Daska Municipal Committee

Energy Audit Report

June 2023

History of the Document

Version	Date	Description
01	May 15, 2023	First Draft
02	June 16, 2023	Final Version

Disclaimer

World Bank Group creates opportunity for people to escape poverty and improve their lives. It fosters sustainable economic growth in developing countries by supporting private sector development, mobilizing private capital, and providing advisory and risk mitigation services to businesses and governments.

The conclusions and judgments contained in this report should not be attributed to, and do not necessarily represent the views of, World Bank or its Executive Directors, or the countries they represent. World Bank do not guarantee the accuracy of the data in this publication and accept no responsibility for any consequences of their use.

ACKNOWLEDGEMENT

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

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

Table of Contents

List of Tables

List of Figures

ABBREVIATIONS

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

UNITS OF MEASUREMENTS

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

CONVERSION FACTORS

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

BASELINE PARAMETERS

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

1 Summary

1.1 Background

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

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

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

1.2 Scope of work

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

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

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

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

1.4 Daska MC Background

The city of Daska is located at 32.3333° N, 74.3500° E. The city is the capital of Daska Tehsil, one of four tehsils of Sialkot District. The city specializes in manufacturing of agro-engineering equipment, woodworks and diesel engines.

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 Daska MC has the following management.

Sr. No	Name of Officer	Designation
1	Mr. Faisal Ahmed	Administrator
2	Mr. Abdul Hayee	Chief Officer

Sr. No	Name of Officer	Designation
3	Mr. Uzair Arshad*	Municipal Officer (Infrastructure)
4	Mr. Fahad	Municipal Officer (Regulation)
5	Mr. Muhammad Usman	Municipal Officer (Finance)
6	Ms. Maryam Siddiqua	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Daska

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	513,164
Electrical energy used by Wastewater Disposal[2]	kWh/year	487,561
Electrical energy used in Buildings[3]	kWh/year	48,608
Electrical energy used by Streetlights[4]	kWh/year	90,522
Diesel used by Vehicles	liter/year	147,792
Petrol used by Vehicles	liter/year	18,672

1.5 Key Performance Indicators

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

1.5.1 Potable Water & Wastewater Pumps

Table 2: KPIs for Potable Water & Wastewater pumps

Sr. No.	Description	Unit	KPI
1	Energy Density of Potable Water Production	(kWh/m^3)	0.24
2	Energy Density of Wastewater Disposal	(kWh/m^3)	0.03
3	Energy Density of Wastewater Treatment	(kWh/m^3) – if applicable	No wastewater treatment is carried out
4	Energy Cost on Potable Water Production	(PKR/m^3)	10.99
5	Energy Cost on Wastewater Disposal	(PKR/m^3)	1.19
6	Energy Cost on Wastewater Treatment	(PKR/m^3) – if applicable	No wastewater treatment is carried out

1.5.2 Streetlights

Table 3: KPIs for Streetlights

Sr. No.	Description	Unit	KPI
1	Average electricity consumed per kilometer of lit roads	(kWh/km)	5,380
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	257
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	42,771
		PKR/Lighting Equipment	39,308
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)	155,602

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

Sr. No.	Description	Unit	KPI
6	Average daily duration of operation	(Hour)	12.0
7	Average energy costs per kilometer of lit roads	(PKR/km)	242,108
8	Average energy costs per light pole/fixture	(PKR/ fixture)	11,572
9	Number and percentage of failed public lights		20%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	25.91
2	Municipal Buildings Heat Consumption	(kWh/m^2)	1.47
3	Average Energy Cost of Heating	(PKR/m^2)	66
4	Average Energy Cost of Cooling	(PKR/m^2)	501
5	Average Energy Cost of Lighting	(PKR/m^2)	198

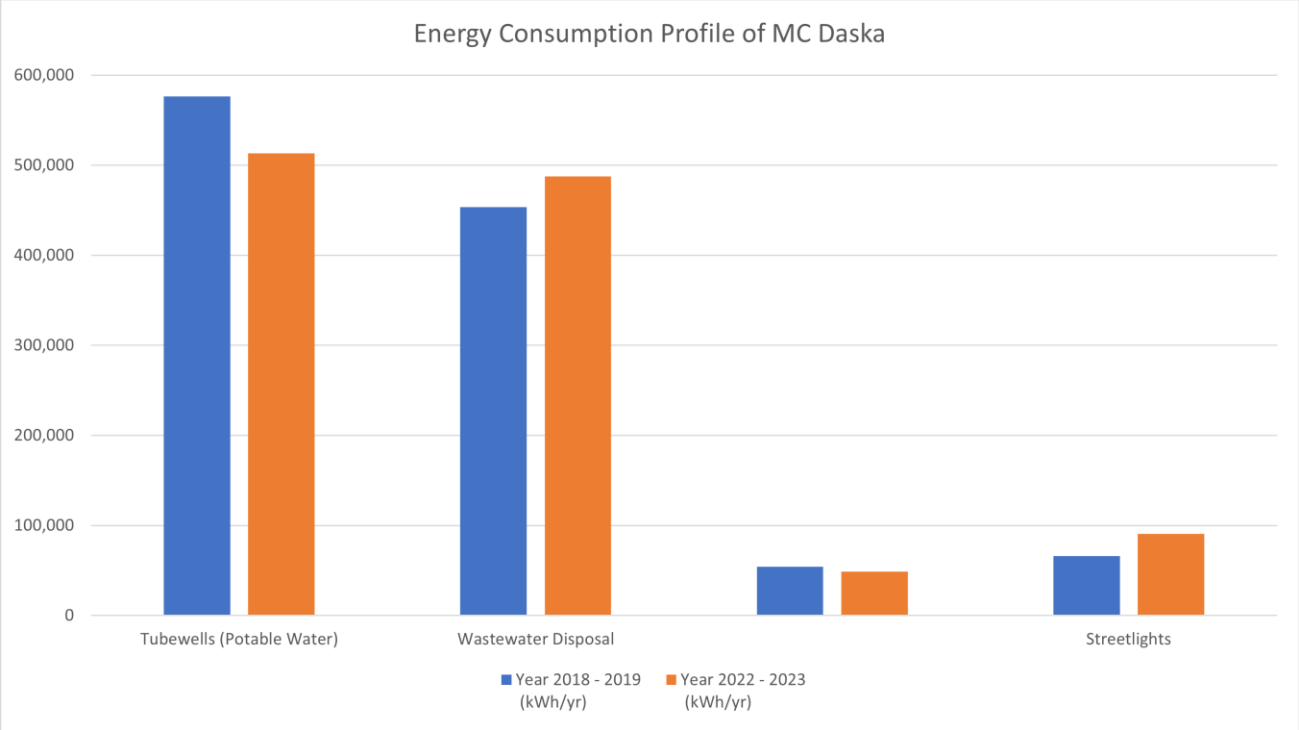
1.5.4 Vehicles

Table 5: KPIs for Vehicles

Sr. No	Description	Unit	KPI
1	Fuel consumption for staff transport vehicles	km/Liter	Cannot be Determined
2	Fuel consumption for solid/liquid waste transport	km/Liter	4.07
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	72

1.6 Impact of Energy Efficiency Investment

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


Energy Consumption Profile of MC Daska
600,000
500,000
400,000
300,000
200,000
100,000
0
Tubewells (Potable Water)
Wastewater Disposal
Streetlights
Year 2018 - 2019 (kWh/yr)
Year 2022 - 2023 (kWh/yr)

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	7	5	576,514	513,164	63,350	0.20 kWh/m3	0.24 kWh/m3	Replacement of 2 Pumpsets was recommended based on the assessment carried out in 2019. However, no pumpset has been replaced by the MC. As seen from the KPI, the overall performance of the water supply has deteriorated. There were 7 operational pumpsets during the 2019 audit, whereas currently, there are 5 operational water supply pumpsets. Moreover, the operational hours of the functional pumps has reduced significantly due to which there is reduction of 63,350 kWh in the annual energy consumption.
2	Wastewater Disposal	9	5	453,445	487,561	-34,116	0.03 kWh/m3	0.03 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal has improved as well. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.
3	Buildings	4	4	54,334	48,608	5,726	N/A	N/A	The KPI for municipal buildings cannot be accurately determined as the meters in the main MC building and the MC office are shared with pumpsets and streetlights. No accurate opinion can be provided on

		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
									the increase in electricity consumption in these buildings as the connections are shared. Electricity consumption from the shared meters has not been included in the comparison.
4	Streetlights	353	421	65,980	90,522	-24,542	6,773 kWh/km	5,380 kWh/km	Based on the previous assessment, there were only 353 MC owned operational lights, whereas, currently there are 421 operational lights. The MC has significantly improved the energy consumption per light fixture. The MC has replaced all of its streetlighting fixtures with LEDs. The total number of light fixtures in the MC has increased due to which the overall electricity consumption for streetlights has increased from the baseline value. The KPI for lighting has improved from the baseline value.

1.7 Energy Efficiency Recommendations Matrix

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

1.7.1 Energy Efficiency Recommendations Matrix

Table 6: High Priority Measures

High Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Replacement of Pumpset at (Sambrial Road - Unique ID: 5130557)	13,774	3,794	1,063,000	2,212	619,815	21	7
Replacement/Installation of Capacitors	Not Quantifiable	1,575	441,315	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	19,966	5,594,443	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	3,072	558	156,300	493	138,238	14	2
Total:	**16,846**	**25,892**	**7,255,058**	**2,705**	**758,053**		**8**

Table 7: Low Priority Measures

Low Priority Energy Efficiency Measure	Water Savings m^3/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Installation of Flow meters integrated with a centralized DCS system	16,442	19,000	5,323,800	0	0	0	Not Quantifiable
Total:	**16,442**	**19,000**	**5,323,800**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Daska MC has seven (7) tubewells for groundwater, all of which are manually operated. Out of these, 5 pumpsets were found to be in working condition.

The MC has three (3) disposal station having twelve (12) pumps. Out of these 9 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are thirteen (13) dewatering sets in the MC, out of which 12 are functional. No record of their fuel consumption and operational hours is being maintained by the MC.

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

The team was unable to

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

(ii) Determine system resistance and duty point on two (2) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake assessment of the following pumpset as no flow could be detected by the flowmeter
   1. Purana Kacheri road (Unique ID: 5130556)

(iv) Undertake assessment of the following pumpset as there was no motor
   1. Bangla Rest House Chowk (Unique ID: 5130559)

(v) Undertake assessment of the following disposal pumpset as the sites are under non-functional
   1. Nawaz Sharif Stadium (Unique ID: 5150573-E)
   2. Nawaz Sharif Stadium (Unique ID: 5150573-F)

(vi) Undertake assessment of the following disposal pumpset as either the flow could not be detected or the flow could not be detected reliably
   1. Pasroor Road (Unique ID: 5150571-A)
   2. Pasroor Road (Unique ID: 5150571-C)

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

2.1 Inventory for water and wastewater pumping equipment

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

2.1.1 Tubewells

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	5130556	Purana Kacheri road	28-12221-1660400	Turbine	Local Made	2000	Newman	2000	32.33128	74.35028
2	5130557	Sambrial Road	28-12221-0900600	Turbine	Beco	1988	Beco	1988	32.33582	74.35331
3	5130558	College Road	28-12221-1529001	Turbine	Peco	1997	Peco	1997	32.3342	74.36006
4	5130559	Bangla Rest House Chowk	28-12221-1668200	Turbine	Peco	1997	Climax	1997	32.33073	74.34802
5	5130560	Civil Hospital	28-12221-0619901	Turbine	KSB	2005	Siemens	2005	32.33328	74.34473
6	5140563	Lari Adda	28-12222-1330100	Turbine	Peco	1997	Newman	1997	32.3273	74.34594
7	5140564	New Kachehri	28-12222-1330300	Turbine	KSB	2003	Siemens	2003	32.31906	74.34972

2.1.2 Dewatering Sets

Table 9: Inventory Table of Dewatering Set

Sr. No.	Unique Id	Location	Quantity	Latitude	Longitude
1	01 Dewatering set	MC Building Office Warehouse	10	32.338994	74.336594
2	02 Dewatering set	Near Mashallah cold corner	1	32.342253	74.354603
3	03 Dewatering set	Near Cheena House Daska	1	32.326781	74.337225
4	04 Dewatering set	Jandu Sahi road	1	32.342253	74.354603

2.1.3 Disposal Works

Table 10: Inventory Table of Disposal Works

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Pump Capacity	Motor Manufacturer	Motor Capacity	Latitude	Longitude
1	5150571-A	Pasroor Road	30-12223-0000400	Centrifugal	KSB	5	Siemens	50	32.3237	74.35434
2	5150571-B	Pasroor Road		Centrifugal	KSB	5	Siemens	50	32.3237	74.35434
3	5150571-C	Pasroor Road		Centrifugal	KSB	5	Siemens	50	32.3237	74.35434
4	5150571-D	Pasroor Road		Centrifugal	KSB	5	Siemens	50	32.3237	74.35434
5	5150570-A	Awami Road	28-12222-1340200	Centrifugal	KSB	5	Siemens	50	32.33374	74.35418
6	5150570-B	Awami Road		Centrifugal	KSB	5	Siemens	50	32.33374	74.35418
7	5150573-A	Nawaz Sharif Stadium	28-12221-0002101	Centrifugal	KSB	5	Siemens	50	32.33889	74.33641
8	5150573-B	Nawaz Sharif Stadium		Centrifugal	KSB	5	Siemens	50	32.33889	74.33641
9	5150573-C	Nawaz Sharif Stadium		Centrifugal	KSB	5	Siemens	50	32.33889	74.33641
10	5150573-D	Nawaz Sharif Stadium		Centrifugal	KSB	5	Siemens	50	32.33889	74.33641
11	5150573-E	Nawaz Sharif Stadium		Centrifugal	KSB	5	Siemens	50	32.33889	74.33641
12	5150573-F	Nawaz Sharif Stadium		Centrifugal	KSB	5	Siemens	50	32.33889	74.33641

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	5140565	Chungi # 8	Centrifugal	1	Golden Pumps	N/A	Golden	32.34361	74.35596
2	5140566	Muhallah Haji Pura	Centrifugal	1	Golden Pumps	N/A	Golden	32.33958	74.36019
3	5140567	Shahab Pura	Centrifugal	1	Golden Pumps	N/A	Golden	32.34008	74.36471
4	5140568	Muhallah Ghagha	Centrifugal	1	Golden Pumps	N/A	ATLAS	32.34098	74.37003
5	5140569	Mission Ground	Centrifugal	1	Golden Pumps	N/A	Golden	32.33374	74.34911

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

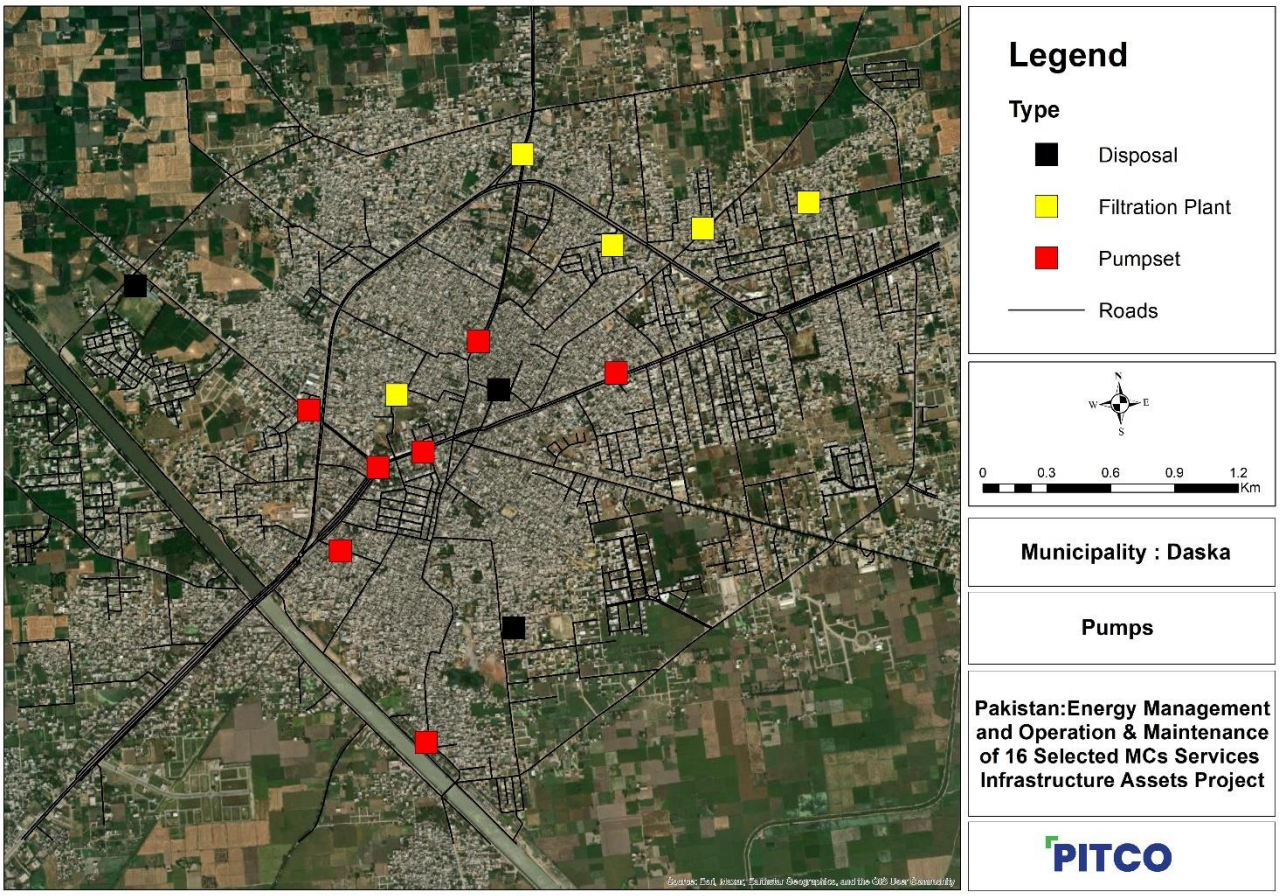


Figure 1: Map for Pumps and Disposal at MC Daska

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	513,164
Electrical energy used by Wastewater Disposal	kWh/y	487,561
Electrical energy used (Total)	kWh/y	1,000,725

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)	7	5	576,514	513,164	63,350	0.20 kWh/m3	0.24 kWh/m3	Replacement of 2 Pumpsets was recommended based on the assessment carried out in 2019. However, no pumpset has been replaced by the MC. As seen from the KPI, the overall performance of the water supply has deteriorated. There were 7 operational pumpsets during the 2019 audit, whereas currently, there are 5 operational water supply pumpsets. Moreover, the operational hours of the functional pumps has reduced significantly due to which there is reduction of 63,350 kWh in the annual energy consumption.
2	Wastewater Disposal	9	5	453,445	487,561	-34,116	0.03 kWh/m3	0.03 kWh/m3	No recommendation for replacement of assets was proposed in the previous assessment. The Consultant had recommended the MC to undertake repair and maintenance of its existing assets. Although the energy consumption at disposal sites has increased, the KPI for water disposal has improved as well. Thereby, indicating that the overall energy consumption per cubic meter of wastewater disposed has decreased.

2.4 Observations and Recommendations

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

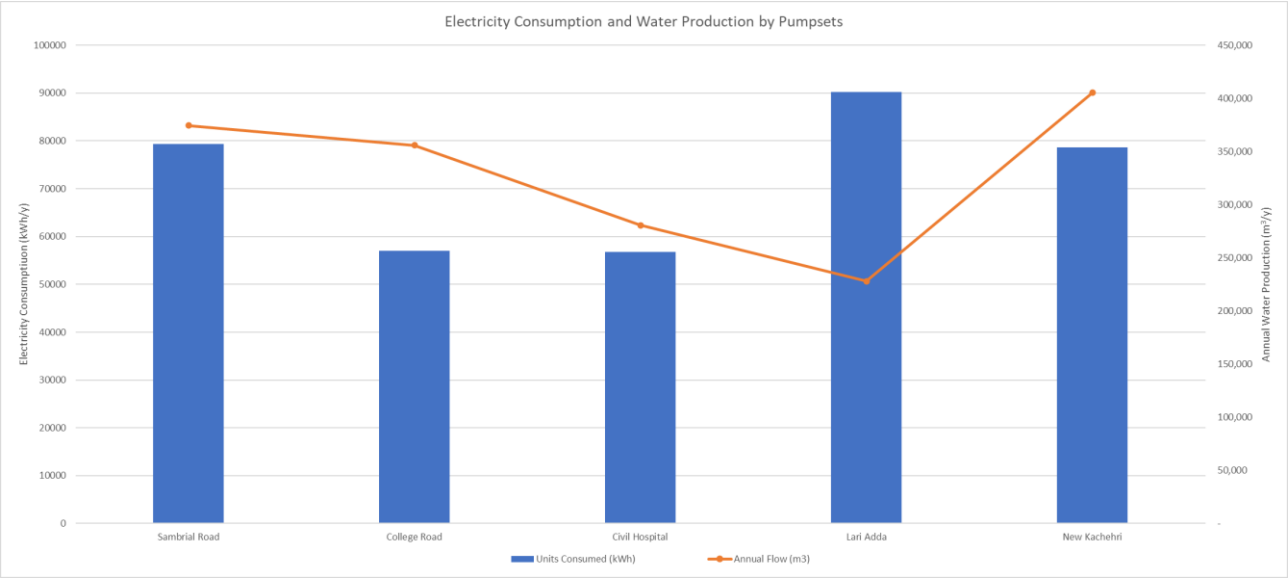
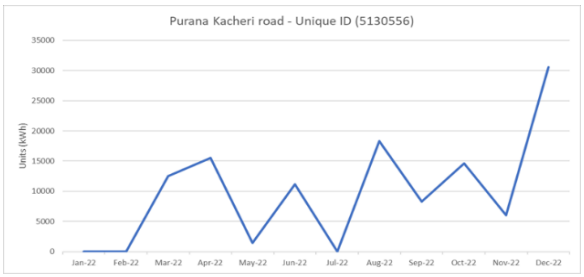


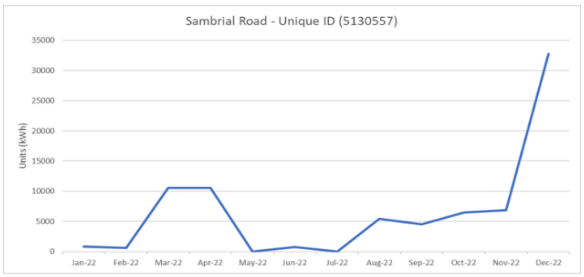
Figure 2: Electricity Consumption and Water Production by Pumpsets

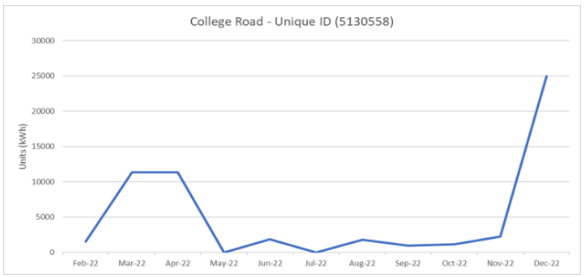
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

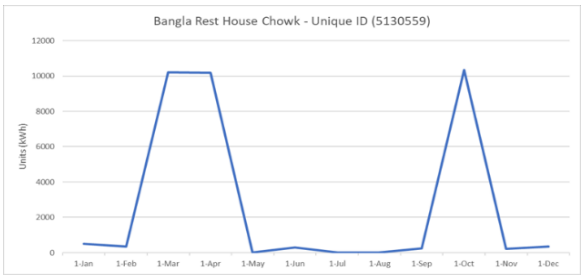
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

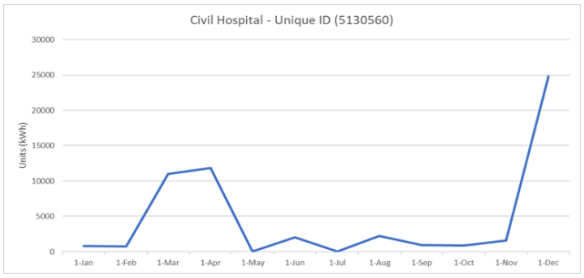
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

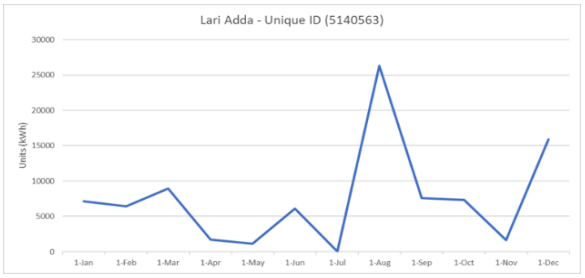


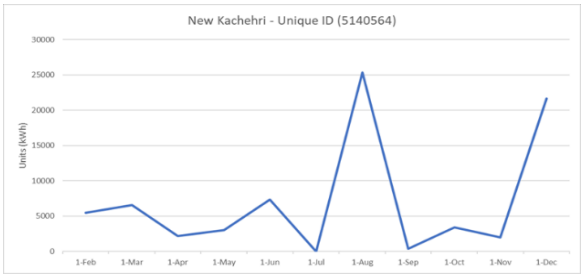


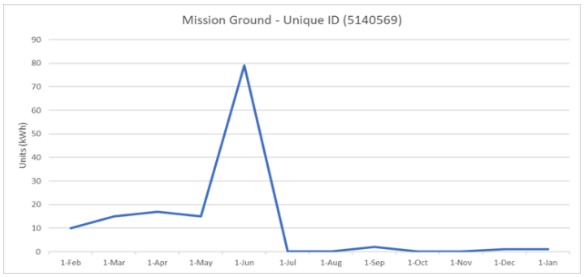


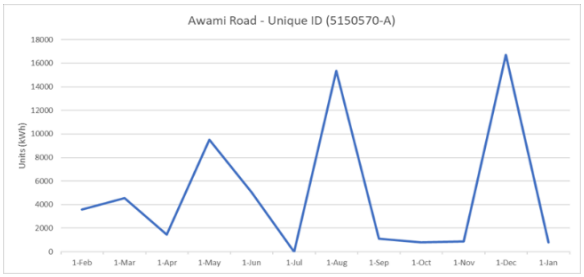


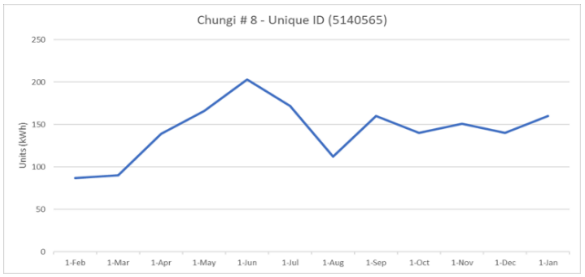


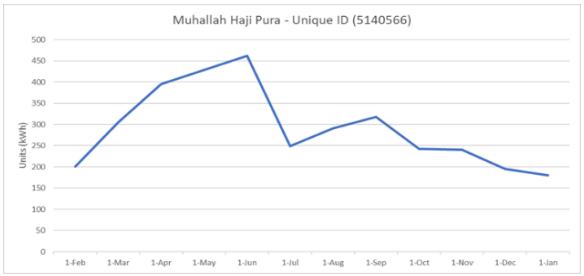


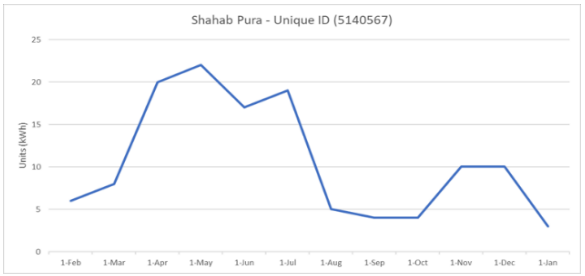












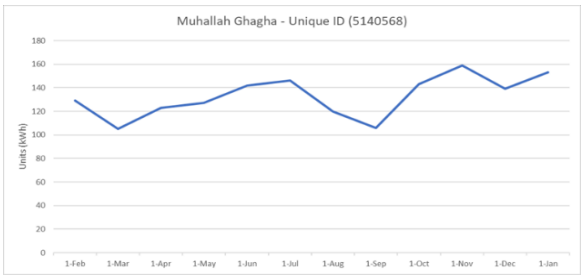
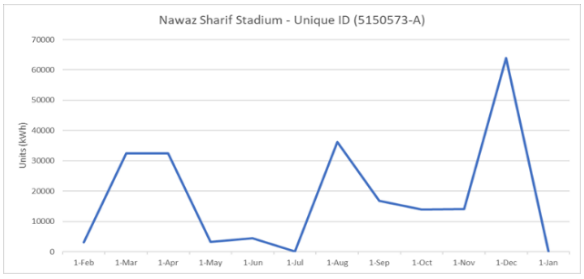


Figure 3: Energy Consumption Trend for Water Pumps



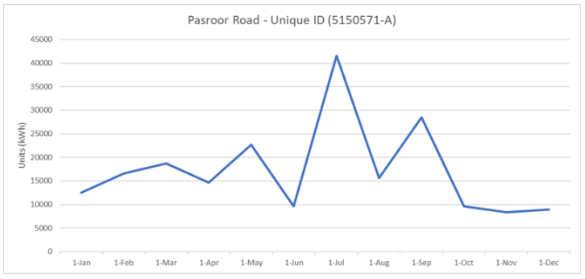


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

Daska MC has seven (7) tubewells for groundwater, all of which are manually operated. Performance evaluation of pumpsets could be carried out at only 5 locations due to the reasons specified under section 2. Performance analysis was carried out for the operational tubewells, by simultaneous measurement of flow and electrical consumption. The list of audit equipment used by the Consultant is attached as Annexure 2. Since the Sluice valves at several pumping stations were either jammed or broken, it was not possible to determine system resistance and/or assess the pumpset performance at its duty point. Nevertheless, the purpose of the energy audit is to evaluate the energy consumption of MC's water supply network based on their actual/existing working condition. Therefore, any measurements made by altering the actual field operating mode/conditions will not be a true representation of the energy consumption of assets.

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

Figure 5: Sample pictures from field audit of pumpsets

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

Table 13: Matrix of Pumpset Assessment and Billing Data Availability

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
1	5130556	Purana Kacheri road	Yes	No
2	5130557	Sambrial Road	Yes	Yes
3	5130558	College Road	Yes	Yes
4	5130559	Bangla Rest House Chowk	Yes	No
5	5130560	Civil Hospital	Yes	Yes
6	5140563	Lari Adda	Yes	Yes
7	5140564	New Kachehri	Yes	Yes

Table 14: Pumpset Primary Performance Parameters

Sr No.	Unique ID	Location	Rated Pump Flow m^3/hr	Measured Flow m^3/hr	Dynamic Head m	Power Consumption kW	Pump Efficiency %	Measured Power Factor	Comments
1	5130557	Sambrial Road	101.9	108.0	20.15	18.20	38%	0.81	Efficiency of the pumpset is unsatisfactory. It is suggested to replace the pumpset. Previously, the efficiency of the pumpset was 41%.
2	5130558	College Road	101.9	82.9	28.71	13.60	56%	0.68	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 60%.
3	5130560	Civil Hospital	101.9	81.0	30.38	14.70	54%	0.76	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Gate valve is jammed. Previous the efficiency of pumpset was 53%.
4	5140563	Lari Adda	101.9	62.8	41.79	15.20	55%	0.69	Efficiency of the pumpset is satisfactory. Gate valve is jammed. Previously, the efficiency of the pumpset was 59%.
5	5140564	New Kachehri	101.9	117.0	21.72	15.10	54%	0.73	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 59%.

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

Table 15: Pumpset Secondary Performance Parameters

Unique ID	Motor Vibration Hz	Temperature of Motor	Winter Operational Hours	Summer Operational Hours	Motor Rated kW	Motor Rated Efficiency	Transformer kVA	Elec. Connection	Line Leakage	Rated Head of Pump	Motor Rated Voltage V	Full Load PF	PF (Measured)	Load factor %	Observations
5130557	18.36	49	11	11	22	-	50	Safe	OK	120	400	0.84	0.81	81%	
5130558	106.10	71	12	14	19	-	-	Unsafe	Not Ok	150	-	-	0.68	73%	
5130560	397.89	47	11	11	19	-	50	Safe	Not Ok	120	380	0.84	0.76	79%	Low PF
5140563	106.10	-	10	12	22	-	50	Unsafe	Not Ok	150	-	-	0.69	68%	Low PF
5140564	676.41	60	11	11	22	-	50	Safe	OK	127	380	0.86	0.73	67%	Low PF

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

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

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
1	5130557	Sambrial Road	102	22.371	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	108.	20.2	Flow at Existing Operating Conditions	18.2	38%
2	105	23.0	Flow nearest to duty point	18.4	42%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
2	5130558	College Road	102	18.6425	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	83	28.7	Flow at Existing Operating Conditions is nearest to duty point	13.6	56%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
3	5140564	New Kachehri	102	22.371	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	117	21.7	Flow at Existing Operating Conditions	15.1	54%
2	105	24.5	Flow nearest to duty point	14.2	58%

2.4.3 Wastewater Disposal System

The MC has three (3) disposal station having twelve (12) centrifugal pumps for suction of wastewater from collecting tanks to main sewage drain. All these pumps are manual and run as per requirement.

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

Table 17: Disposal Performance Parameters

Sr No	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	PITCO Comments
1	5150571-B	Pasroor Road	509.7	402.5	9.14	29.10	41%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 47%.
2	5150571-D	Pasroor Road	509.7	604.4	9.14	30.40	58%	Efficiency of the pumpset is satisfactory. Previously, the pumpset was found to be non-operational during the audit.
3	5150570-A	Awami Road	509.7	508.3	7.62	27.50	45%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 48%.
4	5150570-B	Awami Road	509.7	653.6	7.62	33.10	48%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 47%.
5	5150573-A	Nawaz Sharif Stadium	509.7	496.9	8.23	28.60	46%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 48%.
6	5150573-B	Nawaz Sharif Stadium	509.7	400.6	8.23	21.90	48%	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 47%.
7	5150573-C	Nawaz Sharif Stadium	509.7	472.0	8.23	29.10	43%	Efficiency of the pumpset is satisfactory. Previously, the pumpset was found to be non-operational during the audit.
8	5150573-D	Nawaz Sharif Stadium	509.7	212.4	8.23	14.20	39%	Efficiency of the pumpset is is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, the pumpset was found to be non-operational during the audit.



Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are thirteen (13) dewatering sets in the MC, out of which 3 are functional. It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.



Figure 7: Dewatering Sets

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

2.5 Proposed Resource Efficiency Measures- Water Pumps and Disposals

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

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

Sr No.	Unique ID	Location	Comments	Recommendation
Pumps				
1	5130556	Purana Kacheri road	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
2	5130557	Sambrial Road	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
3	5130558	College Road	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
4	5130560	Civil Hospital	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
5	5140563	Lari Adda	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
6	5140564	New Kachehri	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 2.5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
7	5150570-A	Awami Road	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
8	5150573-A	Nawaz Sharif Stadium	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
9	5150573-B	Nawaz Sharif Stadium	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
10	5150573-C	Nawaz Sharif Stadium	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
11	5150573-D	Nawaz Sharif Stadium	The power factor at the site is below 0.8.	A 7.5 kVAr capacitor should be installed on each phase.
General Observations				
12	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

Sr No.	Unique ID	Location	Comments	Recommendation
13	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 GEPCO during the entire year are given in Annexure 1.
14	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.
15	General	Water Supply Network	Proper O&M of Air Release Valves	Air release valves installed on the network should be properly maintained.

3 Streetlights

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

3.1 Inventory

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

Table 19: Inventory Detail of Streetlights

	Streetlights	MC Operated	Privately Operated
Operational Street Lights	421	421	
Non-Operational Street Lights	107	107	
Total	**528**	**528**	**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 83 light fixtures installed on PC, 51 fixtures are installed on steel structure, 73 fixtures are installed on tubular structure, 156 fixtures are installed on wires and 72 fixtures are installed on walls. The streetlights' structural classification is tabulated below.

Table 20: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Wire	Walls	Grand Total
MC	83	51	73		156	72
Private						0

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

Table 21: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Stadium Road	19	28 12221 0600400 U	1.181
2	Wazirabad Road	14	07122210781900 U	0.258
3	Bank Road	22	28122210003703 U	0.553
4	Bangla Chowk	51	28122211660400 U	1.001
5	Degree College Chowk	27	02122221480806 R	0.032
6	Main Bazar	61	28122221573601 U	1.253
7	Pasroor Road	64	28122221573601 U	2.066
8	Jamkey Road Galliya	85	28122221576602 U	3.944
9	Sambrial Road	42	28 12221 0900600 U	1.875
10	Main Bazar Daska Galliya	143	28122221340100 U	4.662

Out of the 528 surveyed lights in the MC, 421 lights were found to be operational. Details are given in the following table:

Table 22: Details of Operational Streetlights

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours[5]	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	12	15		12.0	788	0
LED	18	171		12.0	13,482	0
LED	30	33		12.0	4,336	0
LED	40	1		12.0	175	0
LED	50	12		12.0	2,628	0
LED	120	189		12.0	99,338	0
Total					**120,748**	


Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

[5] Based on Interview with Client.

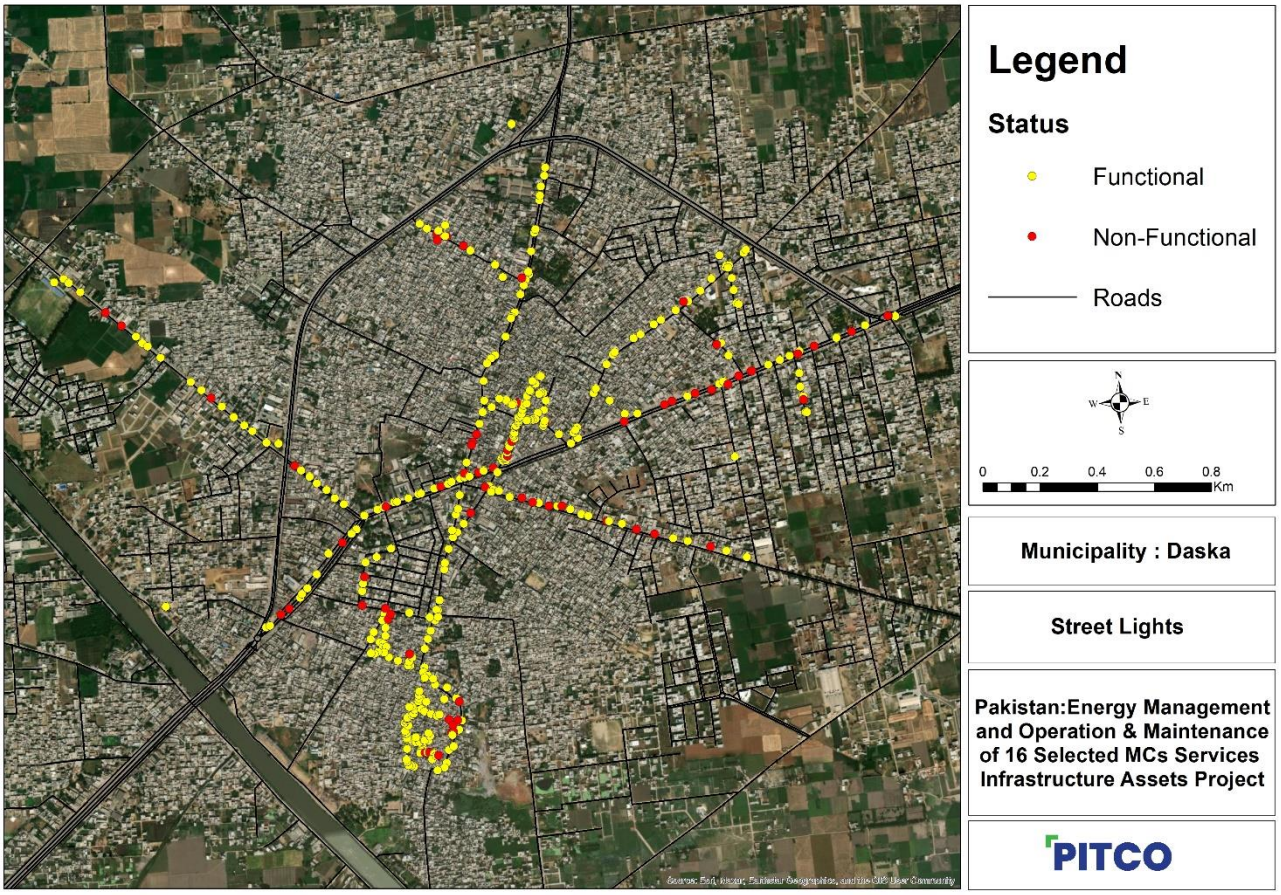


Figure 9: GIS Mapping of street lights in Daska MC

3.3 Baseline Energy Consumption Trend

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

Table 23: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy consumed	kWh/y	**90,522**
Total number of operational lights	No.	**421**

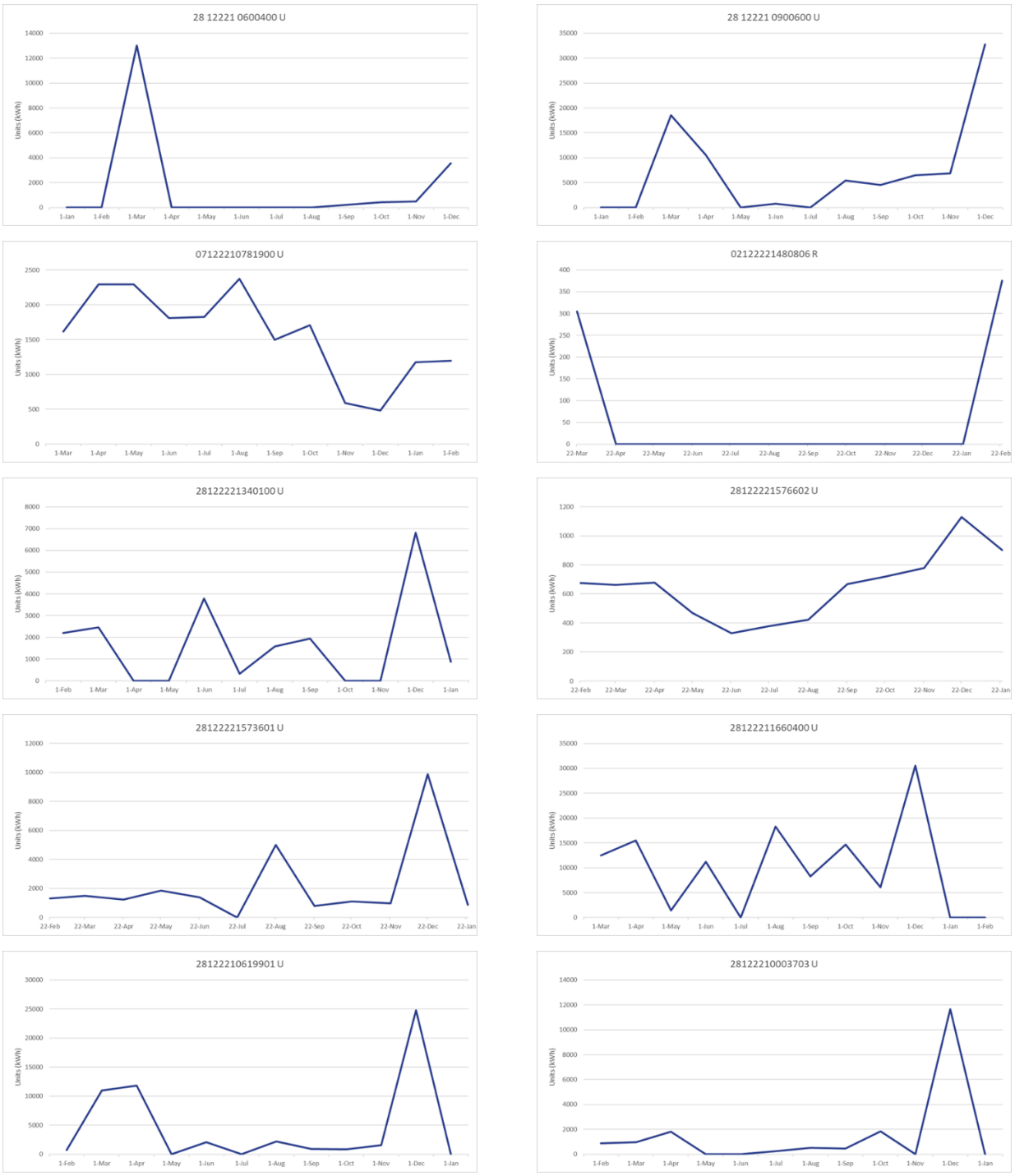


Figure 10: Energy Consumption trend of Streetlights

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Streetlights	353	421	65,980	90,522	-24,542	6,773 kWh/km	5,380 kWh/km	Based on the previous assessment, there were only 353 MC owned operational lights, whereas, currently there are 421 operational lights. The MC has significantly improved the energy consumption per light fixture. The MC has replaced all of its streetlighting fixtures with LEDs. The total number of light fixtures in the MC has increased due to which the overall electricity consumption for streetlights has increased from the baseline value. The KPI for lighting has improved from the baseline value.

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 Daska.

3.5 Observations

- All Streetlights in Daska MC are operated by MC.
- All operational streetlights are LEDs.
- Approximately 45% of the LED streetlights have a rating of 120 Watts.
- Daska MC is not maintaining any record or database of streetlights.

3.6 Action plan for Energy Efficiency Measures – Streetlights

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

Table 24: Streetlights - recommendations for improvement

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

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

4 Vehicles

4.1 Inventory

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

Table 25: Vehicle Inventory Detail

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
1	Unregistered 1	Tractor Trolley	Millat	MF-240	2010	2WD	Transport of Solid Waste	CE99001V624586T	41255/09/10	50HP
2	Unregistered 2	Tractor Front loader	Millat	MF-385	2019	4WD	Loading	LM9B572K508864F	84739/04/19	85HP
3	Unregistered 3	Tractor Front loader	Millat	MF-375	2010	4WD	Loading	LF15W4C43	K75807/11/10	75HP
4	Unregistered 4	Tractor Water Bowser + Front loader	Millat	MF-385	2010	2WD	Water Bowser	6006500040B	G84145/04/10	85HP
5	Unregistered 5	Tractor Front loader	Millat	MF-385	2004	4WD	Loading	LM9B570V510485M	0420/04	85HP
6	Unregistered 6	Tractor Trolley	Millat	MF-240	2019	2WD	Transport of Solid Waste	VP28D34164	43726/09/19	50HP
7	Unregistered 7	Tractor Trolley	Millat	MF-240	2010	2WD	Transport of Solid Waste	CE99001V624742T	41255/12/10	50HP
8	Unregistered 8	Tractor	Millat	MF-240	2010	2WD	Transport of Solid Waste	6E99001V624738T	41255/11/10	50HP
9	Unregistered 9	Tractor Front blade	Hino	MF-385	2010	4WD	Loading	LM9B572V501460T	G84146/01/10	85HP
10	Unregistered 10	Tractor Trolley	Millat	MF-240	N/A	2WD	Transport of Solid Waste	CE97065V527618B	3711164A-1	50HP
11	Unregistered 11	Tractor Driver Set	Millat	MF-240	N/A	2WD	Transport of Solid Waste	CE31089V103110	N/A	50HP
12	Unregistered 12	Mini-Truck	Hino	WU720R-HKFRL3	2021	4WD	Transport of Solid Waste	TNM14734	JHHYJL0H102003689	4600
13	Unregistered 13	Mini-Truck	Hino	WU720R-HKFRL3	2021	4WD	Transport of Solid Waste	TNM14735	JHHYJL0H802003690	4600
14	Unregistered 14	Mini-Truck	Hino	WU720R-HKFRL3	2011	4WD	Transport of Solid Waste	N/A	N/A	4600
15	STD-3274	Fire Brigade	Mazda	T3500	1988	2WD	Water Bowser	50100919	WE24GMQ200225	3500
16	Unregistered 15	Rickshaw Loader	Tez Raftar	TR200	2020	2WD	Transport of Solid Waste	N/A	PS3200MCL000464	200
17	Unregistered 16	Rickshaw Loader	Tez Raftar	TR200	2020	2WD	Transport of Solid Waste	N/A	PS3200MCL000462	200
18	Unregistered 17	Rickshaw Loader	Tez Raftar	TR200	2020	2WD	Transport of Solid Waste	N/A	PS3200MCL000362	200
19	Unregistered 18	Rickshaw Loader	Tez Raftar	TR200	2020	2WD	Transport of Solid Waste	N/A	PS3200MCL000435	200
20	Unregistered 19	Rickshaw	Tez Raftar	TR200	2020	2WD	Transport of Solid Waste	N/A	S3200MCL000468	200
21	Unregistered 20	Rickshaw	Road Prince	RP200	2018	2WD	Transport of Solid Waste	N/A	ZS162ML-P8K600011	200
22	Unregistered 21	Rickshaw	Road Prince	RP200	2018	2WD	Transport of Solid Waste	N/A	N/A	200
23	Unregistered 22	Rickshaw Loader	Road Prince	RP200	2018	2WD	Transport of Solid Waste	N/A	N/A	200
24	Unregistered 23	Sucker Machine	Fuso	Canter	2012	4WD	Suction	4D34-N80501	MMC-04-CN00448	4200
25	Unregistered 24	Jetting Machine	Fuso	Canter	2012	4WD	Suction	4D34-P00818	MMC-04-CN00458	4200

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)
26	Unregistered 25	Tractor Front loader	Millat	MF-385	2022	4WD	No Task Assigned	LM96572V5072874	85525/01/022	85HP
27	Unregistered 26	Tractor Front loader	Millat	MF-385	2022	4WD	No Task Assigned	LM98572V507296H	85526/04/22	85HP
28	Unregistered 27	Tractor Front blade	Millat	MF-385	2022	4WD	No Task Assigned	LM9B572V507289H	85523/02/22	85HP
29	Unregistered 28	Truck	Hino	Euro 500	2022	4WD	No Task Assigned	10505	FGSJKLB-10283	4600
30	Unregistered 29	Truck	Hino	Euro 300	2022	4WD	No Task Assigned	50137	JHHYCKOF304600124	4000
31	Unregistered 30	Water Bowser	Hino	Euro 500	2022	4WD	No Task Assigned	50135	JHHYCKOF04600122	4600
32	Unregistered 31	Mini-Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	PKT381845	SR308PK486509	796
33	Unregistered 32	Mini-Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	PKT381849	SR308PK486519	796
34	STM-7370	Car	Suzuki	Cultus	2006	2WD	Transport of Staff	342566	954375	1000
35	Unregistered 33	Mini-Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	PKT 381793	SR308PK486436	796
36	Unregistered 34	Mini-Tipper	Suzuki	Ravi	2022	2WD	No Task Assigned	PKT 381852	SR308PK486488	796
37	Unregistered 35	Truck	Hino	Euro 300	2022	4WD	No Task Assigned	50132	JHHYCKOFX04600119	4000
38	Unregistered 36	Truck	Hino	Euro 300	2022	4WD	No Task Assigned	50138	JHHYCKOF504600125	4000
39	Unregistered 37	Truck	Hino	Euro 300	2022	4WD	No Task Assigned	50136	JHHYCKOF4600123	4000

4.2 Baseline Fuel Consumption Trend

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

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

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)				
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption
1	Unregistered 1	10:15 AM	11:15 AM	0.79	0.79 Liters/hr	8:30 AM	10:10 AM		4.7	2.82 Liters/hr
2	Unregistered 2	10:18 AM	11:18 AM	1.79	1.79 Liters/hr	8:30 AM	10:05 AM		4.28	2.7 Liters/hr
3	Unregistered 3	10:17 AM	11:17 AM	1.57	1.57 Liters/hr	8:42 AM	10:10 AM		5.68	3.87 Liters/hr
4	Unregistered 4	10:15 AM	11:15 AM	1.5	1.5 Liters/hr	8:45 AM	10:10 AM		7.99	5.64 Liters/hr
5	Unregistered 5	10:25 AM	11:35 AM	2.13	1.83 Liters/hr	8:57 AM	10:23 AM		6	4.19 Liters/hr
6	Unregistered 6	11:12 AM	12:12 AM	0.8	0.06 Liters/hr	8:57 AM	10:10 AM		5.87	4.82 Liters/hr
7	Unregistered 7	11:17 AM	12:17 AM	2.21	0.17 Liters/hr	9:00 AM	11:15 AM		6.69	2.97 Liters/hr
8	Unregistered 12	10:39 AM	11:40 AM	1.51	1.49 Liters/hr	9:12 AM	10:35 AM		5.62	4.06 Liters/hr
9	Unregistered 13	10:40 AM	11:50 AM	1.18	1.01 Liters/hr	9:15 AM	10:35 AM		6	4.5 Liters/hr
10	STD-3274	10:26 AM	11:30 AM	2.51	2.35 Liters/hr	9:22 AM	10:23 AM		8.28	8.14 Liters/hr
11	Unregistered 15	10:55 AM	11:55 AM	1.34	1.34 Liters/hr	9:27 AM	10:45 AM		3.64	2.8 Liters/hr
12	Unregistered 16	10:48 AM	11:48 AM	0.48	0.48 Liters/hr	9:30 AM	10:40 AM		2.63	2.25 Liters/hr
13	Unregistered 17	10:50 AM	11:50 AM	1.12	1.12 Liters/hr	9:30 AM	10:40 AM		3	2.57 Liters/hr
14	Unregistered 18	11:32 AM	12:32 AM	1.4	0.11 Liters/hr	9:33 AM	11:30 AM		2.78	1.43 Liters/hr
15	Unregistered 23	11:35 AM	12:35 AM	5	0.38 Liters/hr	9:38 AM	11:30 AM		25.88	13.86 Liters/hr

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)				
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption
16	Unregistered 24	11:32 AM	12:32 AM	4.27	0.33 Liters/hr	9:48 AM	11:25 AM		37.02	22.9 Liters/hr

Table 27: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	Unregistered 1	2.88
2	Unregistered 2	3.73
3	Unregistered 3	3.81
4	Unregistered 4	3.80
5	Unregistered 5	3.79
6	Unregistered 6	2.84
7	Unregistered 7	6.43
8	Unregistered 8	2.99
9	Unregistered 9	3.55
10	Unregistered 11	5.71
11	Unregistered 12	3.69
12	Unregistered 13	4.98
13	Unregistered 14	5.07
14	STD-3274	1.43
15	Unregistered 15	0.87
16	Unregistered 16	0.88
17	Unregistered 17	0.93
18	Unregistered 18	0.94
19	Unregistered 19	0.89
20	Unregistered 20	0.94
21	Unregistered 21	1.06
22	Unregistered 22	1.05
23	Unregistered 23	3.57
24	Unregistered 24	3.59

The logbooks of remaining vehicles are not available in MC.

The MC made 16 of its vehicles available to the Consultant for carrying out on-field testing. The average fuel consumption of the vehicles in idle condition was found to be 1.02 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 3.76 liters/hour (excluding two vehicles which showed fuel consumption figures of 13.86 Liters/hr and 22.9 Liters/hr).

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

Table 28: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	147,792
Annual Cost of Fuel (Diesel)	PKR/y	43,303,056
Annual Consumption of Fuel (Petrol)	Liter/y	18,672
Annual Cost of Fuel (Petrol)	PKR/y	5,078,784

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 Daska MC are given below.

Figure 11: MC Vehicles

4.4 Observations and Recommendations

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

MC Daska has bought enough new vehicles to meet their daily demand. Based on the logbook data, the consultant cannot make any recommendation for replacement of old vehicles. A 6-month exercise should be

undertaken in which the distance travelled by each vehicle, its fuel consumption, weight of waste carried (in case of waste carrying vehicles), and O&M cost should be properly logged to calculate the efficiency of the vehicles. Once this activity is completed, the inefficient vehicles should be sold in the open market through a transparent auction.

As per information available with the Consultant, PMDFC is in the process of installing tracking devices on all new devices procured under PCP. It is recommended that similar devices are installed on the MC's existing fleet as well.

5 Municipal Buildings

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

5.1 GIS Map

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

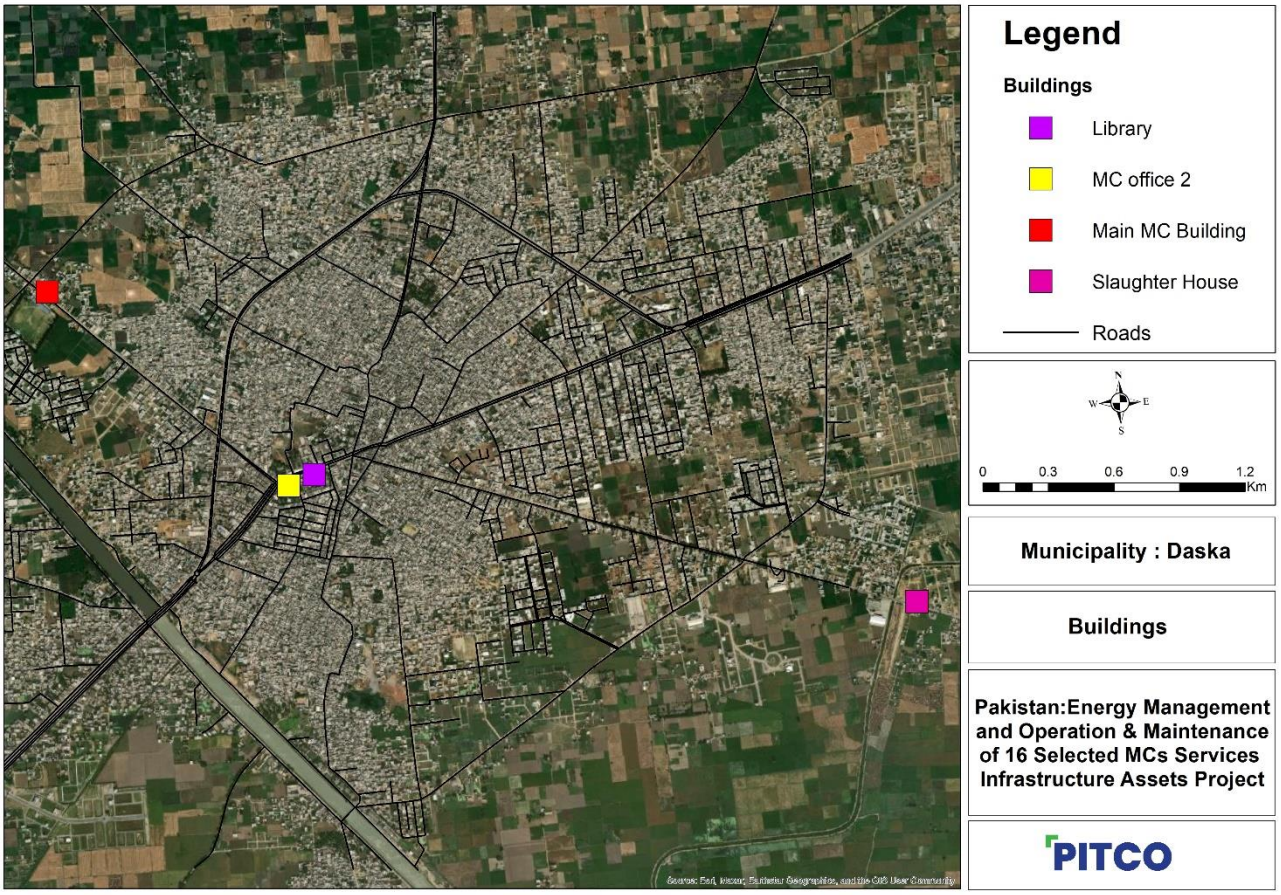


Figure 12: Map for Buildings

5.2 Building Details

Details of the MC buildings are given below.

Table 29: Buildings' Details

Sr. No.	Address	GPS	Unique ID	Ownership	Age of Building	Condition of Building	Total Area (m2)	Insulation of Building	Number of Floors
1	Main MC Building	N:32.339087 E:74.337398	51305061	MC	21	Satisfactory	1,251	No Proper Insulation	1
2	MC office 2	N:32.330646 E:74.348617	51305063	MC	3	Satisfactory	500.2	No Proper Insulation	1
3	Library	N:32.331047 E:74.349890	51405062	MC	11	Satisfactory	125	No Proper Insulation	1
4	Slaughter House	N:32.324589 E:74.378750	51505072	MC	37	Unsatisfactory	1,251	No Proper Insulation	1

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

Table 30: Number of Heating Units in MC Buildings

Sr. No.	Name of Room	Type of Heating Equipment	Equipment Count	Capacity in Watts	Daily operating hours[6]	No. of months used per year	Operating days per year	Annual Energy consumption (kWh/year)
MC Building & Mosque								
1	**Assistant Director office**	Electric Heater	1	1000	5	2	52	260
2	**MOI office**	Electric Heater	1	1000	8	3	78	624
3	**Sub-Engineer office**	Electric Heater	1	1000	8	3	78	624
4	**MOR Branch**	Electric Heater	1	1000	8	3	78	624
5	**MOP Branch**	Electric Heater	1	900	8	3	78	562
6	**Generator Branch**	Electric Heater	1	1000	8	3	78	624
MC office 2								
1	**Union Council**	Geyser	1	2000	1	4	104	208
	Total							**3,526**

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

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
Main MC Building								
1	**Director Office**	Ceiling Fan	1	80	8	7	182	116
2	**Director Office**	Split AC	1	1800	8	6	156	2,246
3	**Director Office**	Exhaust Fan	1	30	8	7	182	44
4	**Director Office**	Bracket Fan	1	50	8	7	182	73
5	**Assistant Director office**	Ceiling Fan	1	80	8	7	182	116
6	**C.O Office**	Ceiling Fan	3	80	8	7	182	349
7	**C.O Office**	Inverter	1	1700	8	8	208	2,829
8	**C.O Office**	Exhaust Fan	1	30	8	7	182	44
9	**MOI Office**	Ceiling Fan	2	80	8	7	182	233
10	**MOI Office**	Inverter	1	1150	8	8	208	1,914
11	**IRS Branch**	Bracket Fan	1	50	8	7	182	73
12	**IRS Branch**	Inverter	1	1150	4	8	208	957
13	**IRS Branch**	Exhaust Fan	1	30	8	7	182	44
14	**MOP Office**	Ceiling Fan	2	80	8	7	182	233
15	**MOP Office**	Inverter	1	1150	8	8	208	1,914
16	**MOP Office**	Exhaust Fan	1	30	8	7	182	44
17	**Open Hall**	Ceiling Fan	2	80	8	7	182	233
18	**Sub-Engineer**	Ceiling Fan	1	80	8	7	182	116
19	**Sub-Engineer**	Inverter	1	1150	8	8	208	1,914
20	**MOR Branch**	Ceiling Fan	1	80	8	7	182	116
21	**MOP Branch**	Ceiling Fan	1	80	8	7	182	116
22	**Open Area**	Ceiling Fan	3	80	8	7	182	349
23	**MOF Office**	Ceiling Fan	2	80	8	7	182	233
24	**MOF Office**	Split AC	1	1800	8	8	208	2,995
25	**General Branch**	Ceiling Fan	1	80	8	7	182	116
26	**Mosque**	Pedestal Fan	1	125	3	7	182	68
27	**Mosque**	Bracket Fan	2	50	3	7	182	55
MC office 2								
1	**Mosque Hall**	Ceiling Fan	1	80	3	7	182	44
2	**Sanitation Branch**	Ceiling Fan	1	80	8	7	182	116
3	**Sanitation Branch**	Inverter	1	1150	5	6	156	897
4	**Sanitation Branch**	Bracket Fan	1	50	2	7	182	18
5	**Sanitation Branch**	Exhaust Fan	4	30	8	7	182	175
6	**Union Council**	Ceiling Fan	1	80	8	7	182	116
7	**Union Council**	Exhaust Fan	1	30	2	7	182	11
8	**Death & Birth Branch**	Ceiling Fan	2	80	8	7	182	233
9	**Death & Birth Branch**	Window AC	1	5000	5	6	156	3,900

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
10	**Death & Birth Branch**	Exhaust Fan	1	30	1	7	182	5
11	**Meeting Hall**	Bracket Fan	4	50	2	7	182	73
12	**Meeting Hall**	Inverter	1	1150	2	6	156	359
13	**Meeting Hall**	Exhaust Fan	3	30	2	7	182	33
14	**Water Supply Branch**	Ceiling Fan	1	80	8	7	182	116
15	**Electric Store**	Ceiling Fan	1	80	8	7	182	116
16	**Open Area**	Ceiling Fan	1	80	8	7	182	116
Library								
1	**Main Hall**	Ceiling Fan	7	80	8	7	182	815
2	**Retiring Room**	Bracket Fan	1	50	4	7	182	36
3	**Outside**	Ceiling Fan	1	80	8	7	182	116
Slaughter House								
1	**Main Hall**	Ceiling Fan	21	80	6	7	182	1,835
	Total Annual kWh							**26,673**

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

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Electricity consumption (kWh/year)
Main MC Building							
1	**Director Office**	LED	6	18	8	312	270
2	**Director Office**	LED	5	12	8	312	150
3	**Assistant Director**	LED	3	18	8	312	135
4	**Assistant Director**	LED	4	7	8	312	70
5	**Assistant Director**	LED	1	18	8	312	45
6	**Outside Director**	LED	2	12	8	312	60
7	**C.O Office**	LED	18	12	8	312	539
8	**C.O Office**	LED	2	7	8	312	35
9	**MOI Office**	LED	14	12	8	312	419
10	**IRS Branch**	LED	5	12	8	312	150
11	**MOP Office**	LED	12	12	8	312	359
12	**MOP Office**	LED	1	7	8	312	17

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

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Electricity consumption (kWh/year)
13	UPS Room	LED	4	12	8	312	120
14	Open Hall	LED	13	12	8	312	389
15	Washroom	LED	3	12	8	312	90
16	Sub-Engineer office	LED	4	12	8	312	120
17	MOR Branch	LED	4	12	8	312	120
18	MOP Branch	LED	4	12	8	312	120
19	Open Area	LED	17	12	8	312	509
20	Kitchen	LED	1	12	8	312	30
21	MOF Office	LED	7	12	8	312	210
22	MOF Office	LED	1	7	8	312	17
23	MOF Office	LED	2	18	8	312	90
24	General Branch	LED	4	12	8	312	120
25	Mosque	LED	2	30	3	312	56
26	Outside Building	LED	4	18	8	312	180
27	Outside Building	LED	4	120	8	312	1,198
28	Outside Building	LED	1	12	8	312	30
MC office 2							
1	Mosque Hall	LED	2	12	2	312	15
2	Kitchen	LED	1	12	4	312	15
3	Sanitation branch	LED	6	12	10	312	225
4	Sanitation branch	LED	1	18	10	312	56
5	Union Council	LED	6	12	8	312	180
6	Union Council	LED	2	18	8	312	90
7	Death & Birth branch	LED	3	30	8	312	225
8	Death & Birth branch	LED	1	12	2	312	7
9	Death & Birth branch	LED	1	18	2	312	11
10	Meeting Hall	LED	16	18	2	312	180
11	Meeting Hall	LED	2	12	2	312	15
12	Water Supply Branch	LED	8	12	8	312	240
13	Electric Store	LED	1	30	8	312	75
14	Open Area	LED	2	12	8	312	60
15	Outside	CFL	2	24	12	312	180
16	Outside	LED	1	12	12	312	45
17	Outside	LED	3	50	12	312	562
Library							
1	Main Hall	LED	35	18	6	312	1,179
2	Main Hall	LED	1	30	8	312	75
3	Retiring Room	LED	4	18	4	312	90
4	Outside	Tube Light	2	40	12	312	300
Slaughter House							
1	Doctor Room	LED	1	12	8	312	30
2	Main Hall	LED	8	30	8	312	599

Sr. No	Name of Room	Type of Lighting Equipment	Equipment Count	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Electricity consumption (kWh/year)
3	**Main Hall**	LED	2	12	8	312	60
4	**Outside**	LED	4	12	12	312	180
5	**Outside**	Mercury Bulb	1	110	0	312	0
	Total Annual kWh						**10,526**

5.3 Baseline Energy Consumption Trend

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

Table 33: Energy consumption in Office Buildings

SI No.	Description	Unit	Value[9]
1	Annual Electricity Consumption	kWh	48,608
2	Annual NG Consumption	MMBTU	N/A
3	Annual Water Consumption	m^3	Not metered

[9] Based on Utility Bills

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

		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Buildings	4	4	54,334	48,608	5,726	N/A	N/A	The KPI for municipal buildings cannot be accurately determined as the meters in the main MC building and the MC office are shared with pumpsets and streetlights. No accurate opinion can be provided on the increase in electricity consumption in these buildings as the connections are shared. Electricity consumption from the shared meters has not been included in the comparison.

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

Table 34: Cooling Equipment Comparison

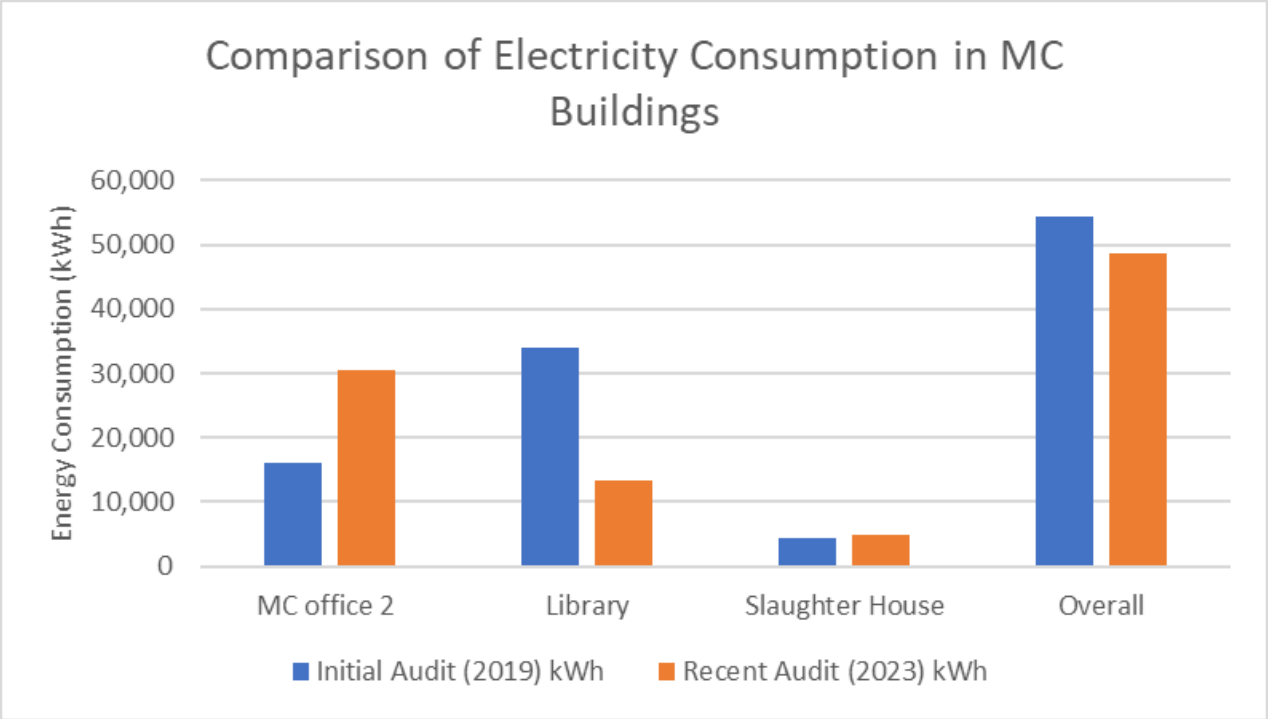
Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Daska main office	Ceiling Fan	9	0	20
MC Daska main office	Bracket Fan	10	0	4
MC Daska main office	Split AC	2	0	2
MC Daska main office	Exhaust Fan	3	0	4
MC Daska main office	Inverter	-	-	5
MC Daska main office	Pedestal Fan	-	-	1
MC library	Ceiling Fans	13	0	8
MC library	Bracket Fan	-	-	1
Slaughter House	Ceiling Fans	26	0	21
Slaughter House	Bracket fans	1	0	0
MC Daska Office 2	Ceiling Fans	2	0	8
MC Daska Office 2	Bracket fans	1	0	5
MC Daska Office 2	Inverter	-	-	2
MC Daska Office 2	Exhaust Fan	-	-	9
MC Daska Office 2	Window AC	-	-	1

Table 35: Lighting Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Daska main office	LED	18	0	148
MC Daska main office	CFL	27	27	0
MC library	Tube Light	9	9	2
MC library	LED	7	0	40
Slaughter House	LED	16	0	15
Slaughter House	Mercury Bulb	-	-	01
MC Daska Office 2	LED	9	0	60
MC Daska Office 2	CFL	2	2	2

Table 36: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh
Main MC Building	Cannot be determined as meter is shared	Cannot be determined as meter is shared
MC office 2	16,065	30,445
Library	33,930	13,404
Slaughter House	4,339	4,759



5.4 Maintenance Logs of Buildings

No record was available with the MC, for the maintenance, replacement and retrofitting (if any) that took place in the office buildings during past few years.

6 Solar Assessment for MC Daska

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

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

MC Main Office Building, Library, and 2 meters of Mc Office No.2 have a Three Phase 400V electrical connection whereas, Slaughterhouse and 1 meters of Mc Office No.2 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 5kW based on the historical electricity bill, the Consultant has provided the detailed assessment of available solar system capacity. Metering details of each building is presented below.

Table 37: Metering details at MC Daska

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Main MC Building	51305061	28122210002101 (3ϕ)	225	A-3a (66)
2	MC office 2	51305063	07122210781900 (3ϕ)	13	A-3a (66)
			28122211668200 (3ϕ)	22	A-3a (66)
			08122221590101 (1ϕ)	2	A-3a (66
3	Library	51405062	28122211660500 (3ϕ)	22	A-3a (66)
4	Slaughterhouse	51505072	01122230509800 (1ϕ)	1	A-3a (66)

6.1 Main MC Building

The project site i.e. Main Office Building is located near Stadium Road, Daska, Punjab, Pakistan while the geographical co-ordinates of location are 32.33866°N (latitude) and 74.33700°E (longitude).

Figure 13: Front view of MC Office Building

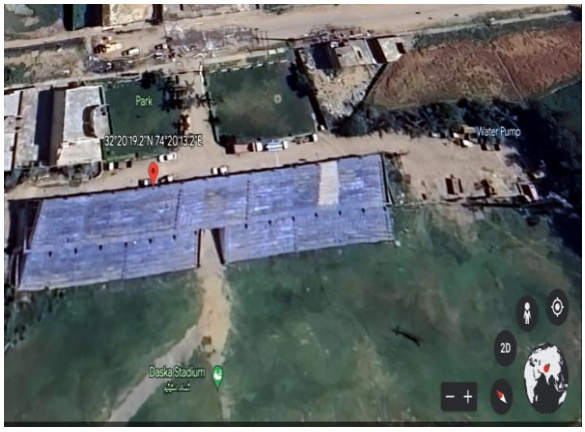


Figure 14: Aerial view of MC Office Buildings

6.1.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of electrical connection at MC Office Building is 217,360 kWh [10]with the peak electricity consumption of 63,840 kWh in December 2022. The annual energy consumption for Main MC building cannot be accurately determined as this meter is shared with disposal pumpset therefore, the Consultant has only carried out the assessment of space availability for the installation of solar system.

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Building is 13,465 ft^2 however, there is no clear space available for the installation of solar system.

Figure 15: Top View of complete building

6.2 MC Office No.2

The project site i.e. Mc Office No.2 is located near civil rest house, kachehri road, Daska, Sialkot, Punjab ,Pakistan while the geographical co-ordinates of location are 32.33037°N (latitude) and 74.34879°E (longitude).

[10] Nawaz Sharif Stadium disposal is the main consumer of this annual electricity consumption.

Figure 16: Front view of Mc Office No.2

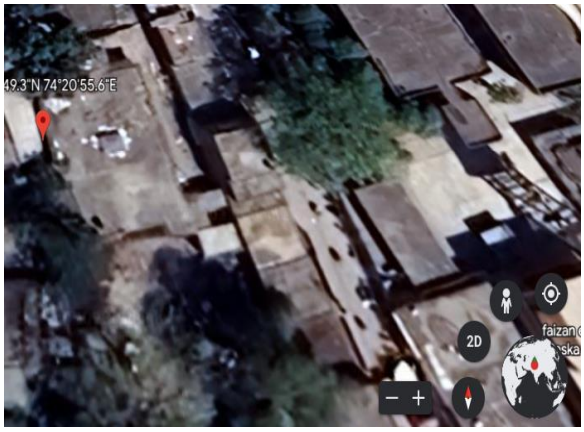


Figure 5: Aerial view of Mc Office No.2

6.2.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Mc office (No.2) at Meter 1 is 17,651 with peak energy consumption is 2,375, Meter 2 is 31,863 with peak energy consumption is 10,343 and Meter 3 is 12,794 with peak energy consumption is 2,548.

The Consultant has estimated the solar system requirement of the building, which is presented below in the following table. Furthermore, the annual energy consumption for Main MC office cannot be accurately determined as Meter 1 is shared with Street lights and Meter 2 is shared with water supply pumpset therefore, the Consultant has estimated the solar system requirement based on the energy consumption of the Meter 3, which is presented below in the following table.

Table 38: Solar System Requirement

Meter Sr. No	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
Meter 1	07122210781900	17,651	1,470	2,375[11]	-
Meter 2	28122211668200	31,863	2,655	10,343[12]	-
Meter 3	08122221590101	12,794	1066	2,548[13]	9

6.2.2 Roof Assessment

As per the Consultant's assessment, the total area of the Mc office No.2 is 5,384 ft^2 whereas, the total area of rooftop available for the solar installation is 2,576 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

[11] Peak of this electric meter is in August 2022.
[12] Peak of this electric meter is in October 2022.
[13] Peak of this electric meter is in Jully 2022.

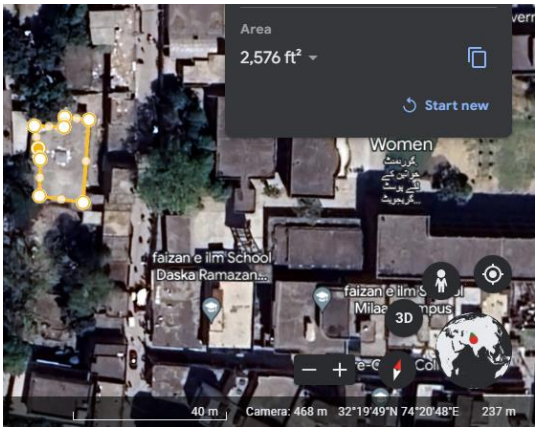


Figure 17: Top View of Complete building

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

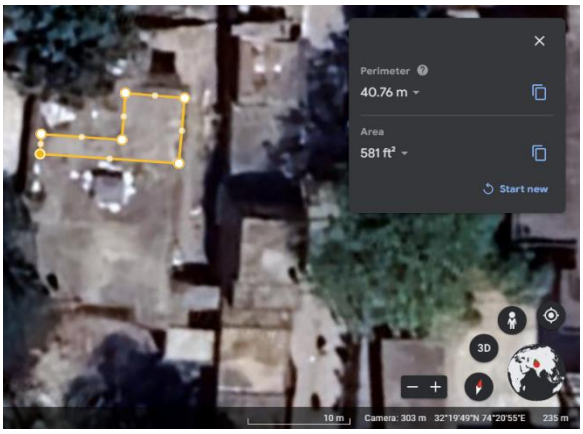


Figure 18: Location for Installation-A

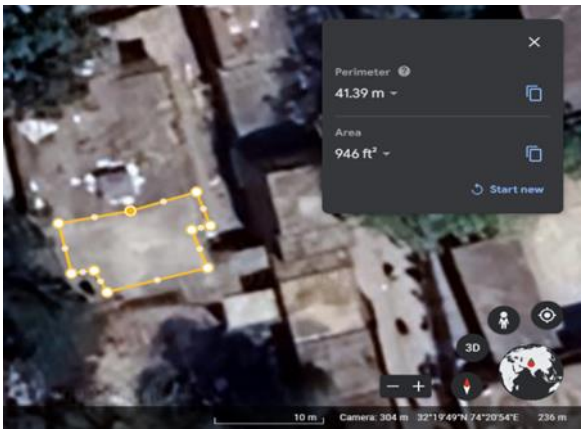


Figure 19: Location for Installation-B

Table 39: System Size Calculation with Respect to Area

Parameters	Location A	Location B	Total
Area availability (ft²)	581	946	1,527
Solar system capacity (kW)	6	9	15

Note: Based on the assessment of the historical billings it is identified that the system requirement at Meter 3 is **9 kW**. It is recommended to install and synchronize solar system with a Three-Phase electrical connection.

6.3 Library

The project site i.e. Library is located near kachehri road, Daska, Sialkot, Punjab, Pakistan while the geographical co-ordinates of location are 32.3310°N (latitude) and 74.3500°E (longitude).

Figure 20: Front view of the Library

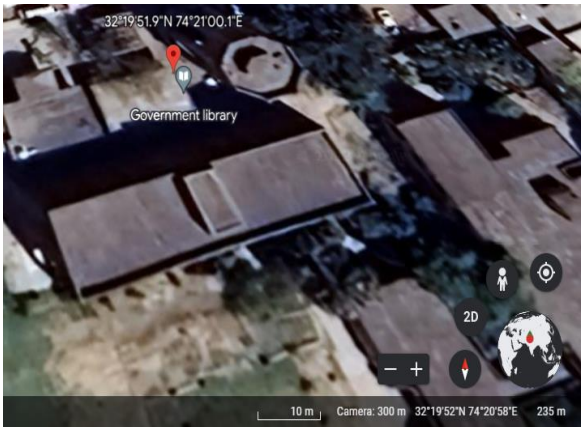


Figure 21: Aerial view of the Library

6.3.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Library is 13,404 kWh with the peak electricity consumption of 6,437 kWh in March 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	28122211660500	13,404	1,117	6,437	10

6.3.2 Roof Assessment

As per the Consultant's assessment, the total area of the Library is 3,588 ft^2 whereas, the total area of rooftop available for the solar installation is 2,042 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

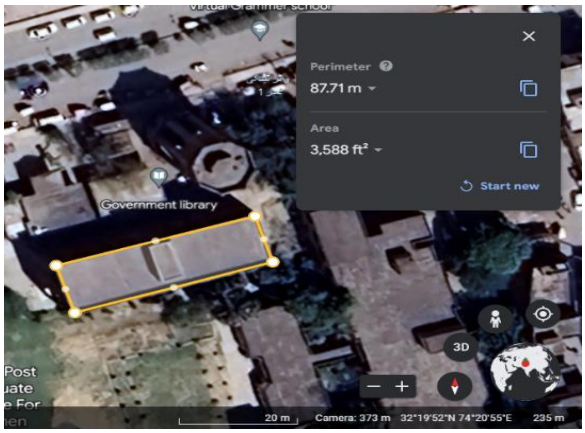


Figure 22: Top View of Complete building

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

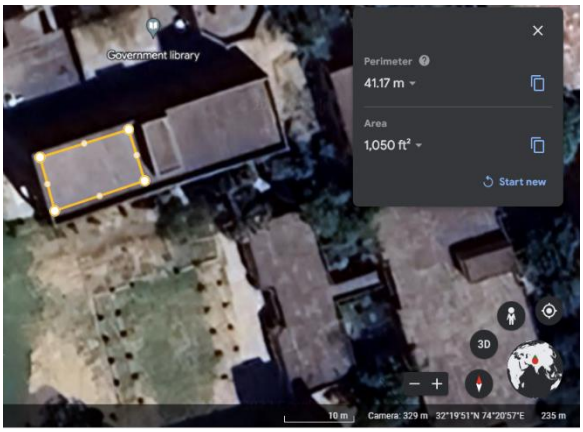


Figure 23: Location for Installation- A

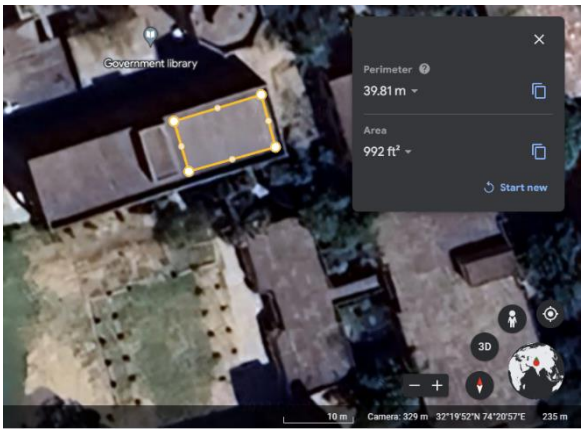


Figure 24: Location for Installation-B

Table 41: Solar System Requirement

Parameters	Location A	Location B	Total
Area availability (ft²)	1,050	992	2,042
Solar system capacity (kW)	10	10	20

Note: Based on the assessment of the historical billings it is identified that the system requirement for this site is **10 kW** with solar installation capacity of 20 kW.

6.4 Slaughterhouse

The project site i.e. Slaughter House is located near Pasrur road, madharian wala kalar, Sialkot, Punjab, Pakistan while the geographical co-ordinates of location are 32.324589°N (latitude) and 74.378750°E (longitude).

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 Slaughterhouse 4,759 kWh with the peak electricity consumption of 526 kWh in January 2023. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 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	01122230509800	4,759	396	526	3

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

6.5 Net Metering Consideration

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

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

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

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

6.5.1 Net-metering application procedure

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

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

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

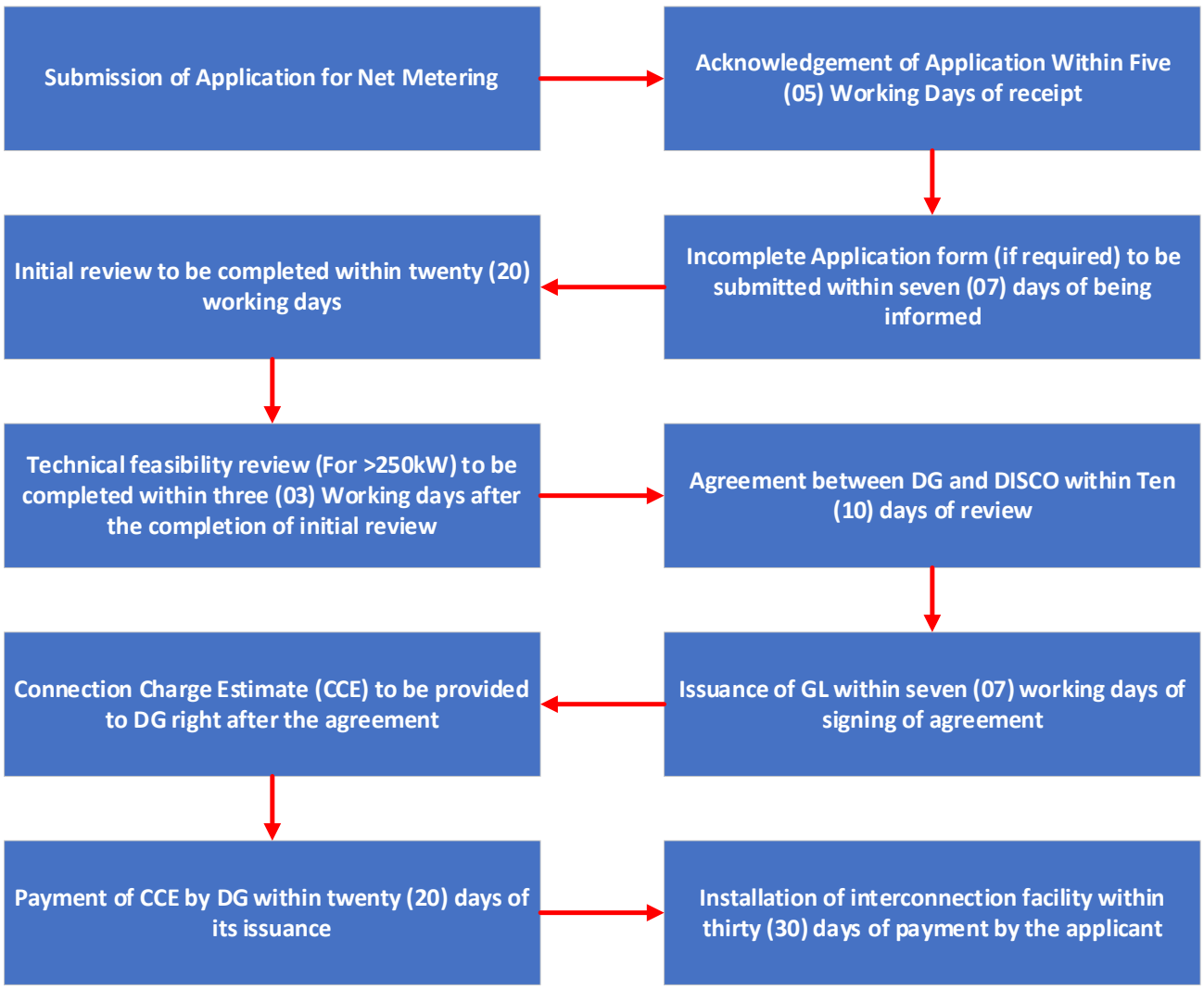


Figure 27: Pakistan Net Metering Application Process

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

A. High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Colony No. 2 water supply - Unique ID: 31206462)

Study & Investigation

Efficiency of existing water pumpset could not be determined due to issues with the bore. The savings are calculated based on the network averages.

Recommended Action

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

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

Saving Assessment

Table 43: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	102
Design Head of Existing Pump	ft	120
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	108
Measured Head	m	20.2
Measured Motor Power	kW	18.20
Pump Efficiency	%	38%
Existing Operational Hours	h	10.5
Proposed Pump Flow	m^3/h	102
Proposed Head	m	30
Power Consumption of Proposed Pump	kW	13.4
Motor Size of Proposed Pump	hp	25.0
Operational Hours of Proposed Pump	h	11.1
Pump Operational Days	days	330
Efficiency	%	82%
Energy Required by Existing Pump	kWh/y	63,063
Energy Required by Proposed Pump	kWh/y	49,289
Saving Potential	kWh/y	13,774
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,212
Investment	US $	3,794
Simple Payback Period	months	21

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

Description

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

Study & Investigation

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

Recommended Action

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

Saving Assessment

Table 44: 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	Purana Kacheri road	5130556	2.5	3.0	50	150
2	College Road	5130558	2.5	3.0	50	150
3	Civil Hospital	5130560	2.5	3.0	50	150
4	Lari Adda	5140563	2.5	3.0	50	150
5	New Kachehri	5140564	2.5	3.0	50	150
6	Awami Road	5150570-A	2.5	3.0	50	150
7	Nawaz Sharif Stadium	5150573-A	2.5	3.0	50	150
8	Nawaz Sharif Stadium	5150573-B	5.0	3.0	50	150
9	Nawaz Sharif Stadium	5150573-C	2.5	3.0	50	150
10	Nawaz Sharif Stadium	5150573-D	7.5	3.0	75	225
Total						**1575**

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

Description

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

Study & Investigation

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

Recommended Action & Benefits

- It is recommended to install nineteen (19) smart water meters on all operational potable water and disposal pumps.
- DCS system will help in water data review, development of KPI, analysis of generation and consumption trends during different seasons and times of year.
- In the long term, the measure will help the GoPb tremendously if it intends to meter the water usage of its commercial and domestic consumers, and determine a water tariff (based on actual consumption).
- Overall reduction in water & corresponding energy consumption

Saving Assessment

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

Table 45: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	1,644,189
Annual Water consumption (post-implementation)	m^3/y	1,627,747
Annual Water saving per year	m^3/y	16,442
Estimate of Investment (including the cost of the server)	US$	19,000

7.2 Energy Efficiency Measures for Streetlights

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

Project

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

Study & Investigation

During the assessment it was observed that there are 528 streetlights are being operated by the municipality. Out of these, 107 were found to be non-operational. It was also observed that all of streetlights are manually operated.

Recommended Action

It is recommended to install LEDs at all non-functional MC operated streetlights along with photocell switches and energy meters for measurement of energy consumption. It is recommended to install 50-watt LED for streetlights installed at a height of 20 feet of more & 30-watt LED for the streetlight installed at a height of less than 20 feet. LED lamps will have less maintenance issues as compared to conventional ballast; also, the life of the lamp will be increased because of electronic ballast. It will improve visibility during night and foggy season and reduce electricity consumption.

Figure 28: 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 46: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	107
Number of non-functional streetlights (>20 feet)	#	43
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	64

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	24
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	5,584,443
Proposed number of photocell switches	#	10
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	10,000
Upfront investment cost	PKR	5,594,443
Upfront investment cost	US$	19,966
Annual Operating Electricity unit	kWh/yr	16,145
Annual Operating Cost	PKR/yr	726,511
Annual maintenance cost	PKR/month	1,440,000
Monthly O&M Cost	PKR/month	180,543
Monthly diesel cost for operating fork lifter for two days	PKR/month	20,000
Monthly cost of renting Fork Lifter for two days	PKR/month	80,000
Miscellaneous Cost	PKR/month	20,000
Monthly maintenance cost	PKR/month	120,000

7.3 Energy Efficiency Measures for Buildings

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

Project

Replacement of inefficient equipment with new efficient equipment.

Study & Investigation

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

Table 47: Replacement of inefficient equipment at office buildings

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment (Watt)	Overall Wattage of Proposed Equipment (Watt)	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters (PKR)
MC Office 2											
1	CFL	2	24	48	120	LED Bulb 13 Watts	13	26	65	350	700
2	Window AC	1	5000	5000	3,900	Inverter 1.5 ton	1,452	1,452	1,133	143,000	143,000
Library											
1	Tube Light	2	40	80	200	LED Rod 20 Watts	20	40	100	2,900	5,800
Slaughter House											
1	Mercury Bulb	1	110	110	275	LED Bulb 50 Watts	50	50	125	6,800	6,800

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 48: Saving & cost benefit analysis

Parameters	Unit	Value
Average Operational Days for Building Lighting Equipment	days/year	312
Average Operational Hours for Building Lighting Equipment	Hours/day	8
Average Operational Days for Building Cooling Equipment	days/year	156
Average Operational Hours for Building Cooling Equipment	Hours/day	5
Energy consumption of inefficient Equipment	kWh/yr	4,494
Energy consumption of Proposed Equipment	kWh/yr	1,422
Energy Savings	kWh/yr	3,072

Parameters	Unit	Value
Unit cost of electricity	PKR/kWh	45
Annual cost savings	USD	493
Upfront Investment (including change in fixtures)	USD	558
Payback Period	Months	14

8 Investment Estimate (including Material Specification/Quantities)

8.1 Potable Water Pump

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

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

Pump Size		10 MC /4 Stages			
Capacity		101.94 m3/hr	Max. O.D bowl		9.5 Inches
Speed		1450 rpm	I.D tubewell	-	
Pump Input		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

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

Column Pipe assembly

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

Component parts of each pumping unit

Pump assembly of	5	stages with flow type impellers				
Column assembly of	6	inches I.D with flanged joins		each 10 ft length	0	Sets
				and one top set	1	feet length
Discharge head Inch	6			column shaft dia	0	mm
Electric Motor vertical hollow shaft 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

8.2 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	43	53,873	2,316,539
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	64	51,061	3,267,904
3	Accessories	Photocell switch				10	1,000	10,000

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
Lumpsum Price (PKR)								**5,594,443**
Lumpsum Price (USD)								**19,966**

8.3 Investment Estimate (including Material Specification/Quantities) Buildings

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

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

Sr. No	Proposed Equipment	Wattage of Proposed Equipment	Equipment Count	Overall Wattage of Proposed Equipment	Individual Cost of Proposed Equipment (PKR)	Cost of Proposed Equipment
1	LED Bulb 13 Watts	13	1	13	350	350
2	LED Rod 20 Watts	20	1	20	2,900	2,900
3	LED Bulb 50 Watts	50	1	50	6,800	6,800
4	Inverter 1.5 ton	1,452	1	1,452	143,000	143,000
Lumpsum Price (PKR)						**156,300**
Lumpsum Price (USD)						**558**

9 Summary of Energy Efficiency Measures

MC Daska's annual energy consumption is 2,809,109 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$ 2,705** with an estimated investment of **US$ 44,892**
- Reduce electricity consumption by approx. **16,846 kWh**
- Reduce GHG Emissions by **8 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of GEPCO

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

Annexure 2: List of Energy Audit Equipment

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

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