport of Staff	B356753	N/A	70
54	4658	Bike	Honda	CD-70	2007	2WD	Transport of Staff	N/A	N/A	70
55	Unregistered Vehicle 22	Pickup/ Dengue Brigade	Suzuki	Pickup	Ravi	2WD	No Task Assigned	N/A	N/A	796
56	JGA-4141	Car	Nissan	Sunny	1988	2WD	No Task Assigned	N/A	N/A	1300
57	Unregistered Vehicle 23	Truck	Isuzu	FGR5MV	2022	4WD	Suction Jetting Machine	RJS	JALFVR90MH7000008	4400
58	Unregistered Vehicle 24	Truck	Isuzu	FGR5MV	2022	4WD	Suction Sucker Machine	RJS	JALFVR90MJ7000021	4400
59	Unregistered Vehicle 25	Truck Dumper	Hino	NR-500	2022	4WD	Transport of Solid Waste	J08EVUM106541	FG8JKLB-10336	4465
60	Unregistered Vehicle 26	Truck	Hino	NR-500	2022	4WD	No Task Assigned	J08EVUM10655	FG8JKLB-10337	4465
61	Unregistered Vehicle 27	Truck	Hino	NR-500	2022	4WD	No Task Assigned	J08EVUM10656	FG8JKLB-10333	4465
62	Unregistered Vehicle 28	Truck	Hino	NR-500	2022	4WD	No Task Assigned	J08EVUM10657	FG8JKLB-10339	4465
63	Unregistered Vehicle 29	Truck	Hino	NR-300	2022	4WD	No Task Assigned	4CWGM50202	JHHYCKOF 2046100177	4009
64	Unregistered Vehicle 30	Truck/ Compactor	Hino	NR-300	2022	4WD	Transport of Solid Waste	4CWGM50203	JHHYCKOF 404600178	4009
65	Unregistered Vehicle 31	Truck	Hino	NR-300	2022	4WD	Water Bowser	4CWGM50204	JHHYCKOF 604600179	4009
66	Unregistered Vehicle 32	Truck	Hino	NR-300	2022	4WD	No Task Assigned	4CWGM20205	JHHYCKOF 204600180	4009
67	Unregistered Vehicle 33	Truck	Hino	NR-300	2022	4WD	No Task Assigned	4CWGM50206	JHHYCKOF 20460018D	4009
68	Unregistered Vehicle 34	Truck	Hino	NR-300	2022	4WD	No Task Assigned	4CWM 50207	JHHYCKOF 604600182	4009
69	Unregistered Vehicle 35	Truck	Hino	NR-300	2022	4WD	No Task Assigned	4CWGM50208	JHHYCKOF 804600183	4009
70	Unregistered Vehicle 36	Truck	Hino	NR-300	2022	4WD	No Task Assigned	4CWGM50209	JHHYCKOF X04600184	4009
71	Unregistered Vehicle 37	Truck	Hino	NR-300	2022	4WD	No Task Assigned	4CWGM50210	JHHYCKOF 104600185	4009
72	Unregistered Vehicle 38	Truck	Hino	NR-300	2022	4WD	No Task Assigned	4CWGM50211	JHHYCKOF 304600186	4009
73	Unregistered Vehicle 39	Truck	Hino	NR-300	2022	4WD	No Task Assigned	4CWGM50212	JHHYCKOF 504600187	4009
74	Unregistered Vehicle 40	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT 388523	SR 308PK493195	796
75	Unregistered Vehicle 41	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	SR 308PK493187	PKT 388524	796

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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)
76	Unregistered Vehicle 42	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	493186	PKT 388525	796
77	Unregistered Vehicle 43	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PK493188	PKT 388527	796
78	Unregistered Vehicle 44	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT 388526	SR308PK 493190	796
79	Unregistered Vehicle 45	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT 388528	SR308PK 493194	796
80	Unregistered Vehicle 46	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT 388529	SR308PK 493189	796
81	Unregistered Vehicle 47	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT 388530	SR308PK 493192	796
82	Unregistered Vehicle 48	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PK 388531	SR308PK 493193	796
83	Unregistered Vehicle 49	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PK 388533	SR308PK 493196	796
84	Unregistered Vehicle 50	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT 388534	SR308PK 493191	796
85	Unregistered Vehicle 51	Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT 388535	SR308PK 493185	796
86	Unregistered Vehicle 52	Pickup	Suzuki	Bolan	2022	2WD	Mobile Workshop	1143823	PKT 1027336	796
87	Unregistered Vehicle 53	Excavator	Doosan	DX 140W2PB	2022	4WD	Excavator	65094115103	WBHEDDOPB0051070	133HP

4.2 Baseline Fuel Consumption Trend

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

Table 22: 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	JGJ-17-41	1:40 PM	2:40 PM	0.864	0.86 Liters/hr	12:02 PM	1:40 PM		8.243	5.05 Liters/hr
2	JG-1051	1:45 PM	2:45 PM	3.13	3.13 Liters/hr	12:02 PM	1:45 PM		7.427	4.33 Liters/hr
3	JGB-7148	1:05 PM	2:05 PM	0.787	0.79 Liters/hr	12:05 PM	1:05 PM		5.447	5.45 Liters/hr
4	Unregistered Vehicle 3	2:05 PM	3:05 PM	1.574	1.57 Liters/hr	12:02 PM	2:05 PM		4.763	2.32 Liters/hr
5	Unregistered Vehicle 4	1:50 PM	2:50 PM	0.325	0.33 Liters/hr	12:50 PM	1:50 PM		1.24	1.24 Liters/hr
6	JGJ-14-16	1:15 PM	2:15 PM	1.706	1.71 Liters/hr	11:50 AM	1:15 PM	10	9.974	1 Liters/km
7	JG-40	1:55 PM	2:55 PM	1.72	1.72 Liters/hr	12:55 PM	1:55 PM	17.5	1.359	0.08 Liters/km
8	JGJ-12-51	12:05 PM	1:05 PM	2.34	2.34 Liters/hr	11:05 AM	12:05 PM	11	4.41	0.4 Liters/km
9	Unregistered Vehicle 23	1:15 PM	2:15 PM	2.613	2.61 Liters/hr	11:45 AM	1:15 PM	20.7	14.289	0.69 Liters/km
10	Unregistered Vehicle 24	1:05 PM	2:05 PM	2.952	2.95 Liters/hr	11:50 AM	1:05 PM	51	9.763	0.19 Liters/km
11	Unregistered Vehicle 25	12:35 PM	1:35 PM	2.781	2.78 Liters/hr	11:25 AM	12:35 PM	23	11.385	0.5 Liters/km
12	Unregistered Vehicle 30	12:15 PM	1:15 PM	0.835	0.83 Liters/hr	11:12 AM	12:15 PM	19	7.314	0.38 Liters/km
13	Unregistered Vehicle 31	12:20 PM	1:20 PM	0.96	0.96 Liters/hr	10:58 AM	12:20 PM	32	19.016	0.59 Liters/km
14	Unregistered Vehicle 43	12:56 PM	1:56 PM	0.399	0.4 Liters/hr	11:53 AM	12:56 PM	17	1.406	0.08 Liters/km
15	Unregistered Vehicle 52	5:40 PM	6:40 PM	0.314	0.31 Liters/hr	3:30 PM	5:40 PM	32	1.638	0.05 Liters/km
16	Unregistered Vehicle 53	12:25 PM	1:25 PM	2.482	2.48 Liters/hr	11:25 AM	12:25 PM		9.165	9.17 Liters/hr

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Table 23: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	JGJ-14-10	3.6
2	JGJ-14-11	4.5
3	JGJ-14-12	4.2
4	JGJ-14-13	4.2
5	Unregistered Vehicle 1	4.3
6	JGJ-15	5.0
7	JGJ-17-41	5.4
8	JGJ-17-42	5.6
9	JG-757	2.0
10	JG-1051	3.1
11	JG-1053	3.6
12	JGA-4765	2.5
13	JGA-4768	2.4
14	JG-5659	2.4
15	JG-5660	2.4
16	JGB-7148	2.4
17	Unregistered Vehicle 3	3.1

The logbooks of remaining vehicles are not available in MC.

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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 1.61 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 4.59 liters/hour and 0.396 liter/km (in cases where the odometer was operational).

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 24: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	70,248
Annual Cost of Fuel (Diesel)	PKR/y	20,582,664
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 Jhang 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 Jhang 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.

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5 Municipal Buildings

There are 19 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.

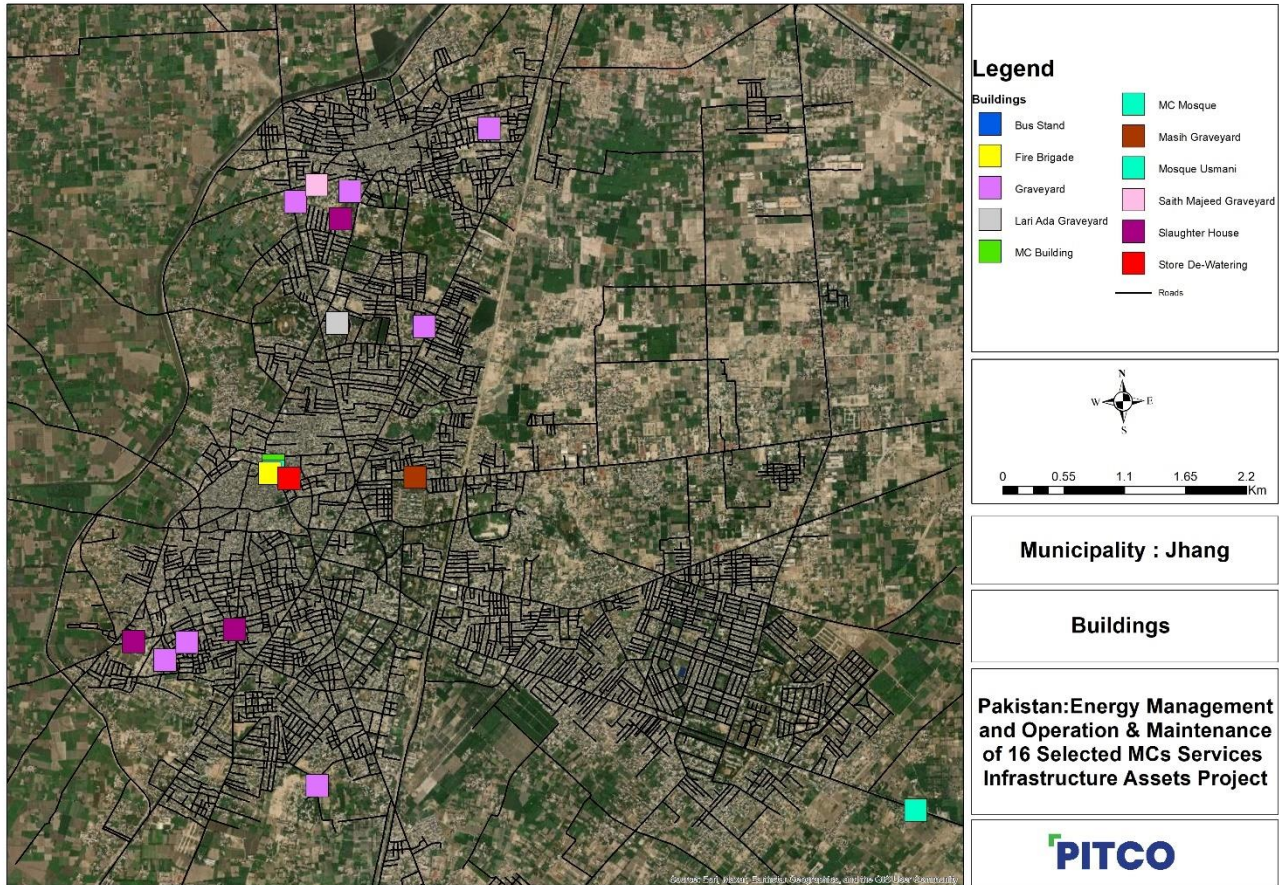


Figure 11: Map for Buildings

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5.2 Building Details

Details of the MC buildings are given below.

Table 25: Buildings' Details

Sr. No.	Address	GPS	Unique ID	Ownership	Condition of Building	Total Area (m2)	Insulation of Building	Number of Floors
1	Main MC Building	N:31.279365 E:72.313600	51705081	MC	Unsatisfactory	4,123	No Proper Insulation	1
2	MC Mosque	N:31.278888 E:72.313556	51705081-1	MC	Satisfactory	430	No Proper Insulation	1
3	General Bus Stand	N:31.290265 E:72.328261	51705081-2	MC	Satisfactory	1,830	No Proper Insulation	1
4	Tiba Ragistan Slaughter House	N:31.299194 E:72.320666	52505146	MC	Unsatisfactory	381	No Proper Insulation	1
5	Mohallah Bag Wala Slaughter House	N:31.266135 E:72.309468	52305129	MC	Satisfactory	889	No Proper Insulation	1
6	Harmal Pur Slaughter House	N:31.265407 E:72.299866	52505145	MC	Satisfactory	431	No Proper Insulation	1
7	Fire Brigade	N:31.278732 E:72.313222	51705082	MC	Satisfactory	202	No Proper Insulation	2
8	Store De-Watering Sets	N:31.278259 E:72.315029	51705081-3	MC	Satisfactory	506	No Proper Insulation	1
9	Ward No.8 Jhang City Graveyard	N:31.306170 E:72.334957	51705081-4	MC	Satisfactory	1,008	No Proper Insulation	1
10	Luhlay Shah Graveyard	N:31.263820 E:72.302797	51705081-5	MC	Satisfactory	1,012	No Proper Insulation	1
11	Masih Graveyard	N:31.278057 E:72.326980	51705081-6	MC	Satisfactory	253	No Proper Insulation	1
12	Sultan Shah Graveyard	N:31.253269 E:72.316827	51705081-7	MC	Satisfactory	1,265	No Proper Insulation	1
13	Sultan Noon Graveyard	N:31.265213 E:72.304922	51705081-8	MC	Satisfactory	506	No Proper Insulation	1
14	Gojra Road Mosque Usmani	N:31.249819 E:72.373401	51705081-9	MC	Satisfactory	506	No Proper Insulation	2
15	Sargodha Road Chungi No 22 Graveyard	N: 31.300723 E:72.316457	51705082-1	MC	Satisfactory	506	No Proper Insulation	1
16	Haidri Mohala Graveyard	N:31.301400 E:72.321623	51705082-2	MC	Satisfactory	1,012	No Proper Insulation	1
17	Rasheed Chowk Graveyard	N:31.290265 E:72.328261	51705082-3	MC	Satisfactory	2,023	No Proper Insulation	1
18	Addi Wala Lari Ada Graveyard	N:31.290745 E:72.320032	51705082-4	MC	Satisfactory	506	No Proper Insulation	1

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Sr. No.	Address	GPS	Unique ID	Ownership	Condition of Building	Total Area (m2)	Insulation of Building	Number of Floors
19	Saith Majeed/Chungi No 22 Graveyard	N:31.302031 E:72.318499	51705082-5	MC	Satisfactory	759	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 26: Number of Heating Units in MC Buildings

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)
Gojra Road Mosque Usmani								
1	Wazu Area	Geysers	1	2000	3	4	104	624
2	Wazu Area	Electric Heater	1	1000	2	4	104	208
3	Wazu Area	Electric Heater	1	1000	2	4	104	208
MC-Mosque								
1	Wazu Area	Electric Heater	1	2000	6	4	104	1,248
MC-Office								
1	Masjid Outside	Electric Geyser	1	2000	5	2	52	520
	Total							2,288

⁵ The “daily operating hours” and “no. of months used per year” are based on interview with the MC staff (IWC)

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Table 27: Number of Cooling Units in Office Buildings of the MC

Sr. No	Name of Room	Type of Cooling Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating months per year	Operating days per year	Annual Energy consumption (kWh/year)
Saith Majeed/ Chungi No. 22 Graveyard								
1	Inside Hall	Ceiling Fan	12	80	1	8	208	200
2	Room	Pedestal Fan	1	125	2	8	208	52
3	Mosque Inside	Ceiling Fan	3	80	1	8	208	50
4	Mosque Outside	Ceiling Fan	2	80	1	8	208	33
Addi Wala lari Ada Graveyard								
1	Inside Hall	Ceiling Fan	7	80	1	8	208	116
2	Room	Ceiling Fan	1	80	6	8	208	100
1	Inside Hall	Ceiling Fan	13	80	1	8	208	216
Haideri Mohallah graveyard								
1	Inside Hall	Ceiling Fan	18	80	1	8	208	300
Gojra Road Mosque Usmani								
1	Inside Hall	Ceiling Fan	10	80	1	8	208	166
2	Inside Hall	Pedestal Fan	2	125	1	8	208	52
Sultan Noor Graveyard								
1	Inside Hall	Ceiling Fan	2	80	1	8	208	33
1	Inside Hall	Exhaust Fan	5	30	0	0	0	0
Lohly Shah Graveyard								
1	Inside Hall	Ceiling Fan	30	80	1	8	208	499
2	Inside Hall	Exhaust Fan	2	30	1	8	208	12
MC-Mosque								
1	Outside Hall	Ceiling Fan	17	80	2	8	208	566
2	Outside Hall	Split AC	1	1800	0	0	0	0
3	Inside Hall	Ceiling Fan	8	80	3	8	208	399
4	Inside Hall	Air Cooler	2	125	1	8	208	52
5	Inside Hall	Split AC	1	1800	0	0	0	0
6	Inside Hall	Bracket Fan	1	50	1	8	208	10
1	Room	Ceiling Fan	1	80	24	8	208	399
2	Room 2	Ceiling Fan	1	80	24	8	208	399
3	Room 2	Pedestal Fan	1	125	24	8	208	624
4	Room 3	Ceiling Fan	1	80	8	8	208	133
5	Room 3	Pedestal Fan	1	125	4	8	208	104
Waad 8 Jhang City Graveyard								
1	Inside Hall	Ceiling Fan	17	80	1	8	208	283
2	Room	Ceiling Fan	1	80	1	8	208	17
General Bus stand								
1	Inside Hall	Ceiling Fan	2	80	12	8	208	399
2	Police Choki Room	Ceiling Fan	1	80	8	8	208	133
3	Room 2	Ceiling Fan	1	80	8	8	208	133
4	Dispensary	Ceiling Fan	1	80	6	8	208	100

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Sr. No	Name of Room	Type of Cooling Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating months per year	Operating days per year	Annual Energy consumption (kWh/year)
5	Dispensary	Pedestal Fan	1	125	0	0	0	0
MC-Office								
1	Engineering Branch	Ceiling Fan	1	80	8	8	208	133
2	Head Seak Room	Exhaust Fan	1	30	0	0	0	0
3	MOI Room	Ceiling Fan	1	80	0	0	0	0
4	MOI Room	Window AC	1	5000	6	8	208	6,240
5	MOI Room	Exhaust Fan	1	30	6	12	312	56
6	MOI PA office	Ceiling Fan	1	80	8	8	208	133
7	SDO office	Ceiling Fan	1	80	8	8	208	133
8	SDO office	Air Cooler	1	125	5	8	208	130
9	SDO office	Exhaust Fan	1	30	8	12	312	75
10	SDO PA office	Ceiling Fan	1	80	80	8	208	1,331
11	SDO PA office	Exhaust Fan	1	30	10	12	312	94
12	Head Clerk	Ceiling Fan	1	80	8	8	208	133
13	Head Clerk	Air Cooler	1	125	8	8	208	208
14	UC office	Exhaust Fan	1	30	8	8	208	50
15	UC office	Air Cooler	2	125	8	8	208	416
16	UC office	Ceiling Fan	3	80	8	8	208	399
17	Store 1	Ceiling Fan	2	80	1	8	208	33
18	Store 2	Ceiling Fan	2	80	1	8	208	33
19	Gallery 1	Ceiling Fan	4	80	8	8	208	532
20	MOP Branch	Ceiling Fan	1	80	8	8	208	133
21	MOP Branch	Split AC	1	1800	8	8	208	2,995
22	MOP Branch store	Ceiling Fan	1	80	8	8	208	133
23	Sanitation Room	Ceiling Fan	1	80	8	8	208	133
24	Sanitation Room	Air Cooler	1	125	8	8	208	208
25	Sanitation Room	Ceiling Fan	1	80	8	8	208	133
26	MOR office	Ceiling Fan	2	80	8	8	208	266
27	MOR office	Window AC	1	5000	8	8	208	8,320
28	MOR office	Exhaust Fan	2	30	0	0	0	0
29	MOF office	Ceiling Fan	1	80	8	8	208	133
30	MOF office	Split AC	1	1800	8	8	208	2,995
31	Encroachment office	Ceiling Fan	1	80	8	8	208	133
32	Encroachment office	Exhaust Fan	1	30	8	12	312	75
33	Regulation office	Ceiling Fan	1	80	8	8	208	133
34	IT office	Ceiling Fan	1	80	8	8	208	133
35	IT office	Air Cooler	1	125	8	8	208	208
36	Account office	Ceiling Fan	1	80	8	8	208	133
37	Account office	Air Cooler	1	125	8	8	208	208
38	Pension Branch	Ceiling Fan	1	80	8	8	208	133
39	Superintendent office	Ceiling Fan	1	80	8	8	208	133

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Sr. No	Name of Room	Type of Cooling Equipment	Count of Equipment	Capacity in Watts	Daily operating hours	Operating months per year	Operating days per year	Annual Energy consumption (kWh/year)
40	Record Room	Ceiling Fan	1	80	8	8	208	133
41	Main Store	Ceiling Fan	2	80	5	8	208	166
42	Main Store	Pedestal Fan	1	125	5	8	208	130
43	Operator Room	Ceiling Fan	1	80	8	8	208	133
44	Operator Room	Split AC	1	1800	8	8	208	2,995
45	Operator Room	Exhaust Fan	1	30	8	8	208	50
46	Meeting Room	Ceiling Fan	3	80	8	8	208	399
47	Meeting Room	Exhaust Fan	1	30	8	12	312	75
48	Meeting Room	Bracket Fan	1	50	8	8	208	83
49	Administrator office	Ceiling Fan	4	80	8	8	208	532
50	Administrator office	Inverter AC	1	1452	8	8	208	2,416
51	Retains Room	Ceiling Fan	2	80	8	8	208	266
52	Retains Room	Exhaust Fan	1	30	8	8	208	50
53	Retains Room	Bracket Fan	1	50	8	8	208	83
54	Iqbal Hall	Exhaust Fan	2	30	2	8	208	25
55	Co-office	Ceiling Fan	2	80	8	8	208	266
56	Co-office	Split AC	1	2700	8	8	208	4,493
57	Co-office	Split AC	1	1800	8	8	208	2,995
58	Audit office	Ceiling Fan	1	80	8	8	208	133
59	Audit office	Exhaust Fan	2	30	8	8	208	100
60	Audit office	Split AC	1	1650	8	8	208	2,746
61	Gallery 3	Ceiling Fan	2	80	4	8	208	133
62	Complaint Cell	Ceiling Fan	1	80	8	8	208	133
63	Complaint Cell	Air Cooler	1	125	8	8	208	208
64	Complaint Cell	Exhaust Fan	1	30	8	8	208	50
65	Audit Room	Ceiling Fan	2	80	8	8	208	266
66	Audit Room	Split AC	1	1800	8	8	208	2,995
67	Tax Branch	Ceiling Fan	1	80	8	8	208	133
68	Tax Branch	Air Cooler	1	125	8	8	208	208
69	Light Branch	Ceiling Fan	3	80	8	8	208	399
70	Light Branch	Air Cooler	1	125	8	8	208	208
71	Electrician Room	Ceiling Fan	1	80	8	8	208	133
	Total							55,591

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Table 28: 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)
Saith Majeed/ Chungi No. 22 Graveyard							
1	Inside Hall	ILB	1	60	0	312	0
2	Inside Hall	LED	5	12	1	312	19
3	Inside Hall	LED	1	30	0	312	0
4	Inside Hall	LED	1	50	1	312	16
5	Outside Area	CFL	1	24	0	312	0
6	Outside Area	LED	1	50	0	312	0
7	Outside Area	LED	1	12	12	312	45
8	Room	LED	2	12	2	312	15
9	Mosque Inside	LED	4	12	1	312	15
10	Mosque Outside	CFL	1	24	1	312	7
11	Mosque Outside	LED	5	12	1	312	19
Addi Wala lari Ada Graveyard							
1	Inside Hall	LED	6	12	1	312	22
2	Outside Area	LED	2	100	8	312	499
3	Outside Area	LED	25	50	8	312	3,120
4	Room	LED	1	50	6	312	94
5	Room	LED	2	12	6	312	45
6	Room	LED	1	12	0	312	0
7	Room	Zero Bulb	2	12	4	312	30
Rasheed Chowk Graveyard							
1	Inside Hall	SMD	18	7	1	312	39
2	Outside Area	LED	5	12	1	312	19
3	Outside Area	LED	1	12	10	312	37
4	Wazu Area	CFL	1	24	1	312	7
5	Wazu Area	SMD	10	7	1	312	22
Haideri Mohallah graveyard							
1	Inside Hall	LED	27	12	1	312	101
2	Inside hall	LED	4	50	1	312	62
3	Outside Area	CFL	2	24	12	312	180
4	Outside Area	LED	12	12	12	312	539
5	Outside Area	LED	2	50	12	312	374
6	Wazu Area	LED	4	12	12	312	180
7	Wazu Area	LED	1	50	12	312	187
Sargoda Road Chungi No. 22 Graveyard							
1	Inside Hall	LED	1	12	1	312	4
2	Outside Area	LED	2	12	1	312	7
Gojra Road Mosque Usmani							
1	Inside Hall	SMD	27	12	1	312	101

⁶ “Daily operating hours” is based on interview with the MC staff (IWC)

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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)
2	Outside Area	LED	1	12	12	312	45
3	Wazu Area	LED	1	12	12	312	45
4	Hall	SMD	6	12	1	312	22
Sultan Noor Graveyard							
1	Inside Hall	LED	4	12	1	312	15
1	Inside Hall	LED	40	12	0	312	0
2	Inside Hall	LED	14	40	0	312	0
3	Outside	LED	4	18	0	312	0
4	Room	LED	2	12	0	312	0
5	Room	LED	1	40	0	312	0
Meshi Graveyard							
1	Room	LED	1	12	1	312	4
2	Room	LED	26	12	1	312	97
Lohly Shah Graveyard							
1	Inside Hall	CFL	7	24	1	312	52
2	Inside Hall	LED	24	12	1	312	90
3	Inside Hall	LED	5	18	1	312	28
4	Outside	LED	1	30	1	312	9
5	Outside	CFL	3	24	1	312	22
6	Outside	LED	12	12	1	312	45
7	Wazu Area	LED	2	18	1	312	11
8	Wazu Area	LED	4	12	1	312	15
9	Washroom	LED	2	12	1	312	7
MC-Mosque							
1	Outside Area	LED	5	12	2	312	37
2	Inside Hall	CFL	2	24	2	312	30
3	Inside Hall	LED	6	12	2	312	45
4	Wazu Area	CFL	1	24	3	312	22
5	Wazu Area	LED	2	18	3	312	34
6	Wazu Area	LED	5	12	3	312	56
Fire Brigade							
1	Inside Hall	CFL	1	24	12	312	90
2	Inside Hall	LED	3	12	12	312	135
3	Outside Area	CFL	3	24	0	312	0
4	Room	CFL	1	10	12	312	37
5	Room	LED	1	18	12	312	67
6	Room	CFL	1	5	12	312	19
7	Room	LED	2	12	12	312	90
8	Room 2	LED	1	12	12	312	45
9	Room 3	LED	4	12	8	312	120
Waad 8 Jhang City Graveyard							
1	Inside Hall	Tube Light	5	40	1	312	62
2	Inside Hall	CFL	1	24	1	312	7

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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	Inside Hall	LED	1	35	1	312	11
4	Inside Hall	LED	1	45	1	312	14
5	Inside Hall	LED	2	18	1	312	11
6	Inside Hall	LED	4	18	1	312	22
7	Inside Hall	LED	5	12	1	312	19
8	Outside Area	Tube Light	1	40	1	312	12
9	Outside Area	CFL	2	24	1	312	15
10	Outside Area	LED	3	45	12	312	505
11	Outside Area	LED	3	18	1	312	17
12	Outside Area	LED	11	12	1	312	41
13	Washroom	LED	1	5	1	312	2
14	Washroom	LED	1	12	1	312	4
15	Room	LED	1	12	1	312	4
16	Room	LED	1	100	12	312	374
17	Room	LED	1	50	12	312	187
Tiba Ragistan Slaughter House							
1	Room	ILB	1	60	4	312	75
General Bus stand							
1	Inside Hall	LED	2	50	8	312	250
2	Police Chowki Room	LED	2	12	8	312	60
3	Room 2	Tube Light	2	40	0	312	0
4	Dispensary	ILB	1	60	2	312	37
5	Dispensary	Tube Light	2	40	0	312	0
6	Dispensary	LED	3	12	6	312	67
7	Washroom	LED	4	12	6	312	90
8	Washroom	SMD	29	12	0	312	0
9	Outside Area	LED	1	12	24	312	90
MC-Office							
1	Engg Branch Head Clerk room	LED	1	12	8	312	30
2	Engg Branch Head Clerk room	LED	4	18	8	312	180
3	MOI Room / office	Tube Light	1	40	4	312	50
4	MOI Room / office	LED	2	12	8	312	60
5	MOI Room / office	LED	3	18	8	312	135
6	MOI PA office	CFL	1	24	0	312	0
7	MOI PA office	LED	1	50	10	312	156
8	MOI PA office	LED	2	18	10	312	112
9	SDO office	LED	1	40	8	312	100
10	SDO office	LED	3	18	8	312	135
11	SDO office	SMD	2	7	8	312	35
12	SDO PA office	LED	3	18	8	312	135
13	SDO PA office	SMD	2	7	8	312	35
14	SDO PA office	LED	1	12	8	312	30
15	SDO PA office	LED	1	50	8	312	125

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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)
16	Head clerk office	Tube Light	1	40	8	312	100
17	Head clerk office	LED	2	18	8	312	90
18	Head clerk office	LED	1	12	8	312	30
19	UC office	LED	9	12	8	312	270
20	UC office	LED	2	18	8	312	90
21	Store 1	Tube Light	2	40	1	312	25
22	Store 1	LED	2	18	1	312	11
23	Store 2	Tube Light	2	40	1	312	25
24	Store 2	LED	2	18	1	312	11
25	Gallery 1	ILB	1	60	0	312	0
26	Gallery 1	Tube Light	4	40	12	312	599
27	Gallery 1	CFL	2	24	12	312	180
28	Gallery 1	LED	2	12	12	312	90
29	MAP Branch	CFL	2	24	8	312	120
30	MAP Branch	LED	1	18	8	312	45
31	MAP Branch	LED	1	30	8	312	75
32	MOP Branch store	LED	2	18	8	312	90
33	Sanitation Room	CFL	2	24	8	312	120
34	Sanitation Room	LED	2	12	8	312	60
35	Sanitation Store	LED	2	12	8	312	60
36	MOR office	CFL	3	24	8	312	180
37	MOR office	LED	2	18	8	312	90
38	MOF office	CFL	1	85	8	312	212
39	MOF office	LED	1	45	8	312	112
40	MOF office	LED	1	12	8	312	30
41	MOF office	LED	1	50	0	312	0
42	Encroachment office	CFL	1	24	8	312	60
43	Encroachment office	LED	4	18	8	312	180
44	Regulation office	Tube Light	1	40	0	312	0
45	Regulation office	LED	1	18	8	312	45
46	IT office	Tube Light	1	40	8	312	100
47	IT office	LED	3	18	8	312	135
48	Account office	CFL	2	24	8	312	120
49	Account office	LED	2	18	8	312	90
50	Pension Branch	CFL	1	24	8	312	60
51	Pension Branch	LED	1	18	8	312	45
52	Superintendent office	Tube Light	1	40	8	312	100
53	Superintendent office	LED	2	18	8	312	90
54	Record Room	LED	1	18	8	312	45
55	Record Room	LED	1	12	8	312	30
56	Gallery 2	LED	3	18	8	312	135
57	Main Store	Tube Light	2	40	5	312	125
58	Main Store	CFL	2	24	5	312	75

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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)
59	Kitchen	CFL	1	24	8	312	60
60	Operator Room	LED	1	12	8	312	30
61	Meeting Room	LED	4	50	8	312	499
62	Meeting Room	SMD	8	7	8	312	140
63	Administrative office	Tube Light	10	40	8	312	998
64	Administrative office	LED	2	50	8	312	250
65	Administrative office	Tube Light	2	40	0	312	0
66	Administrative office	SMD	8	7	8	312	140
67	Retaining Room	Tube Light	2	40	8	312	200
68	Retaining Room	SMD	4	7	8	312	70
69	Iqbal Hall	SMD	88	24	0	312	0
70	Co-office	Tube Light	2	40	8	312	200
71	Co-office	LED	6	12	8	312	180
72	Co-office	LED	2	18	8	312	90
73	Audit office	Tube Light	2	40	8	312	200
74	Audit office	LED	1	12	8	312	30
75	Audit office	LED	2	45	8	312	225
76	Gallery 3	Tube Light	3	40	12	312	449
77	Gallery 3	LED	1	12	12	312	45
78	Gallery 3	SMD	4	7	12	312	105
79	Complaint Cell	CFL	2	45	8	312	225
80	Audit office 2	LED	1	45	8	312	112
81	Audit office 2	SMD	4	7	0	312	0
82	Audit office 2	LED	1	18	8	312	45
83	Audit office 2	LED	3	18	0	312	0
84	Tax Branch	Tube Light	1	40	8	312	100
85	Tax Branch	LED	2	18	8	312	90
86	Light Branch	LED	2	12	8	312	60
87	Light Branch	LED	4	18	8	312	180
88	Electrician Room	LED	1	12	8	312	30
89	Electrician Room	LED	1	50	12	312	187
90	Electrician room	Mercury Bulb	1	125	12	312	468
	Total						19,988

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5.3 Baseline Energy Consumption Trend

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

Table 29: Energy consumption in Office Buildings

SI No.	Description	Unit	Value ⁷
1	Annual Electricity Consumption	kWh	81,732
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m ³	Not metered

⁷ Based on Utility Bills

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Buildings	6	19	51,434	37,494	13,940	8.22 kWh/m2	5.99 kWh/m2	The energy consumption of Main MC Building, MC Mosque, Tiba Ragistan Slaughter House, Mohallah Bag Wala Slaughter House, Harmal Pur Slaughter House and Fire Brigade building are included for the purpose of this comparison. Furthermore, during the last assessment, the electricity units on bill of the Fire Brigade building are shown as zero so, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations. Remaining buildings were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of those buildings have not been considered in the overall energy consumption and KPI calculations.

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

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Table 30: Cooling Equipment Comparison

Building Name	Type of Cooling Equipment	Initial Audit (2019)		Recent Audit (2023)
		Count	Proposed Replacements	Count
MC Building	Bracket Fan	4	0	2
MC Building	Ceiling Fan	62	0	56
MC Building	Air Cooler	12	0	10
MC Building	Split AC	8	0	7
MC Building	Window AC	2	2	2
MC Building	Exhaust Fan	-	-	16
MC Building	Pedestal Fan	-	-	1
MC Building	Inverter	-	-	1
Mosque MC Jhang	Ceiling Fan	20	0	25
Mosque MC Jhang	Air Cooler	2	0	2
Mosque MC Jhang	Split AC	-	-	2
Mosque MC Jhang	Air Cooler	-	-	1

Table 31: Lighting Equipment Comparison

Building Name	Type of Cooling Equipment	Initial Audit (2019)		Recent Audit (2023)
		Count	Proposed Replacements	Count
MC Building	LED	165	0	107
MC Building	CFL	93	93	20
MC Building	Tube Lights	49	49	37
MC Building	Incandescent Light Bulb	1	1	1
MC Building	SMD	-	-	120
MC Building	Mercury Bulb	-	-	1
Mosque MC Jhang	CFL	20	20	3
Mosque MC Jhang	LED	-	-	18
Mohallah Bagwala Slaughter House	Incandescent Light Bulb	1	1	0
Harmal Pur Slaughter House	Incandescent Light Bulb	3	3	0
Tiba Ragistan Slaughter House	Incandescent Light Bulb	1	1	1

Table 32: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh	Comments
MC Building	42,403	31,339	The energy consumption of Main MC Building, MC Mosque, Tiba Ragistan Slaughter House, Mohallah Bag Wala Slaughter House, Harmal Pur Slaughter House and Fire Brigade building are included for the purpose of this comparison. Furthermore, during the last assessment, the electricity units on bill of the Fire Brigade building are shown as zero so, for the purpose of this comparison, the energy consumption of this building has not been considered in the overall energy consumption and KPI calculations.
Mosque MC Jhang	4,449	2,928	
Mohallah Bagwala Slaughter House	2,306	1,645	
Harmal Pur Slaughter House	1,396	1,027	
Tiba Ragistan Slaughter House	880	555	
Overall	51,434	37,494	Remaining buildings were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of those buildings have not been considered in the overall energy consumption and KPI calculations.

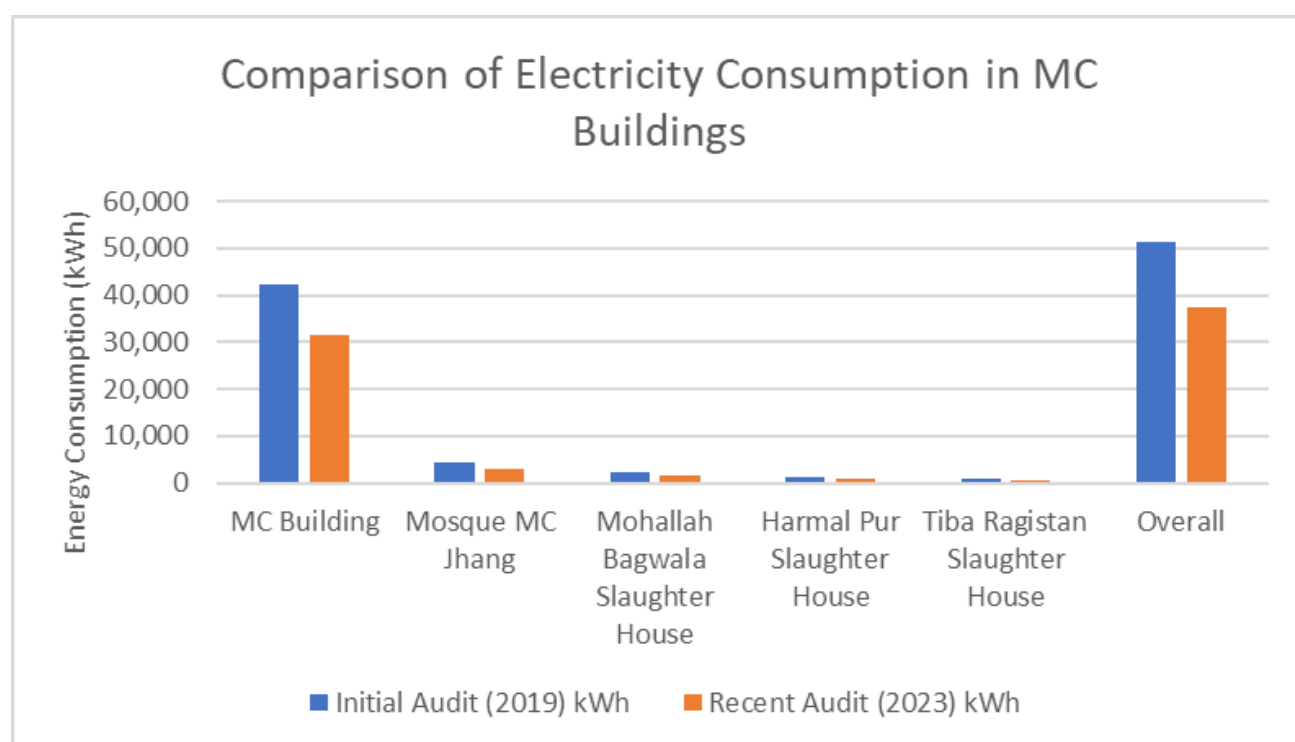


Figure 12: Comparison of Electricity Consumption in MC Buildings

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.

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6 Solar Assessment for MC Jhang

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 Jhang 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 nineteen buildings/sites that are owned and operated by MC.

Main MC Building (two out of seven electrical connections), Store dewatering sets, SultanShah Graveyard, Rasheed Chowk Graveyard have a Three Phase 400V electrical connection whereas, Main MC Building (five out of seven electrical connections), MC Mosque, General Bus Stand, Tiba Ragistan Slaughter House, Mohallah Bag Wala Slaughter House, Harmal Pur Slaughter House, Fire Brigade, Ward No.8 Jhang City Graveyard, LuhlayShah Graveyard, Masih Graveyard, Sultan Noon Graveyard, Gojra Road Mosque Usmani, Sargodha Road Chungi No 22 Graveyard, Haidri Mohala Graveyard, Addi Wala Lari Ada Graveyard and Saith Majeed/Chungi No 22 Graveyard 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 33: Metering details at MC Jhang

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Main MC Building	51705081	15133411491200 (3φ)	6	A-3a (66)
			15133411491300 (3φ)	5	A-3a (66)
			15133411491400 (1φ)	1	A-3a (66)
			15133411491500 (1φ)	1	A-3a (66)
			15133411491600 (1φ)	2	A-3a (66)
			15133411491700 (1φ)	3	A-3a (66)
			15133411491800 (1φ)	2	A-3a (66)
2	MC Mosque	51705081-1	15133411491100 (1φ)	1.5	A-3a (66)
3	General Bus Stand	51705081-2	20133412152700 (1φ)	3	A-3a (66)
4	Tiba Ragistan Slaughter House	52505146	18133171793904 (1φ)	2	A-3a (66)
5	Mohallah Bag Wala Slaughter House	52305129	09133150602300 (1φ)	2	A-3a (66)

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Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
6	Harmal Pur Slaughter House	52505145	02133410155900 (1φ)	2	A-3a (66)
7	Fire Brigade	51705082	14133111750100 (1φ)	1	A-3a (66)
8	Store De-Watering Sets	51705081-3	24133415302000 (3φ)	46	A-3a (66)
9	Ward No.8 Jhang City Graveyard	51705081-4	19133171945200 (1φ)	3	A-3a (66)
10	Luhlay Shah Graveyard	51705081-5	24133155305102 (1φ)	2	A-3a (66)
11	Masih Graveyard	51705081-6	09133410923500 (1φ)	1.8	A-3a (66)
12	Sultan Shah Graveyard	51705081-7	01133410000200 (3φ)	15	A-3a (66)
13	Sultan Noon Graveyard	51705081-8	24133155305103 (1φ)	3	A-3a (66)
14	Gojra Road Mosque Usmani	51705081-9	10133180479000 (1φ)	3	A-1a (01)
15	Sargodha Road Chungi No 22 Graveyard	51705082-1	15133171355200 (1φ)	3	A-3a (66)
16	Haidri Mohala Graveyard	51705082-2	18133171912400 (1φ)	3	A-3a (66)
17	Rasheed Chowk Graveyard	51705082-3	11133170932000 (3φ)	5	A-3a (66)
18	Addi Wala Lari Ada Graveyard	51705082-4	20133412268700 (1φ)	3	A-3a (66)
19	Saith Majeed/Chungi No 22 Graveyard	51705082-5	20133171467100 (1φ)	3	A-3a (66)

6.1 Main MC Building

The project site i.e. Main Office Building is located near Zia-ul-haq stadium, Circular Road, Madina Colony, Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.279365°N (latitude) and 72.313600°E (longitude).

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Figure 13: Front view of Main MC Building



Figure 14: Aerial view of Main MC 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 Building is 31,339 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 34: 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	15133411491200	6,266	522	1,226 ⁸	5
2	15133411491300	9,457	788	2,066 ⁹	7
3	15133411491400	4,122	343	700 ¹⁰	3
4	15133411491500	5,939	495	946 ¹¹	4
5	15133411491600	1,062	89	142 ¹²	1
6	15133411491700	2,337	195	785 ¹³	2
7	15133411491800	2,156	180	422 ¹⁴	2
Total					24

Note: Based on the assessment of the historical billings it is identified that the system requirement for this site is **24 kW** with a five out of seven single-phase connection. It is highly recommended to replace single-phase connection to three-phase connection before the installation of solar system as estimated by the Consultant.

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Building 44,379 ft² whereas, the total area of rooftop available for the solar installation is 23,923 ft². The area assumed for system installation is clear

⁸ Peak of this electric meter is in month June 2022

⁹ Peak of this electric meter is in month January 2023

¹⁰ Peak of this electric meter is in month July 2022

¹¹ Peak of this electric meter is in month August 2022

¹² Peak of this electric meter is in month January 2023

¹³ Peak of this electric meter is in month October 2022

¹⁴ Peak of this electric meter is in month August 2022

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roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heightened building, mumty room, air vents, sky lights and trees.

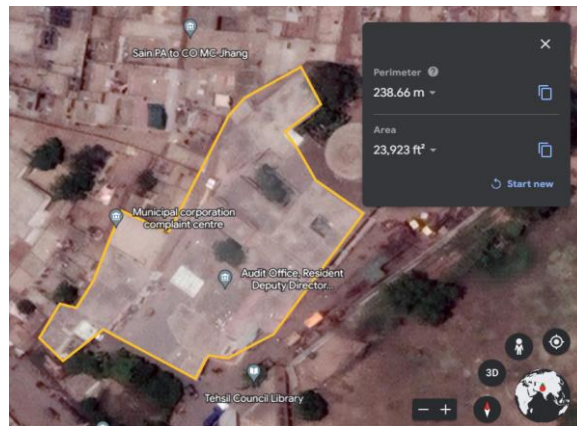


Figure 15: Top View of complete building

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

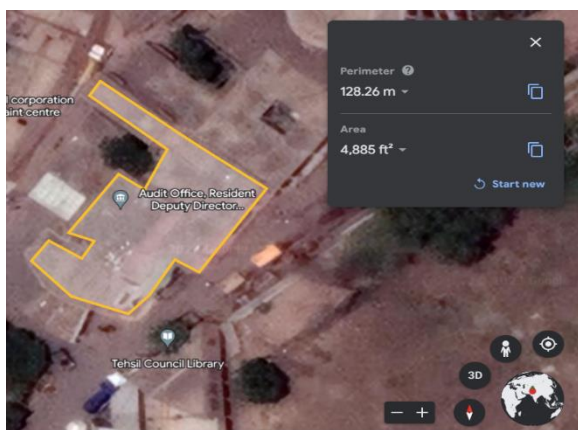


Figure 16: Location for Solar Installation-A

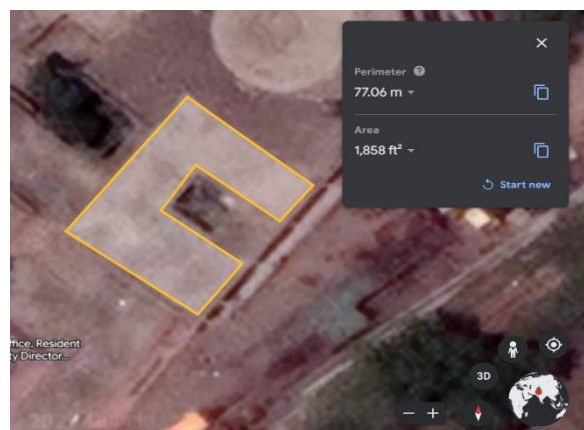


Figure 17: Location for Solar Installation – B

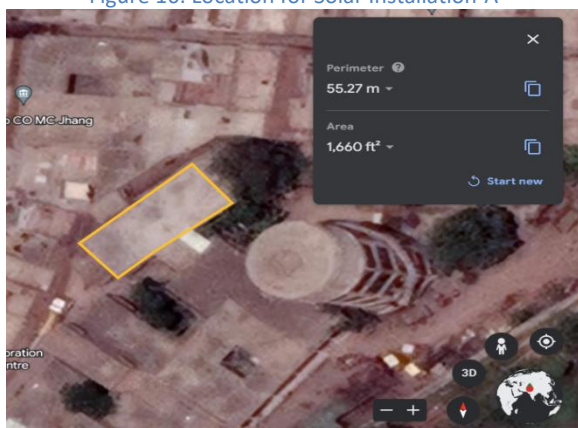


Figure 18: Location for Solar Installation-C

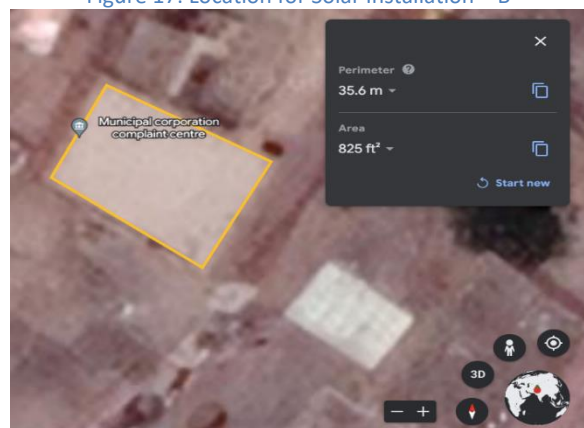


Figure 19: Location for Solar Installation-D

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Figure 20: : Location for Solar Installation-E

Table 35: System Size Calculation with Respect to Area

Parameters	Location A	Location B	Location C	Location D	Location E	Total
Area availability (ft ²)	4,885	1,858	1,660	825	1,213	10,441
Solar system capacity (kW)	49	9	17	8	12	95

6.2 MC Mosque

The project site i.e. MC Mosque Building is located near Zia-ul-haq stadium, Circular Road, Madina Colony, Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.27878°N (latitude) and 72.313404°E (longitude).



Figure 21: Front view of Mc Mosque



Figure 22: Aerial view of MC Mosque

6.2.1 Solar System Requirement

Based on the analysis of energy bills April from 2022 to March 2023, it is identified that the annual energy consumption of MC Mosque is 2,928 kWh with the peak electricity consumption of 593 kWh in October 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 36: Solar System Requirement

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Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	15133411491100	2,928	244	593	2

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

6.3 General Bus Stand

The project site i.e. General Bus stand is located Sargodha road, Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.28923°N (latitude) and , 72.32069°E (longitude).



Figure 23: Front view of General Bus Stand



Figure 24: Aerial View of General 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 Library is 4,042 kWh with the peak electricity consumption of 699 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 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	20133412152700	4,042	336	699	3

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

6.4 Tiba Ragistan Slaughter House

The project site i.e. Slaughter House is located near Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.299194°N (latitude) and 72.320666°E (longitude).

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Figure 25: Front view of Slaughter House

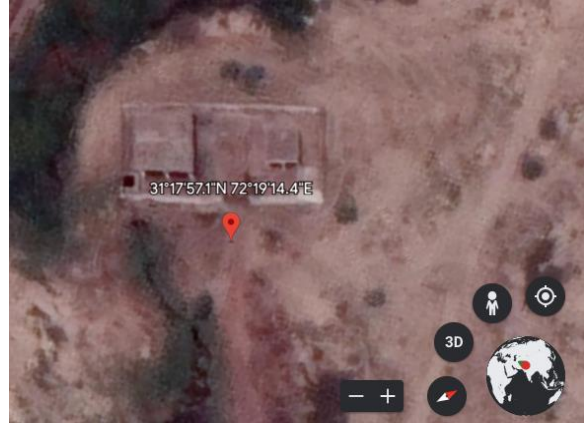


Figure 26: Aerial view of Slaughter House

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 Slaughter House 555 kWh with the peak electricity consumption of 92 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 38: Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	18133171793904	555	46	92	1

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

6.5 Mohallah Bagh Wala Slaughter House

The project site i.e., Slaughter House is located near Mohalla Bagh Wala, Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.299194°N (latitude) and 72.320666° E (longitude).



Figure 27: Front view of Slaughter House



Figure 28: 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 Slaughter House 1,645 kWh with the peak electricity consumption of 217 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 39: Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	09133150602300	1,645	137	217	1

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

6.6 Harmal Pur Slaughter House

The project site i.e., Slaughter House is located near Looalay Shah Rd, Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.265407°N (latitude) and 72.299866°E (longitude).

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Figure 29: Front view of Slaughter House



Figure 30: Aerial view of Slaughter House

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 Slaughter House 1,027 kWh with the peak electricity consumption of 117 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 40: Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	02133410155900	1,027	86	117	1

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

6.7 Fire Brigade

The project site i.e. Fire Brigade is located near Circular Road, Madina Colony, Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.278732°N (latitude) and 72.313222°E (longitude).



Figure 31: Front view of Fire Brigade



Figure 32: Aerial view of Fire Brigade

6.7.1 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 3,987 kWh with the peak electricity consumption of 486 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 41: 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	14133111750100	3,987	332	486	3

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

6.8 Store De-Watering Sets

The project site i.e. Store De-Watering Sets is located near Madina Colony, Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.278259°N (latitude) and 72.315029°E (longitude).



Figure 33: Aerial view of Store De-Watering Sets

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6.8.1 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 Store De-Watering Sets 12,108 kWh with the peak electricity consumption of 1,546 kWh in June 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 42: Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	24133415302000	12,108	1009	1,546	9

6.8.2 Roof Assessment

As per the Consultant’s assessment, the total area of the Store De-Watering Sets is 5,445 ft² whereas, the total area of rooftop available for the solar installation is 1,858 ft². 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 heightened building, mumty room, air vents, sky lights and trees.

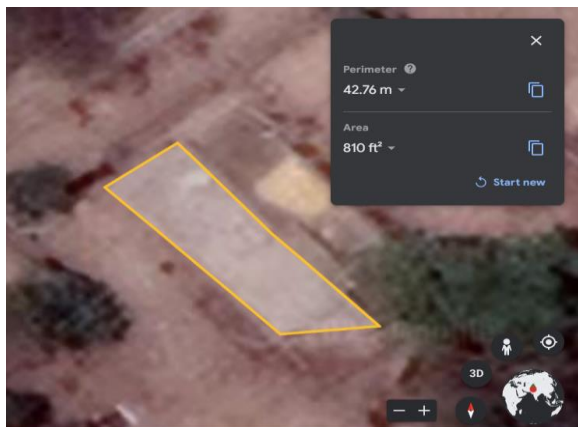


Figure 34: Top View Of Complete Building Section-A

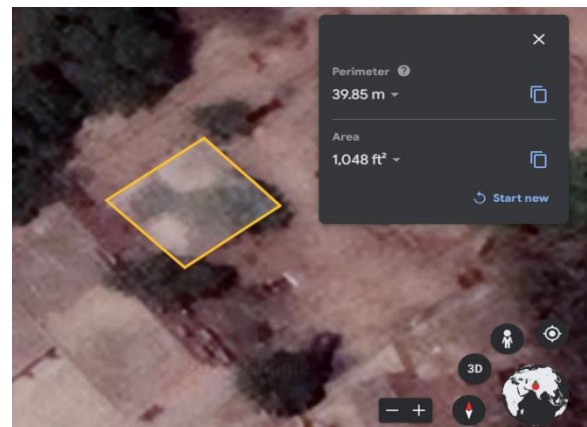


Figure 35: Top View Of Complete Building Section-B

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



Figure 36: Location for Solar Installation

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Table 43: System Size Calculation with Respect to Area

Parameters	Location
Area availability (ft ²)	746
Solar system capacity (kW)	7

6.9 Ward No.8 Jhang City Graveyard

The project site i.e. Ward No.8 Jhang City Graveyard is located near Ward No.8, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.306170°N (latitude) and 72.334957°E (longitude).

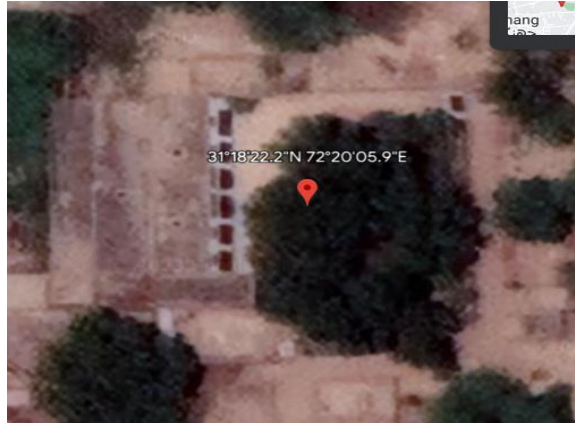


Figure 37: Aerial View Of Graveyard

6.9.1 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 Ward No.8 Jhang City Graveyard 3,756 kWh with the peak electricity consumption of 583 kWh in June 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 44: 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	19133171945200	3,756	313	583	3

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

6.10 Luhlay Shah Graveyard

The project site i.e. Luhlay Shah Graveyard is located near, Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.263820°N (latitude) and 72.302797°E (longitude).

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Figure 38: Aerial view of Graveyard

6.10.1 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 Luhlay Shah Graveyard is 1,099 kWh with the peak electricity consumption of 152 kWh in March 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 45: Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	24133155305102	1,099	91	152	1

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

6.11 Masih Graveyard

The project site i.e Masih Graveyard is located near, Jhang Faisalabad road, Jhang, Punjab , Pakistan while the geographical co-ordinates of location are 31.278057°N (latitude) and 72.326980°E (longitude).

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Figure 39: Front View Of Graveyard



Figure 40: Aerial view of Graveyard

6.11.1 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 Masih Graveyard is 502 kWh with the peak electricity consumption of 81 kWh in November 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 46: 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	09133410923500	502	42	81	1

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

6.12 Sultan Shah Graveyard

The project site i.e. Sultan Shah Graveyard is located near, Jhang sadar, Jhang, Punjab , Pakistan while the geographical co-ordinates of location are 31.253269°N (latitude) and 72.316827°E (longitude).

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Figure 41: Front View Of Graveyard



Figure 42: Aerial view of Graveyard

6.12.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 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.

6.13 Sultan Noon Graveyard

The project site i.e. Sultan Noon Graveyard is located near Plot 316, Basti Sultan Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.265213 °N (latitude) and 72.304922°E (longitude).



Figure 43: Aerial View Of Graveyard

6.13.1 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 Sultan Noon Graveyard is 2,721 kWh with the peak electricity consumption of 337 kWh in April 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 47: 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	24133155305103	2,721	227	337	2

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

6.14 Gojra Road Mosque Usmani

The project site i.e. Gojra Road Mosque Usmani is located near Gojra road, Naya Shehar, Jhang, Punjab, Pakistan, while the geographical co-ordinates of location are 31.249819°N (latitude) and 72.373401°E (longitude).



Figure 44: Front View Of Mosque



Figure 45: Aerial View Of Mosque

6.14.1 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 Gojra Road Mosque Usmani is 2,539 kWh with the peak electricity consumption of 284 kWh in April 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 48: 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	10133180479000	2,539	212	284	2

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

6.15 Sargodha Road Chungi No 22 Graveyard

The project site i.e. Sargodha Road Chungi No 22 Graveyard is located near Sargodha Road Chungi No 22, Jhang, Punjab, Pakistan, while the geographical co-ordinates of location are 31.300723°N (latitude) and 72.316457°E (longitude).

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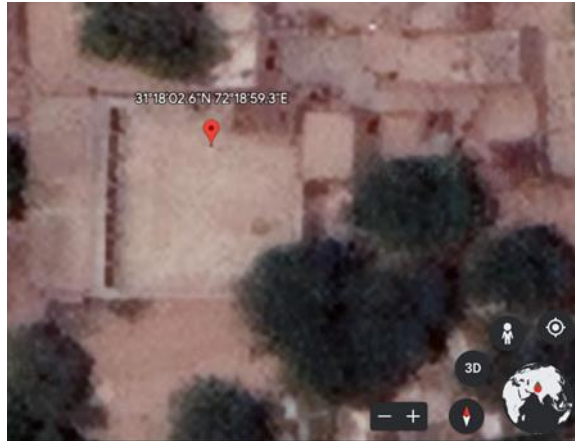


Figure 46: Aerial View of graveyard

6.15.1 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 Chungi No 22 Graveyard is 196 kWh with the peak electricity consumption of 49 kWh in April 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 49: Solar System Requirement

Sr No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	15133171355200	196	16	49	1

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

6.16 Haidri Mohala Graveyard

The project site i.e. Haidri Mohala Graveyard is located near Haidri Mohala ,Jhang, Punjab, Pakistan, while the geographical co-ordinates of location are 31.301400°N (latitude) and 72.321623°E (longitude).

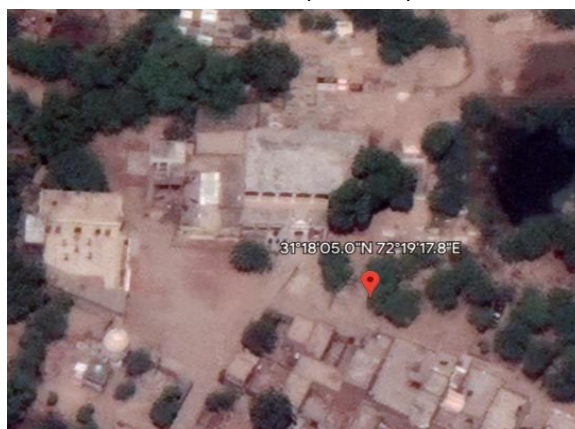


Figure 47: Aerial View Of Graveyard

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6.16.1 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 Haidri Mohala Graveyard is 846 kWh with the peak electricity consumption of 89 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 50: 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	18133171912400	846	70	89	1

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

6.17 Rasheed Chowk Graveyard

The project site i.e. Rasheed Chowk Graveyard is located near Old Chiniot road, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.290265°N (latitude) and 72.328261°E (longitude).



Figure 48: Aerial View of graveyard

6.17.1 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 Rasheed Chowk Graveyard is 1207 kWh with the peak electricity consumption of 159 kWh in June 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 51: 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	11133170932000	1,207	100	159	1

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

6.18 Addi Wala Lari Ada Graveyard

The project site i.e. Addi Wala Lari Ada Graveyard is located near Adhiwal, Jhang Sadar, Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.290745°N (latitude) and 72.320032°E (longitude).

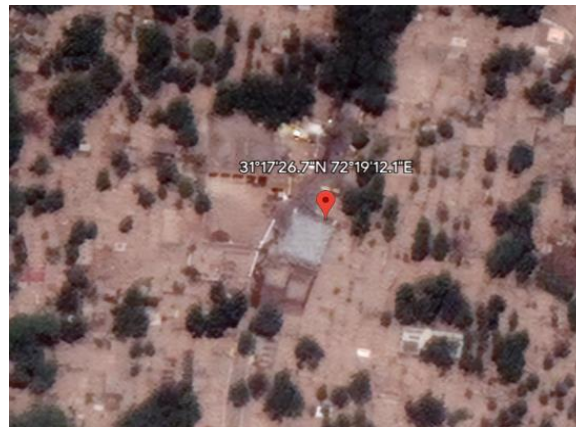


Figure 49: Aerial View of graveyard

6.18.1 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 Addi Wala Lari Ada Graveyard is 9,070 kWh with the peak electricity consumption of 1,029 kWh in May 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 52: 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	20133412268700	9,070	756	1,029	7

Note: Based on the analysis of the historical electricity billing data, it is identified that the solar system requirement for this site is only **7 kW**, however due to non-availability of clear space for the installation of solar system and security concerns for the solar equipment, it is not recommended to install the solar system at this site.

6.19 Saith Majeed/Chungi No 22 Graveyard

The project site i.e. Saith Majeed/Chungi No 22 Graveyard is located in Jhang, Punjab, Pakistan while the geographical co-ordinates of location are 31.302031°N (latitude) and 72.318499°E (longitude).

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Figure 50: Front View of graveyard



Figure 51: Aerial View of graveyard

6.19.1 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 Addi Wala Lari Ada Graveyard is 2,165 kWh with the peak electricity consumption of 381 kWh in June 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 53: 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	20133171467100	2,165	180	381	2

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

6.20 Net Metering Consideration

With the rising costs of electricity in Pakistan and owing 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 $\pm 5\%$ in Voltage and $\pm 1\%$ 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.

6.20.1 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.

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- 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.

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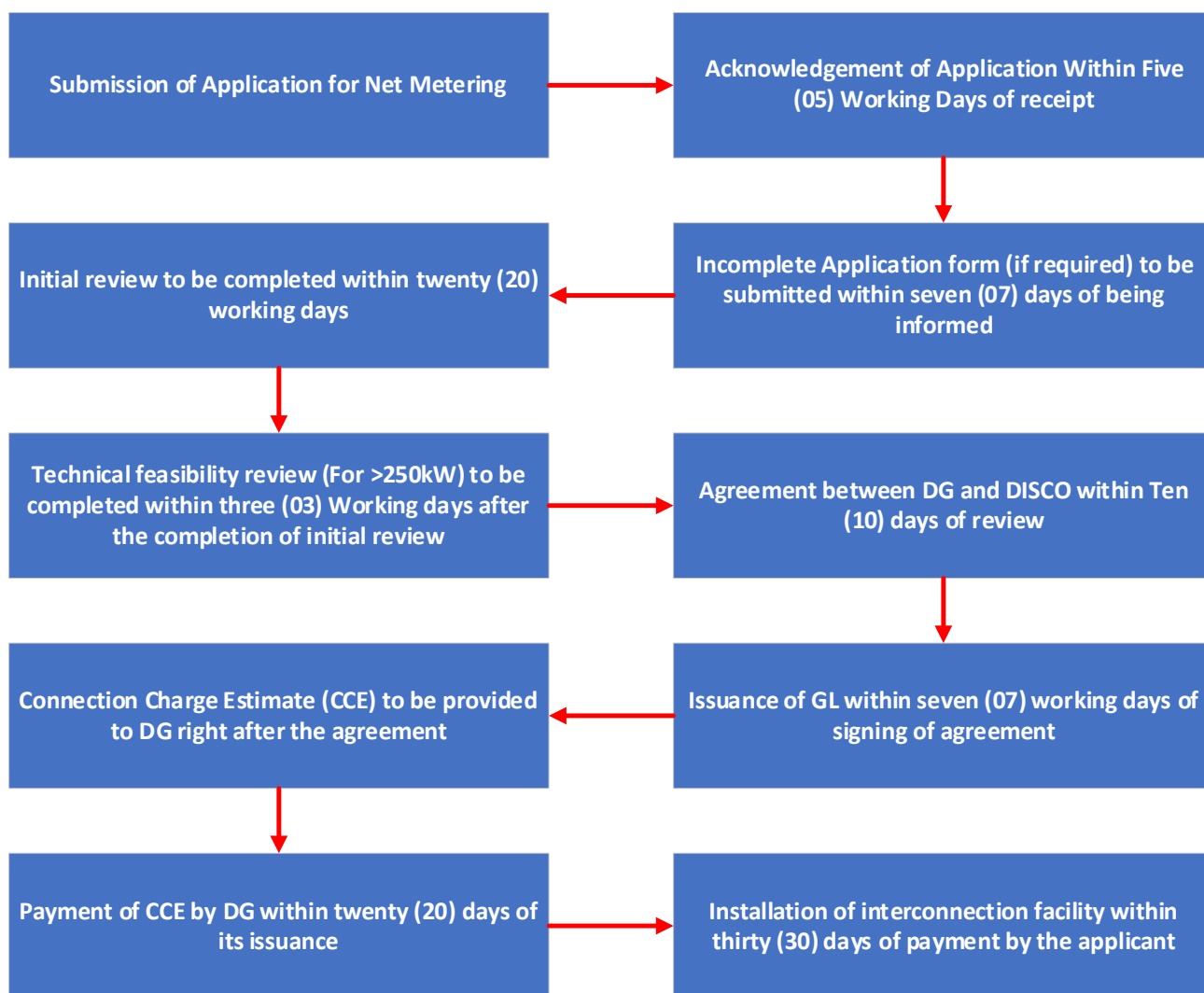


Figure 52:Pakistan Net Metering Application Process

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/installation of Capacitors for Power Factor improvement.

Description

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

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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 54: 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	Ghadiyan Wala New	52105115	2.5	3.0	50	150
2	Islam Nagar	52205124	5.0	3.0	50	150
3	Harmul Pura	52105110-A	12.5	3.0	0	0
4	Harmul Pura	52105110-B	5.0	3.0	50	150
5	Gharay Band	52105111-B	2.5	3.0	50	150
6	Lakhi Wala	52105112-B	2.5	3.0	50	150
7	Noor shah	52105113-B	2.5	3.0	50	150
8	Tibba Raigstan	52205121-A	2.5	3.0	50	150
9	Farooqabad	52205126-A	2.5	3.0	50	150
10	Farooqabad	52205126-B	5.0	3.0	50	150
Total						1350

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 7,018 streetlights are being operated by the municipality. Out of these, 5,562 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 or 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 53: 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 55: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	5562
Number of non-functional streetlights (>20 feet)	#	7
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	5,555

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Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	284,020,966
Proposed number of photocell switches	#	182
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	182,000
Upfront investment cost	PKR	284,202,966
Upfront investment cost	US\$	1,014,286
Annual Operating Electricity unit	kWh/yr	731,460
Annual Operating Cost	PKR/yr	32,915,700
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	2,862,975
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 7,018 streetlights operated by municipality out of which 1,456 are operational. 1345 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 or 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 56: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	111
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)	#	111

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Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Upfront investment cost	PKR	5,667,771
Upfront investment cost	US\$	20,228
Annual Operating Electricity unit	kWh/yr	14,585
Annual Electricity Consumption of Existing Lights	kWh/yr	1,888
Financial Savings	US\$/yr	-2,039
Payback	months	-119

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 57: 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
Saith Majeed/ Chungi No. 22 Graveyard											
1	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
Rasheed Chowk Graveyard											
2	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
Haideri Mohallah graveyard											
3	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700
Lohly Shah Graveyard											
4	CFL	7	24	168	419	LED Bulb 13 Watts	13	91	227	350	2,450
5	CFL	3	24	72	180	LED Bulb 13 Watts	13	39	97	350	1,050
MC-Mosque											
6	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700
7	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
Fire Brigade											
8	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
9	CFL	1	10	10	25	LED Bulb 8 Watts	8	8	20	330	330
Waad 8 Jhang City Graveyard											
10	Tube Light	5	40	200	499	LED Rod 20 Watts	20	100	250	2,900	14,500
11	CFL	1	24	24	60	LED Rod 20 Watts	20	20	50	2,900	2,900
12	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
13	CFL	2	24	48	120	LED Rod 20 Watts	20	40	100	2,900	5,800
Tiba Ragistan Slaughter House											
14	ILB	1	60	60	150	LED Bulb 8 Watts	8	8	20	330	330
General Bus stand											
15	ILB	1	60	60	150	LED Bulb 8 Watts	8	8	20	330	330
MC-Office											
16	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
17	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
18	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
19	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800

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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
20	Tube Light	4	40	160	399	LED Rod 20 Watts	20	80	200	2,900	11,600
21	CFL	2	24	48	120	LED Rod 20 Watts	20	40	100	2,900	5,800
22	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700
23	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700
24	CFL	3	24	72	180	LED Bulb 13 Watts	13	39	97	350	1,050
25	CFL	1	85	85	212	LED Bulb 50 Watts	50	50	125	6,800	6,800
26	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
27	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
28	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700
29	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
30	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
31	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
32	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700
33	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
34	Tube Light	10	40	400	998	LED Rod 20 Watts	20	200	499	2,900	29,000
35	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
36	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
37	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
38	Tube Light	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
39	CFL	2	45	90	225	LED Bulb 13 Watts	13	26	65	350	700
40	Tube Light	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
41	Mercury Bulb	1	125	125	312	LED Bulb 13 Watts	13	13	32	350	350
1	Window AC	1	5000	5000	12,480	Inverter 1.5 ton	1,452	1,452	2,114	143,000	143,000
2	Window AC	1	5000	5000	12,480	Inverter 1.5 ton	1,452	1,452	2,114	143,000	143,000
	Total										436,540

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 58: 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	208
Average Operational Hours for Building Cooling Equipment	Hours/day	7
Energy consumption of inefficient Equipment	kWh/yr	32,243
Energy consumption of Proposed Equipment	kWh/yr	7,795
Energy Savings	kWh/yr	24,448
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	3,926
Upfront Investment (including change in fixtures)	USD	1,558
Payback Period	Months	5

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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 /4 Stages, 15hp Motor

Pump Size		8 HC /4 Stages	
Capacity	76.46 m ³ /hr	Max. O.D bowl	7.5 Inches
Speed	1450 rpm	I.D tubewell	-
Pump Input	15 HP	Length of suction pipe	
Prime Mover (SEM/DE)	15 HP	Length of bowl assembly	
		Length of column pipe	
		Length of top pipe	0 Ft
		Total length of column	0 Ft
Material Specifications			
Pump Assembly		Column Pipe assembly	
Bowls	Cast Iron	Column Pipe	Steel
Impellers	Bronze	Shaft	Carbon Steel
Wearing Ring	Cast Iron	Shaft Sleeves	S.S
Shaft	Stainless Steel	Shaft Couplings	Steel
Shaft Sleeves	Bronze	Bearings	Rubber Lined
Bearing	Bronze	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	each 10 ft length	0 Sets
Column assembly of	4 insches I.D with flanged joins	and one top set	0 feet length
		column shaft dia	0mm
Electric Motor vertical hollow shaft 15 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: 630,000
		Sales Tax @ 17%	Rs: 107,100
		Total Cost of Pumpset	Rs: 737,100

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8.1.2 Investment Estimate (including Material Specification/Quantities) for PECO 10 MC /4 Stages, 30hp 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	30 HP	Length of suction pipe	
Prime Mover (SEM/DE)	30 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		Column Pipe assembly	
Bowls	Cast Iron	Column Pipe	Steel
Impellers	Bronze	Shaft	Carbon Steel
Wearing Ring	Cast Iron	Shaft Sleeves	S.S
Shaft	Stainless Steel	Shaft Couplings	Steel
Shaft Sleeves	Bronze	Bearings	Rubber Lined
Bearing	Bronze	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 30 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: 964,104
		Sales Tax @ 17%	Rs: 163,898
		Total Cost of Pumpset	Rs: 1,128,002

8.1.3 Investment Estimate (including Material Specification/Quantities) for PECO 8 LC /3 Stages, 5hp Motor

Pump Size		8 LC /3 Stages	
Capacity	76.46 m3/hr	Max. O.D bowl	7.5 Inches
Speed	1450 rpm	I.D tubewell	-
Pump Input	5 HP	Length of suction pipe	
Prime Mover (SEM/DE)	5 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		Column Pipe assembly	
Bowls	Cast Iron	Column Pipe	Steel
Impellers	Bronze	Shaft	Carbon Steel
Wearing Ring	Cast Iron	Shaft Sleeves	S.S
Shaft	Stainless Steel	Shaft Couplings	Steel
Shaft Sleeves	Bronze	Bearings	Rubber Lined
Bearing	Bronze	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 inches 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 5 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: 550,000
		Sales Tax @ 17%	Rs: 93,500
		Total Cost of Pumpset	Rs: 643,500

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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	7	53,873	377,111
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	5,555	51,061	283,643,855
3	Accessories	Photocell switch				182	1,000	182,000
Lumpsum Price (PKR)								284,202,966
Lumpsum Price (USD)								1,014,286

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	111	51,061	5,667,771
Lumpsum Price (PKR)								5,667,771
Lumpsum Price (USD)								20,228

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	Inverter 1.5 ton	1,452	2	2,904	143,000	286,000
2	LED Bulb 13 Watts	13	60	780	350	21,000
3	LED 50 Watts	50	8	400	6,800	54,400

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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
4	LED Bulb 20 Watts	20	7	140	830	5,810
5	LED Bulb 8 Watts	8	1	8	330	330
6	LED 100 Watts	100	1	100	14,900	14,900
7	LED 150 Watts	150	8	1,200	21,000	168,000
8	LED Rod 20 Watts	20	45	900	2,900	130,500
Lumpsum Price (PKR)						680,940
Lumpsum Price (USD)						2,430

9 Summary of Energy Efficiency Measures

MC Jhang's annual energy consumption is 2,281,651 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\$ 1,887** with an estimated investment of **US\$ 23,136**¹⁵
- Reduce electricity consumption by approx. **11,751 kWh**
- Reduce GHG Emissions by **5 tCO₂/y**

¹⁵ Does not include cost of replacement of non-functional lights (1,014,286 USD)

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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-

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Annexure 2: List of Energy Audit Equipment

Sr. No.	Name	Picture	Function	Type	Model	Manufacturer
1	Ultrasonic Flow Meter – Tubewell		Measurement of Flow Rate (m3/sec)	Contact Type	SL 1168P	Sitelab
2	Ultrasonic Flow Meter – 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

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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

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