Bahawalnagar Municipal Committee

Energy Audit Report

June 2023

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

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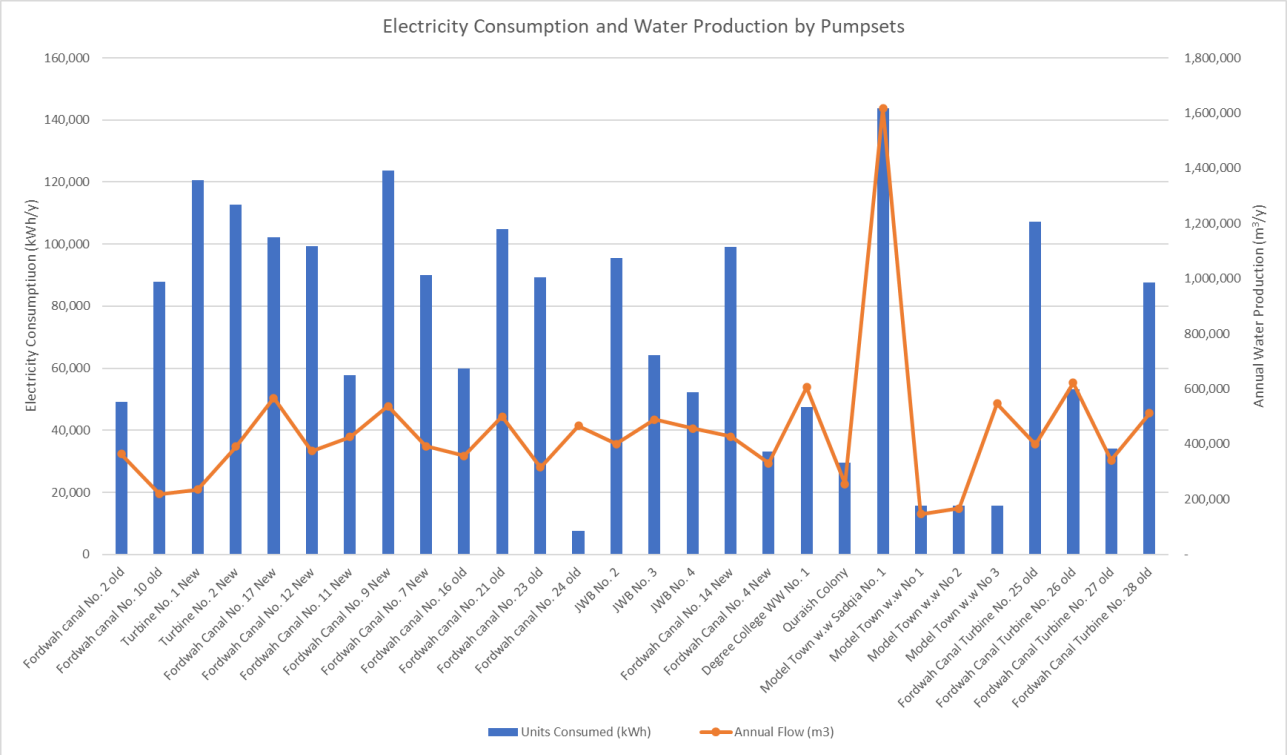


ABBREVIATIONS

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

UNITS OF MEASUREMENTS

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

CONVERSION FACTORS

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

BASELINE PARAMETERS

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

1 Summary

1.1 Background

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

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

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

1.2 Scope of work

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

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

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

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

1.4 Bahawalnagar MC Background

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

Bahawalnagar is one of the important cities of the former Bahawalpur state and is the connecting link for Fort Abbas and Meleod Ganj, two important Mandis (markets), with the main Karachi – Peshawar Railway line, which passes through Samasatta.

Bahawalnagar is a small town with narrow roads. The main road of the town runs through the city and the railway colony. On the eastern side, it leads to grain market and on the south – west it connects the city to the road running towards Haroonabad. The road on the western side along with the railway line connects the city with Chistian and Hasilpur.

The Administration consists of Administrator, Chief Officer and 3 Municipal Officers to provide basic services to its customers i.e. town planning, water supply, sewerage, streetlights, roads, regulate markets, issue permits and licenses etc. The Bahawalnagar MC has the following management.

Sr. No.	Name of Officer	Designation
1	Mr. Muhammad Sohaib Butt	Administrator
2	Mr. Muhammad Shafiq	Chief Officer
3	Mr. Abdul Razzaq*	Municipal Officer (Infrastructure)
4	Mr. Muhammad Shafiq	Municipal Officer (Regulation)
5	Mr. Muhammad Usman	Municipal Officer (Planning)

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

1.4.1 Baseline Energy Consumption of Bahawalnagar

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

Table 1: Baseline Energy Data

Particulars	Unit	Value
Electrical energy used by Tubewells[1]	kWh/year	2,848,281
Electrical energy used by Wastewater Disposal[2]	kWh/year	461,652
Electrical energy used in Buildings[3]	kWh/year	62,990
Electrical energy used by Streetlights[4]	kWh/year	99,952
Diesel used by Vehicles	liter/year	31,116
Petrol used by Vehicles	liter/year	10,368

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)	0.22
2	Energy Density of Wastewater Disposal	(kWh/m^3)	0.04
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)	9.77
5	Energy Cost on Wastewater Disposal	(PKR/m^3)	1.91
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)	3,876
2	Average electricity consumed per light pole/fixture	(kWh/year/ fixture)	284
3	Average cost of purchase of (i) pole/fixture and (ii) lighting equipment	PKR/Pole	41,666

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

Sr. No.	Description	Unit	KPI
		PKR/Lighting Equipment	38,518
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)	93,878
6	Average daily duration of operation	(Hour)	12.0
7	Average energy costs per kilometer of lit roads	(PKR/km)	174,416
8	Average energy costs per light pole/fixture	(PKR/ fixture)	12,778
9	Number and percentage of failed public lights		46%

1.5.3 Buildings

Table 4: KPIs for Buildings

Sr. No	Description	Unit	KPI
1	Municipal Buildings Electricity Consumption	(kWh/m^2)	2.42
2	Municipal Buildings Heat Consumption	(kWh/m^2)	0.03
3	Average Energy Cost of Heating	(PKR/m^2)	1
4	Average Energy Cost of Cooling	(PKR/m^2)	44
5	Average Energy Cost of Lighting	(PKR/m^2)	27

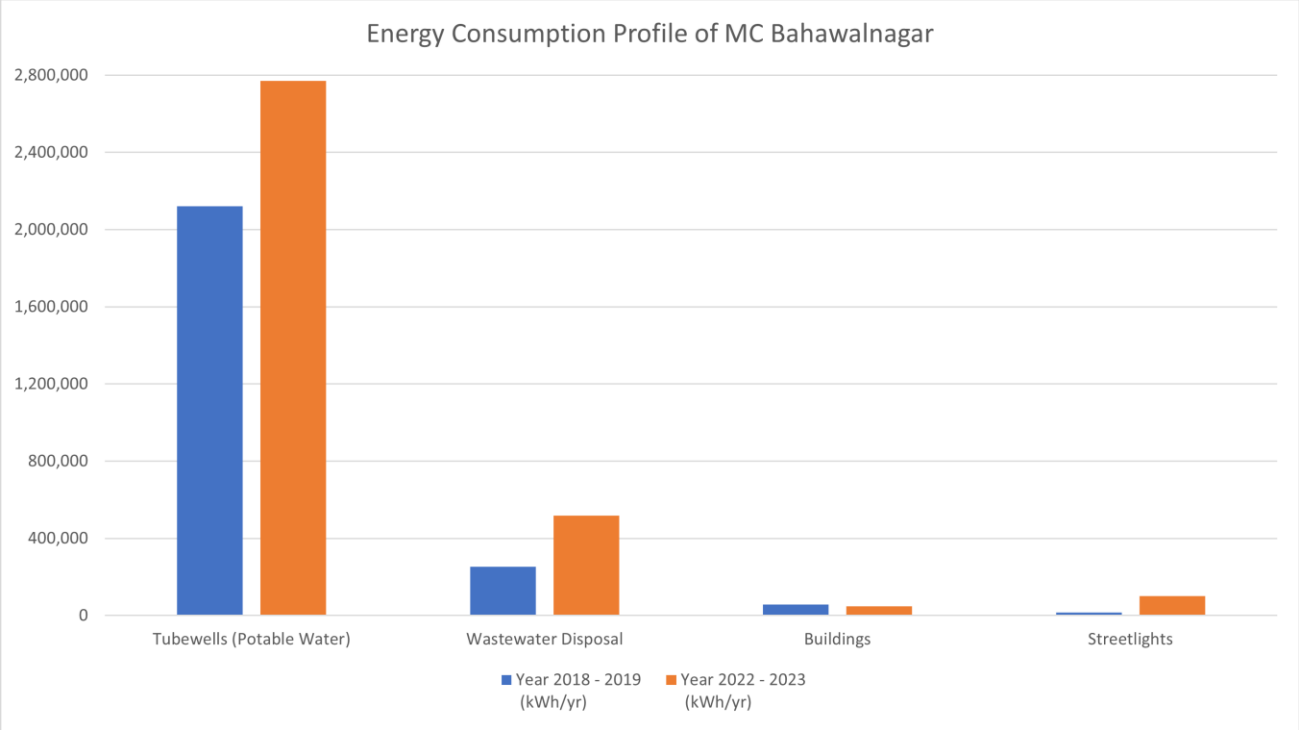
1.5.4 Vehicles

Table 5: KPIs for Vehicles

Sr. No	Description	Unit	KPI
1	Fuel consumption for staff transport vehicles	Liter/km	Cannot be Determined
2	Fuel consumption for solid/liquid waste transport	Liter/km	0.09
3	Expenditure on fuel for staff transport vehicles	PKR/km	Cannot be Determined
4	Expenditure on fuel for solid/liquid waste transport	PKR/km	26

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 Bahawalnagar
2,800,000
2,400,000
2,000,000
1,600,000
1,200,000
800,000
400,000
0
Tubewells (Potable Water)
Wastewater Disposal
Buildings
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)	32	35	2,120,752	2,848,281	-727,529	0.30 kWh/m3	0.22 kWh/m3	Replacement of 23 pumpsets were recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 11 pumpsets which has resulted in significant improvement in the KPI for water supply. As seen from the KPI, the water supply pumpsets are performing efficiently and the corresponding water supply to the MC has increased significantly. Moreover, number of operational pumpsets have increased due to which the annual energy consumption has increased.
2	Wastewater Disposal	6	10	252,863	461,652	-208,789	0.05 kWh/m3	0.04 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	6	57,473	48,838	8,635	8.29 kWh/m2	7.05 kWh/m2	Bus Stand building and Audit Branch building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these building has not been considered in

		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 overall energy consumption and KPI calculations. Furthermore, there are no electricity units in the electricity bill of Slaughter House for this assessment period and there was no electricity bill for Fire Brigade building during the last assessment so, for the purpose of this comparison, their energy consumption are also not considered in the overall energy consumption and KPI calculations.
4	Streetlights	65	254	14,393	99,952	-85,559	1,043 kWh/km	3,876 kWh/km	Although the MC has undertaken replacement of inefficient streetlights withs LEDs and installed 189 new efficient LEDs, a sevenfold increase in the overall billing for streetlights has been observed. This points to potential misuse of the MC's electricity connections resulting in significantly increased billing for the MC. This needs to be further investigated together.

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 (Fordwah canal No. 2 old - Unique ID: 31806588)	17,070	3,594	1,007,000	2,742	768,169	16	9
Replacement of Pumpset at (Fordwah canal No. 10 old - Unique ID: 31806594)	19,692	3,594	1,007,000	3,163	886,141	14	10
Replacement of Pumpset at (Turbine No. 1 New - Unique ID: 31806595)	49,206	3,594	1,007,000	7,902	2,214,251	5	25
Replacement of Pumpset at (Fordwah Canal No. 11 New - Unique ID: 31806607)	11,148	3,594	1,007,000	1,790	501,662	24	6
Replacement of Pumpset at (Fordwah canal No. 23 old - Unique ID: 31806624)	28,544	3,594	1,007,000	4,584	1,284,487	9	14
Replacement of Pumpset at (JWB No. 4 - Unique ID: 31906645)	10,158	3,594	1,007,000	1,631	457,112	26	5
Replacement of Pumpset at (JWB No. 5 - Unique ID: 33107038)	35,191	3,594	1,007,000	5,652	1,583,615	8	18
Replacement of Pumpset at (Degree College WW No. 1 - Unique ID: 31806640-1)	32,899	4,151	1,163,000	5,284	1,480,440	9	17
Replacement of Pumpset at (Quraish Colony - Unique ID: 33007036-1)	10,335	4,151	1,163,000	1,660	465,094	30	5
Replacement of Pumpset at (Model Town w.w Sadqia No. 1 - Unique ID: 82907316-1)	42,647	4,657	1,305,000	6,849	1,919,094	8	21
Replacement of Pumpset at (Model Town w.w No 1 - Unique ID: 82907316-2A)	16,615	4,151	1,163,000	2,668	747,694	19	8
Replacement/Installation of Capacitors	Not Quantifiable	5,600	1,569,120	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Installation of LEDs at all non-functional MC operated streetlights	Not Quantifiable	40,588	11,372,703	Not Quantifiable	Not Quantifiable	Not Quantifiable	Not Quantifiable
Replacement of inefficient equipment in the buildings	7,306	493	138,000	1,173	328,761	5	4
Total:	**280,812**	**88,947**	**24,922,823**	**45,098**	**12,636,521**		**141**

Table 7: Medium Priority Measures

Medium Priority Energy Efficiency Measure	Electricity Saving kWh/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Replacement of existing MC operated non efficient streetlights with LEDs	526	182	51,061	84	23,652	26	0
Total:	**526**	**182**	**51,061**	**84**	**23,652**	**26**	**0**

Table 8: Low Priority Measures

Low Priority Energy Efficiency Measure	Water Savings m^3/y	Investment Cost US $	Investment Cost PKR	Monetary Savings US $/y	Monetary Savings PKR/y	Simple Payback Months	Annual Emission Reduction tCO_2/y
Installation of Flow meters integrated with a centralized DCS system	129,385	106,000	29,701,200	0	0	0	Not Quantifiable
Total:	**129,385**	**106,000**	**29,701,200**	**0**	**0**	**0**	**0**

2 Water Pumps and Disposals

Bahawalnagar MC has seventy-seven (77) tubewells for groundwater, all of which are manually operated. Out of these, 35 pumpsets were found to be in working condition.

The MC has seven (7) disposal station having twenty-nine (29) pumps. Out of these 10 pumps were found to be in working condition. The pumps are used to dispose the wastewater to the nearby drain. There are eight (8) dewatering sets in the MC, out of which six 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 twenty-four (24) operational sites since the Sluice valves were either jammed or broken.

(iii) Undertake assessment of the following pumpsets as they were under maintenance

1. Ford wah # 1 Old (Unique ID: 31806587)
2. Fordwah canal No. 3 old (Unique ID: 31806589)
3. Fordwah Canal No.19 (old) (Unique ID: 31806620)
4. Fordwah canal No. 20 old (Unique ID: 31806621)
5. Model Town w.w Sadqia No. 2 (Unique ID: 82907316-2)
6. Fordwah Canal Turbine No. 29 old (Unique ID: 82907776)

(iv) Undertake assessment of the following pumpsets as the sites have been abandoned by the MC

1. Ford wah Canal # 01 Old (Unique ID: 31806586)
2. Fordwah canal No. 5 old (Unique ID: 31806590)
3. Fordwah canal No. 6 old (Unique ID: 31806591)
4. Fordwah canal No. 7 old (Unique ID: 31806592)
5. Fordwah canal No. 9 old (Unique ID: 31806593)
6. Turbine No. 3 New (Unique ID: 31806597)
7. Fordwah Canal No. 21 New (Unique ID: 31806598)
8. Fordwah Canal No. 20 New (Unique ID: 31806599)
9. Fordwah Canal No. 19 New (Unique ID: 31806600)
10. Fordwah Canal No. 18 New (Unique ID: 31806601)
11. Fordwah Canal No. 16 New (Unique ID: 31806603)

12. Fordwah Canal No. 13 New (Unique ID: 31806605)
13. Fordwah Canal No. 10 New (Unique ID: 31806608)
14. Fordwah Canal No. 8 New (Unique ID: 31806610)
15. Fordwah Canal No. 6 New (Unique ID: 31806612)
16. Fordwah Canal No. 5 New (Unique ID: 31806613)
17. Fordwah canal No. 15 old (Unique ID: 31806614)
18. Fordwah canal No. 14 old (Unique ID: 31806615)
19. Fordwah Canal No. 22 (old) (Unique ID: 31806623)
20. JWB No. 6 (Unique ID: 31906647)
21. JWB No. 7 (Unique ID: 31906648)
22. JWB No. 8 (Unique ID: 31906649)
23. JWB No. 9 (Unique ID: 31906650)
24. JWB No. 10 (Unique ID: 31906651)
25. JWB No. 1 (Unique ID: 31906657)
26. Fordwah canal No. 8 old (Unique ID: 32307024)
27. Fordwah canal No. 11 old (Unique ID: 32507025)
28. Fordwah canal No. 12 old (Unique ID: 32507026)
29. Fordwah canal No. 13 old (Unique ID: 32507027)
30. Fordwah Canal No. 15 New (Unique ID: 32507029)
31. Fordwah canal No. 4 old (Unique ID: 31806589-1)
32. Degree College WW No. 2 (Unique ID: 31806640-2)
33. Fordwah canal No. 8-1 old (Unique ID: 32307024-1)
34. Quraish Colony (Unique ID: 33007036-2)
35. Shahzad Nagar w.w (Unique ID: 33007037-4)
36. Fordwah Canal Pump No. 18 old (Unique ID: 82907771)

(v) Undertake assessment of the following disposal pumpset as the sites non-functional

1. Islam Nagar (Unique ID: 31806626-A)
2. Islam Nagar (Unique ID: 31806626-B)
3. Islam Nagar (Unique ID: 31806626-C)
4. Islam Nagar (Unique ID: 31806626-D)
5. Islam Nagar (Unique ID: 31806626-E)
6. Madni Colony (Unique ID: 31806629-A)
7. Madni Colony (Unique ID: 31806629-B)
8. Madni Colony (Unique ID: 31806629-C)
9. Madina Town New (Unique ID: 31806631-A)
10. Madina Town New (Unique ID: 31806631-B)
11. Madina Town New (Unique ID: 31806631-D)
12. Madina Town New (Unique ID: 31806631-E)
13. Madina Town New (Unique ID: 31806631-F)
14. Madina Town New (Unique ID: 31806631-G)

(vi) Undertake assessment of the following disposal pumpsets as the sites are under maintenance

1. Hussainabad (Unique ID: 31808881-A)
2. Hussainabad (Unique ID: 31808881-B)
3. Hussainabad (Unique ID: 31808881-C)

4. Hussainabad (Unique ID: 31808881-D)

(vii) Undertake assessment of the following disposal pumpset as the site has been relocated

1. Madni Colony (Unique ID: 31806629-D)

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

2.1 Inventory for water and wastewater pumping equipment

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

2.1.1 Tubewells

Table 9: Inventory of Tubewells/Water Pumps (Potable Water)

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	Year of Motor Manufacturing	Latitude	Longitude
1	31806620	Fordwah Canal No.19 (old)	29-15812-0376800	Turbine	PECO	N/A	PECO	N/A	30.013855	73.241285
2	31806586	Fordwah canal No. 01 old	27-15812-0132900	N/A	N/A	N/A	N/A	N/A	30.019722	73.25
3	31806587	Fordwah canal No. 1 old	NA	Turbine	PECO	1983	PECO	1983	30.019722	73.25
4	31806588	Fordwah canal No. 2 old	27-15812-0376000	Turbine	N/A	N/A	PECO	N/A	30.017502	73.251554
5	31806589	Fordwah canal No. 3 old	29-15812-0376200	Turbine	PECO	1983	PECO	1983	30.017596	73.252303
6	31806590	Fordwah canal No. 5 old	NA	N/A	N/A	N/A	N/A	N/A	30.017611	73.253527
7	31806591	Fordwah canal No. 6 old	N/A	N/A	N/A	N/A	N/A	N/A	30.017652	73.254107
8	31806592	Fordwah canal No. 7 old	NA	N/A	N/A	N/A	N/A	N/A	30.017665	73.255076
9	31806593	Fordwah canal No. 9 old	29-15812-0376100	Turbine	PECO	1999	Local	1999	30.018523	73.257406
10	31806594	Fordwah canal No. 10 old	29-15812-0377301	Turbine	PECO	N/A	PECO	N/A	30.018963	73.258366
11	31806595	Turbine No. 1 New	29-15812-0377302	Turbine	KSB	2004	Siemens	2004	30.019735	73.259585
12	31806596	Turbine No. 2 New	29-15812-0377303	Turbine	KSB	2020	Siemens	2020	30.020538	73.260531
13	31806597	Turbine No. 3 New	NA	Turbine	KSB	2007	N/A	2007	30.02134	73.261379
14	31806598	Fordwah Canal No. 21 New	29-15812-0390951	Turbine	KSB	2020	N/A	2020	30.037727	73.27963
15	31806599	Fordwah Canal No. 20 New	29-15812-0396912	Turbine	KSB	2004	Siemens	2004	30.036508	73.278157
16	31806600	Fordwah Canal No. 19 New	29-15812-0390956	Turbine	KSB	2004	Siemens	2004	30.036539	73.278177
17	31806601	Fordwah Canal No. 18 New	29-15812-0390910	Turbine	KSB	2004	Siemens	2004	30.034794	73.276599
18	31806602	Fordwah Canal No. 17 New	29-15812-0390914	Turbine	KSB	2020	Siemens	2020	30.034801	73.2766
19	31806603	Fordwah Canal No. 16 New	29-15812-0390952	Turbine	KSB	2020	Siemens	2020	30.03274	73.274657
20	31806605	Fordwah Canal No. 13 New	29-15812-0390908	Turbine	KSB	2004	Siemens	2004	30.029467	73.271935
21	31806606	Fordwah Canal No. 12 New	29-15812-0390957	Turbine	KSB	2020	Siemens	2020	30.02869	73.271249
22	31806607	Fordwah Canal No. 11 New	29-15812-0390953	Turbine	KSB	2004	Siemens	2004	30.027669	73.270302
23	31806608	Fordwah Canal No. 10 New	29-15812-0390955	Turbine	KSB	2004	Siemens	2004	30.026692	73.269076
24	31806609	Fordwah Canal No. 9 New	29-15812-0390911	Turbine	KSB	2020	Siemens	2020	30.02669	73.269105
25	31806610	Fordwah Canal No. 8 New	29-15812-0390954	Turbine	KSB	2004	Siemens	2004	30.025002	73.266932
26	31806611	Fordwah Canal No. 7 New	29-15812-0390915	Turbine	KSB	2020	Siemens	2020	30.022723	73.260503
27	31806612	Fordwah Canal No. 6 New	29-15812-0377307	Turbine	KSB	2004	Siemens	2004	30.021184	73.262159
28	31806614	Fordwah canal No. 15 old	29-15812-0377300	Turbine	PECO	N/A	PECO	N/A	30.01752	73.256552
29	31806615	Fordwah canal No. 14 old	29-15812-0377200	N/A	N/A	N/A	N/A	N/A	30.017233	73.255107
30	31806618	Fordwah canal No. 16 old	27-15812-0377000	Turbine	Flow Pak	2007	Siemens	2007	30.016072	73.24573
31	31806619	Fordwah canal No. 17 old	29-15812-0377305	Turbine	KSB	N/A	Siemens	N/A	30.015713	73.244855
32	31806621	Fordwah canal No. 20 old	29-15812-0376801	Turbine	HMA	N/A	Siemens	N/A	30.012752	73.239517
33	31806622	Fordwah canal No. 21 old	29-15812-0343302	Turbine	KSB	2020	Siemens	2020	30.012193	73.238833
34	31806623	Fordwah Canal No. 22 (old)	29-15812-0376802	Turbine	PECO	N/A	PECO	N/A	30.011504	73.237518
35	31806624	Fordwah canal No. 23 old	29-15812-0596400	Turbine	Flow Pak	N/A	Siemens	N/A	30.005538	73.227408
36	31806625	Fordwah canal No. 24 old	29-15812-0497044	Turbine	KSB	2009	Siemens	2009	30.002018	73.221419

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
37	31906643	JWB No. 2	29-15813-0631753	Turbine	Flow Pak	2010	Siemens	2010	29.94544	73.388428
38	31906644	JWB No. 3	29-15813-0631754	Turbine	KSB	2010	Siemens	2010	29.946813	73.390568
39	31906645	JWB No. 4	29-15813-0631755	Turbine	Flow Pak	2010	Siemens	2010	29.949305	73.394457
40	31906647	JWB No. 6	29-15813-0631757	Turbine	Flow Pak	2010	Siemens	2010	29.951917	73.398814
41	31906648	JWB No. 7	29-15813-0631758	Turbine	Flow Pak	2010	Siemens	2010	29.95322	73.400833
42	31906649	JWB No. 8	29-15813-0631759	Turbine	Flow Pak	2010	N/A	2010	29.95444	73.4029
43	31906650	JWB No. 9	29-15813-1344802	Turbine	Flow Pak	2010	N/A	2010	29.955698	73.404798
44	31906651	JWB No. 10	29-15813-0631752	Turbine	Flow Pak	2010	Siemens	2010	29.957197	73.407074
45	31906657	JWB No. 1	29-15813-0631751	Turbine	Flow Pak	2010	Siemens	2010	29.94357	73.38548
46	32307024	Fordwah canal No. 8 old	N/A	N/A	N/A	N/A	N/A	N/A	30.018009	73.255784
47	32507025	Fordwah canal No. 11 old	N/A	N/A	N/A	N/A	N/A	N/A	30.016847	73.249943
48	32507026	Fordwah canal No. 12 old	N/A	N/A	N/A	N/A	N/A	N/A	30.017066	73.251618
49	32507027	Fordwah canal No. 13 old	N/A	N/A	N/A	N/A	N/A	N/A	30.017165	73.253131
50	32507028	Fordwah Canal No. 14 New	29-15812-0390913	Turbine	KSB	2020	Siemens	2020	30.030904	73.27314
51	32507029	Fordwah Canal No. 15 New	N/A	Turbine	N/A	N/A	N/A	N/A	30.031797	73.273721
52	32707033	Fordwah Canal No. 4 New	29-15812-0377201	Turbine	PECO	2018	Siemens	2018	30.018347	73.258205
53	31806613	Fordwah Canal No. 5 New	29-15812-0377306	Turbine	KSB	2004	N/A	2004	30.020296	73.261134
54	33107038	JWB No. 5	29-15813-0631756	Turbine	Flow Pak	2010	Siemens	2010	29.950578	73.396438
55	31806589-1	Fordwah canal No. 4 old	N/A	N/A	N/A	N/A	N/A	N/A	30.017634	73.252914
56	31806592-1	Fordwah canal No. 7 old	27-15812-0377400	Turbine	PECO	1999	PECO	1999	30.017665	73.255076
57	31806640-1	Degree College WW No. 1	27-15811-0318601	Centrifugal	Meco	2003	Siemens	2003	29.994037	73.267
58	31806640-2	Degree College WW No. 2	27-15811-0318601	Centrifugal	Meco	2003	Siemens	2003	29.994037	73.267
59	3180686-1	Fordwah canal No. 0 New	27-15812-0132900	Turbine	KSB	2020	Siemens	2020	30.019722	73.25
60	32307024-1	Fordwah canal No. 8-1 old	N/A	N/A	N/A	N/A	N/A	N/A	30.017961	73.25566
61	33007036-1	Quraish Colony	27-15812-0313506	Centrifugal	Meco	2005	Siemens	2005	30.001345	73.245767
62	33007036-2	Quraish Colony	27-15812-0313506	Centrifugal	Meco	2005	Siemens	2005	30.001345	73.245767
63	33007037-1	Shahzad Nagar w.w	29-15811-0360800	Centrifugal	Meco	2005	Siemens	2005	29.989693	73.255692
64	33007037-2	Shahzad Nagar w.w	29-15811-0360800	Centrifugal	Meco	2005	Siemens	2005	29.989693	73.255692
65	33007037-3	Shahzad Nagar w.w	29-15811-0360800	Centrifugal	Beco	1993	Beco	1993	29.989693	73.255692
66	33007037-4	Shahzad Nagar w.w	29-15811-0360800	Centrifugal	Beco	1993	Beco	1993	29.989693	73.255692
67	82907316-1	Model Town w.w Sadqia No. 1	27-15813-2497402	Centrifugal	KSB	N/A	Siemens	N/A	29.9777156	73.256622
68	82907316-2	Model Town w.w Sadqia No. 2	27-15813-2497402	Turbine	N/A	N/A	Siemens	N/A	29.9777156	73.256622
69	82907316-2A	Model Town w.w No 1	27-15813-0074700	Centrifugal	Meco	N/A	Siemens	N/A	29.977409	73.256685
70	82907316-2B	Model Town w.w No 2	27-15813-0074700	Centrifugal	Meco	N/A	Siemens	N/A	29.977409	73.256685
71	82907316-2C	Model Town w.w No 3	27-15813-0074700	Centrifugal	KSB	N/A	Siemens	N/A	29.9777	73.256657
72	82907775	Fordwah Canal Turbine No. 28 old	29-15812-03909012	Turbine	PECO	2018	Siemens	2018	30.013076	73.239346
73	82907776	Fordwah Canal Turbine No. 29 old	29-15812-0377202	N/A	PECO	2018	Siemens	2018	30.014676	73.241656
74	82907773	Fordwah Canal Turbine No. 26 old	29-15812-0377204	Turbine	PECO	2018	Siemens	2018	30.006632	73.228063
75	82907774	Fordwah Canal Turbine No. 27 old	29-15812-0377203	Turbine	PECO	2018	Siemens	2018	30.008378	73.230168

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
76	82907772	Fordwah Canal Turbine No. 25 old	29-15812-0377205	Turbine	PECO	2018	Siemens	2018	30.005344	73.226432
77	82907771	Fordwah Canal Pump No 18. (old)	N/A	N/A	N/A	N/A	N/A	N/A	30.01541	73.243811

2.1.2 Disposal Works

Table 10: Inventory Table of Disposal Works

Sr. No.	Unique ID	Location	Meter Reference No	Existing Pump Type	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	Year of Motor Manufacturing	Latitude	Longitude
1	31806628	Karmawala	29-15813-1344821	Submersible	HMA	N/A	HMA	N/A	30.011185	73.272255
2	31806626-A	Islam Nagar	27-15812-0001007	Centrifugal	MECO	N/A	MECO	N/A	30.015604	73.261424
3	31806626-B	Islam Nagar	27-15812-0001007	Centrifugal	MECO	N/A	MECO	N/A	30.015604	73.261424
4	31806626-C	Islam Nagar	27-15812-0001007	Centrifugal	MECO	N/A	MECO	N/A	30.015604	73.261424
5	31806626-D	Islam Nagar	27-15812-0001007	Centrifugal	MECO	N/A	MECO	N/A	30.015604	73.261424
6	31806626-E	Islam Nagar	27-15812-0001007	Centrifugal	MECO	N/A	MECO	N/A	30.015604	73.261424
7	31806626-F	Islam Nagar	27-15812-0001007	Submersible	HMA	N/A	HMA	N/A	30.015604	73.261424
8	31806626-G	Islam Nagar	27-15812-0001007	Centrifugal	MECO	N/A	MECO	N/A	30.015604	73.261424
9	31806629-A	Madni Colony	27-15813-2449404	Centrifugal	MECO	N/A	MECO	N/A	29.986155	73.26168
10	31806629-B	Madni Colony	27-15813-2449404	Centrifugal	MECO	N/A	MECO	N/A	29.986155	73.26168
11	31806629-C	Madni Colony	27-15813-2449404	Centrifugal	MECO	N/A	MECO	N/A	29.986155	73.26168
12	31806629-D	Madni Colony	27-15813-2449404	Centrifugal	MECO	N/A	MECO	N/A	29.986155	73.26168
13	31806629-E	Madni Colony	27-15813-2449404	Centrifugal	Master	N/A	Siemens	N/A	29.986155	73.26168
14	31806631-A	Madina Town	27-15811-0786503	Submersible	HMA	N/A	HMA	N/A	29.99261	73.239592
15	31806631-B	Madina Town	27-15811-0786503	Submersible	HMA	N/A	HMA	N/A	29.99261	73.239592
16	31806631-C	Madina Town	27-15811-0786503	Submersible	HMA	N/A	HMA	N/A	29.99261	73.239592
17	31806631-D	Madina Town	27-15811-0786503	Submersible	HMA	N/A	HMA	N/A	29.99261	73.239592
18	31806631-E	Madina Town	27-15811-0786503	Submersible	HMA	N/A	HMA	N/A	29.99261	73.239592
19	31806631-F	Madina Town	27-15811-0786503	Submersible	HMA	N/A	HMA	N/A	29.99261	73.239592
20	31806631-G	Madina Town	27-15811-0786503	Submersible	HMA	N/A	HMA	N/A	29.99261	73.239592
21	31806631-H	Madina Town	27-15811-0786503	Centrifugal	MECO	N/A	MECO	N/A	29.99261	73.239592
22	31808881-A	Hussainabad	27-15813-1344821	Submersible	HMA	N/A	HMA	N/A	29.999234	73.27105
23	31808882-A	Foard Wah	27-15812-0003004	Submersible	Grundfos	N/A	Grundfos	N/A	30.01877	73.257475
24	31808883	Model Town	28-15811-0000103	Centrifugal	Master	N/A	Siemens	N/A	29.976682	73.260998
25	31808881-B	Hussainabad	27-15813-1344821	Submersible	HMA	N/A	HMA	N/A	29.999234	73.27105
26	31808882-B	Foard Wah	27-15812-0003004	Submersible	Grundfos	N/A	Grundfos	N/A	30.01877	73.257475
27	31808881-C	Hussainabad	27-15813-1344821	Submersible	HMA	N/A	HMA	N/A	29.999234	73.27105
28	31808881-D	Hussainabad	27-15813-1344821	Submersible	HMA	N/A	HMA	N/A	29.999234	73.27105
29	31808881-E	Hussainabad	27-15813-1344821	Submersible	HMA	N/A	HMA	N/A	29.999234	73.27105

2.1.3 Dewatering Sets

Table 11: Inventory of Dewatering Sets

Sr. No.	Unique ID	Location	Quantity	Latitude	Longitude
1	31806570 A	Near Bismillah Football Ground	1	29.98705	73.26043
2	31806570 B	Near Bismillah Football Ground	1	29.98705	73.26043
3	31806570 C	Near Press Club	1	30.000951	73.256652
4	31806570 D	Near Eid Gaah Mosque	1	30.001277	73.256872
5	31806570 E	Near Eid Gaah Mosque	2	30.001259	73.25686
6	31806570 D	Nazir Colony	1	30.010814	73.267454
7	31806570 F	Revenue Colony	1	30.008983	73.250151

2.1.4 Filtration Units

Table 12: Inventory of Filtration Units

Sr. No.	Unique ID	Location	Type	Quantity	Pump Manufacturer	Year of Pump Manufacturing	Motor Manufacturer	North	East
1	32207018	Wuqla Colony Z.A Syed	Connected with Ford Wah Canal 26,27 & 28					29.993668	73.24682
2	32207019	Quraish Colony	Connected with Canal Pump 16 & 17 old					30.000977	73.245374
3	32207020	Faisal Colony	Connected with Canal Pump 16 & 17 old					30.004559	73.245722
4	32207021	Civil Club	Connected with Canal Pump 5,6 New & 15 old					30.011674	73.25585
5	32207022	Muslim Colony	Connected with Canal Pump 9,10,12 & 13 New					29.999078	73.262778
6	32307023	City Tanki	Connected with Canal Pump 4,5 & 6 New					30.000629	73.258185
7	32907315	Farooqabad Nizam Pura	Connected with Shehzad Nagar Pump (33007036-1)					29.987833	73.252468
8	80907318	Degree College Hussainabad F.P	Connected with Pump (31806640-1)					29.994324	73.269215
9	82907316	Model Town	Connected with Model Town WW (82907316-2A, 82907316-2B)					29.977682	73.257033
10	82907317	Shahzad Nagar	Connected with Canal Pump# 8,9,12,13 and 17 New					29.989836	73.255698
11	82907319	Khadmabad	Connected with Canal Pump# 12,13 & 17					30.006905	73.26722
12	82907320	Green Market (GhalaMandi)	Connected with City Tank					30.00186	73.261344
13	82907321	Amir Jan Pura	Connected with MC Water Network					30.009089	73.258364

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

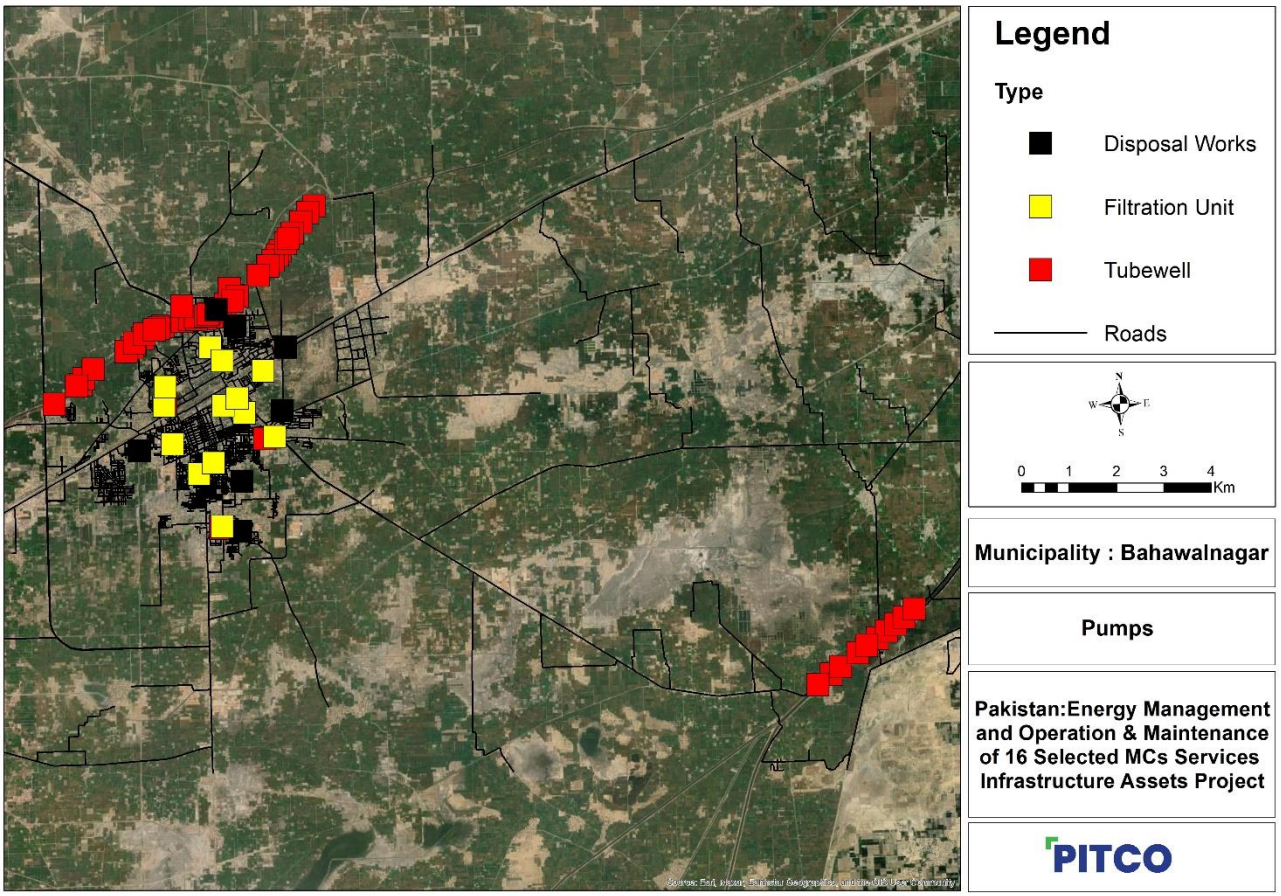


Figure 1: Map for Pumps and Disposal at MC Bahawalnagar

2.3 Baseline Energy Consumption Trend

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

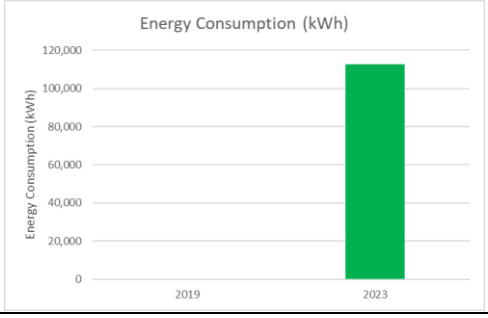
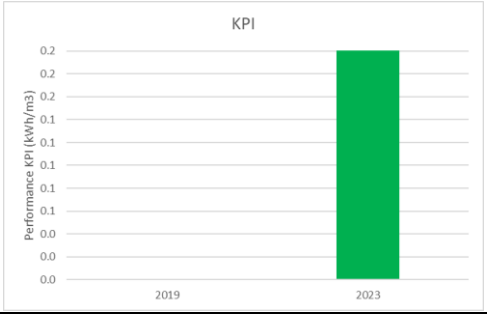
Table 13: Baseline Energy Consumption Trend

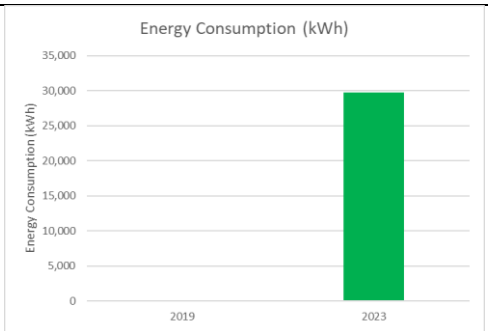
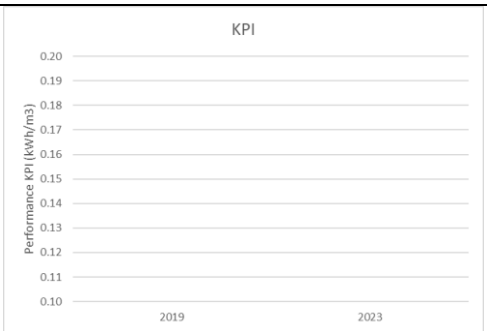
Particulars	Unit	Value
Electrical energy used by Tubewells (Potable Water)	kWh/y	2,848,281
Electrical energy used by Wastewater Disposal	kWh/y	461,652
Electrical energy used (Total)	kWh/y	3,480,302

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:

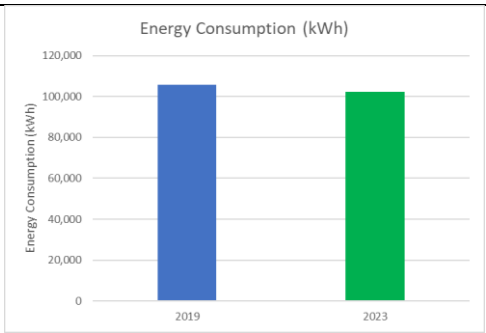
		Operational Assets		Energy Consumption		Actual Energy Savings (kWh/yr)	KPI		
Sr. #	Parameter	Year 2018 - 2019	Year 2022 - 2023	Year 2018 - 2019 (kWh/yr)	Year 2022 - 2023 (kWh/yr)	kWh/yr	Year 2018 - 2019	Year 2022 - 2023	Comments
1	Tubewells (Potable Water)	32	35	2,120,752	2,848,281	-727,529	0.30 kWh/m3	0.22 kWh/m3	Replacement of 23 pumpsets were recommended based on the assessment carried out in 2019. The MC has undertaken replacement of 11 pumpsets which has resulted in significant improvement in the KPI for water supply. As seen from the KPI, the water supply pumpsets are performing efficiently and the corresponding water supply to the MC has increased significantly. Moreover, number of operational pumpsets have increased due to which the annual energy consumption has increased.
2	Wastewater Disposal	6	10	252,863	461,652	-208,789	0.05 kWh/m3	0.04 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.

Replacement of 23 Pumpsets was recommended based on the assessment carried out in 2019. The MC has undertaken installation of 11 new pumpsets. A discussion on each newly installed asset is presented below:

Turbine No. 2 New - Unique ID (31806596)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	112,633 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.29 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No calculations of the KPI has been calculated for the previous audit, as there was no pumpset installed and there were no billing details available for this site.	

Fordwah Canal No. 21 New - Unique ID (31806598)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	29,717 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	N/A
	
Comments:	
A new pumpset has been installed at this site. This site was found to be non-operational during the current audit due to burnt motor windings. No calculations of the KPI has been calculated for the previous audit, as there was no motor installed and there were no billing details available for this site.	

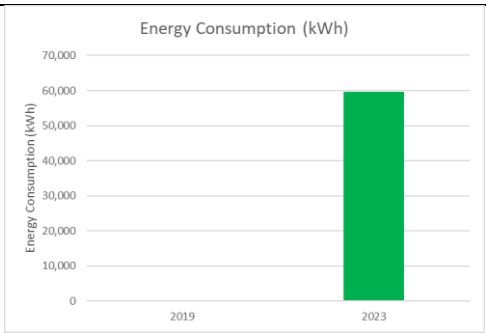
Fordwah Canal No. 17 New - Unique ID (31806602)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
105,851 kWh	102,164 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.21 kWh/m3	0.18 kWh/m3

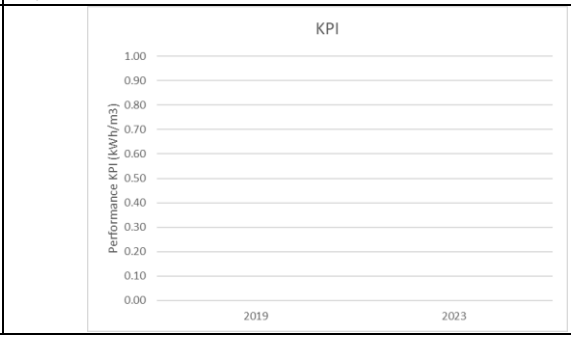


Comments:

A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. Previously, replacement of pumpset was recommended due to the low efficiency. Annual energy consumption of this pumpset in 2019 was 105,851 kWh whereas, annual energy consumption of this pumpset of current year is 102,164 kWh with an annual energy savings of 3,687 kWh. As seen from the KPI, the new pumpset is performing efficiently and the corresponding water supply to the MC from this pumpset has increased significantly.

Fordwah Canal No. 16 New - Unique ID (31806603)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	59,657 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	N/A

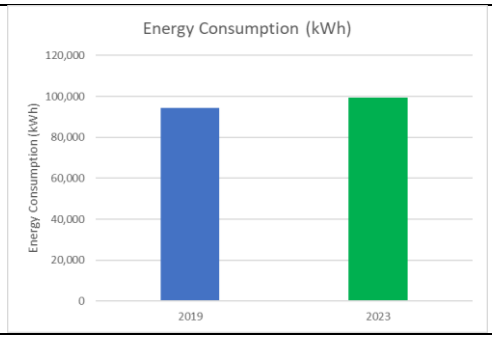
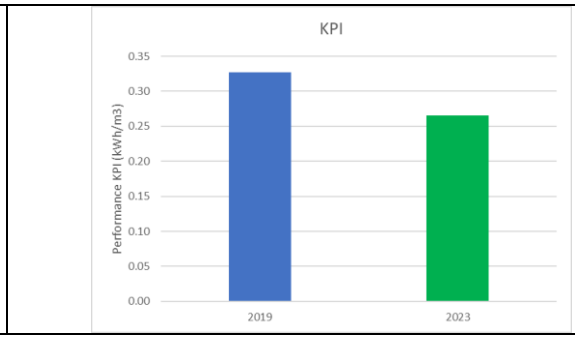


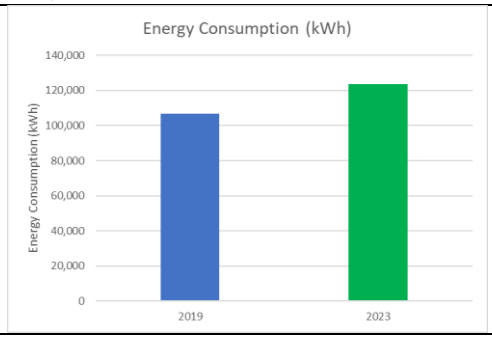


Comments:

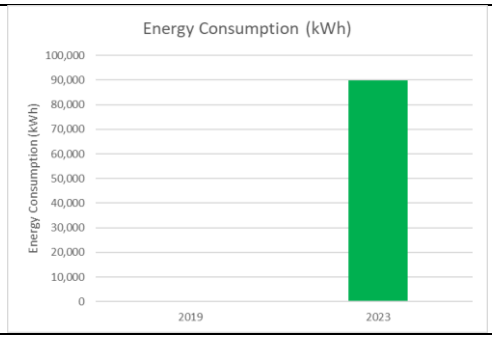
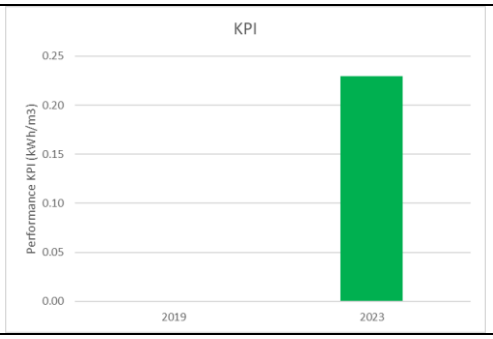
A new pumpset has been installed at this site. This site was found to be non-operational during the current audit due to burnt motor windings. No calculations of the KPI has been calculated for the previous audit, as there was no pumpset installed and there were no billing details available for this site.

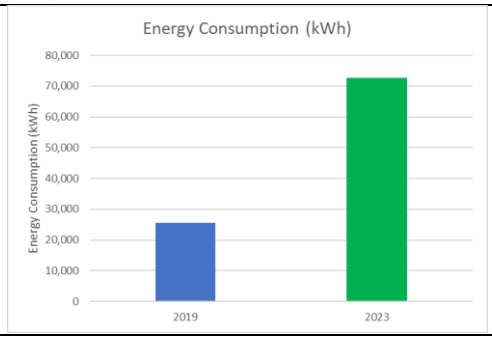
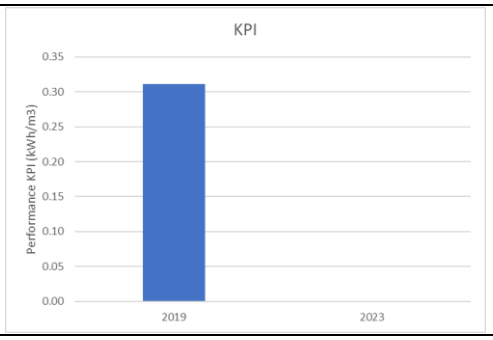
Fordwah Canal No. 12 New - Unique ID (31806606)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
94,431 kWh	99,329 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.33 kWh/m3	0.27 kWh/m3

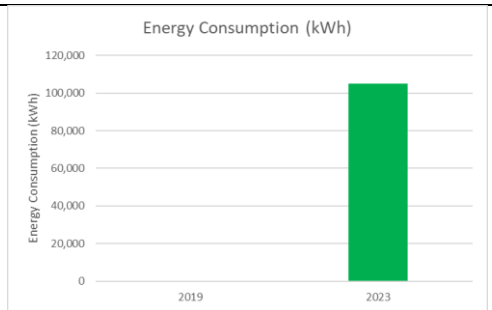
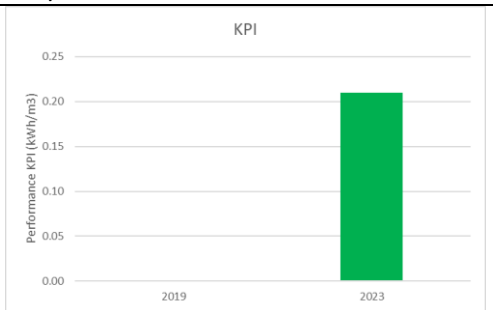
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. As seen from the KPI, the new pumpset is performing efficiently. Annual energy consumption of this pumpset in 2019 was 94,431 kWh whereas, annual energy consumption of this pumpset of current year is 99,329 kWh with an increase of 4,898 kWh in an annual energy consumption. Although, the overall energy consumption has increased corresponding, water supply to the MC through this pumpset has increased as well.	

Fordwah Canal No. 9 New - Unique ID (31806609)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
106,800 kWh	123,574 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.33 kWh/m3	0.23 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. As seen from the KPI, the new pumpset is performing efficiently. Annual energy consumption of this pumpset in 2019 was 106,800 kWh whereas, annual energy consumption of this pumpset of current year is 123,574 kWh with an increase of 16,774 kWh in an annual energy consumption. Although, the overall energy consumption has increased corresponding, water supply to the MC through this pumpset has increased as well.	

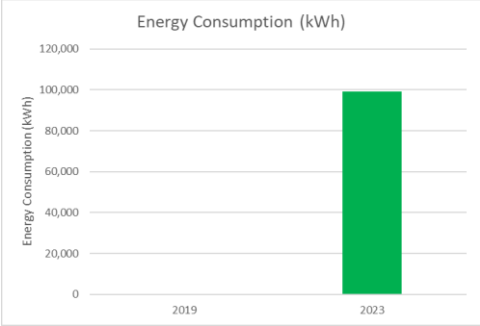
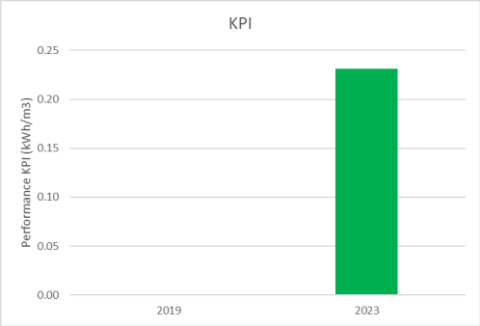
Fordwah Canal No. 7 New - Unique ID (31806611)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	89,922 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.23 kWh/m3

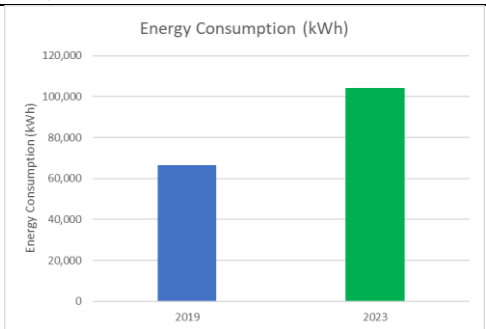
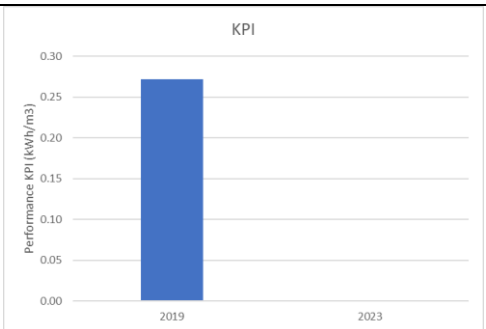
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No calculations of the KPI has been calculated for the previous audit, as there was no pumpset installed and there were no billing details available for this site.	

Fordwah canal No. 17 old - Unique ID (31806619)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
25,665 kWh	72,641 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.31 kWh/m3	N/A
	
Comments:	
A new pumpset has been installed at this site. Annual energy consumption of this pumpset in 2019 was 25,665 kWh whereas, annual energy consumption of this pumpset of current year is 72,641 kWh with an increase of 46,976 kWh. No calculations of the KPI has been calculated for the current audit, as no flow could be detected due to extremely rusty condition and heavy leakage in the delivery line.	

Fordwah canal No. 21 old - Unique ID (31806622)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	104,873 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.21 kWh/m3
	

Comments:
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. As seen from the KPI of 2023 audit, the new pumpset is performing efficiently. No calculations of the KPI has been calculated for the previous audit, as there was no pumpset installed and there were no billing details available for this site.

Fordwah Canal No. 14 New - Unique ID (32507028)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
0 kWh	99,070 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
N/A	0.23 kWh/m3
	
Comments:	
A new pumpset has been installed at this site. Efficiency of the new pumpset is satisfactory. i.e., above 55%. However, the MC is not currently receiving bill on this newly installed pumpset due to which the savings are not reflected in the KPIs. There are no KPI and billing calculations for 2019 audit, as there was no pumpset installed at this site and there were no billing details available.	

Fordwah canal No. 0 New - Unique ID (3180686-1)	
Energy Consumption as per 2019 Energy Audit	**Energy Consumption as per 2023 Energy Audit**
66,628 kWh	104,130 kWh
KPI as per 2019 Energy Audit	**KPI as per 2023 Energy Audit**
0.27 kWh/m3	N/A
	
Comments:	
A new pumpset has been installed at this site. Annual energy consumption of this pumpset in 2019 was 66,628 kWh whereas, annual energy consumption of this pumpset of current year is 104,130 kWh with an increase of 37,502 kWh. No calculations of the KPI has been calculated for the current audit, as no flow could be measured due insufficient space to install ultrasonic flowmeter.	

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.

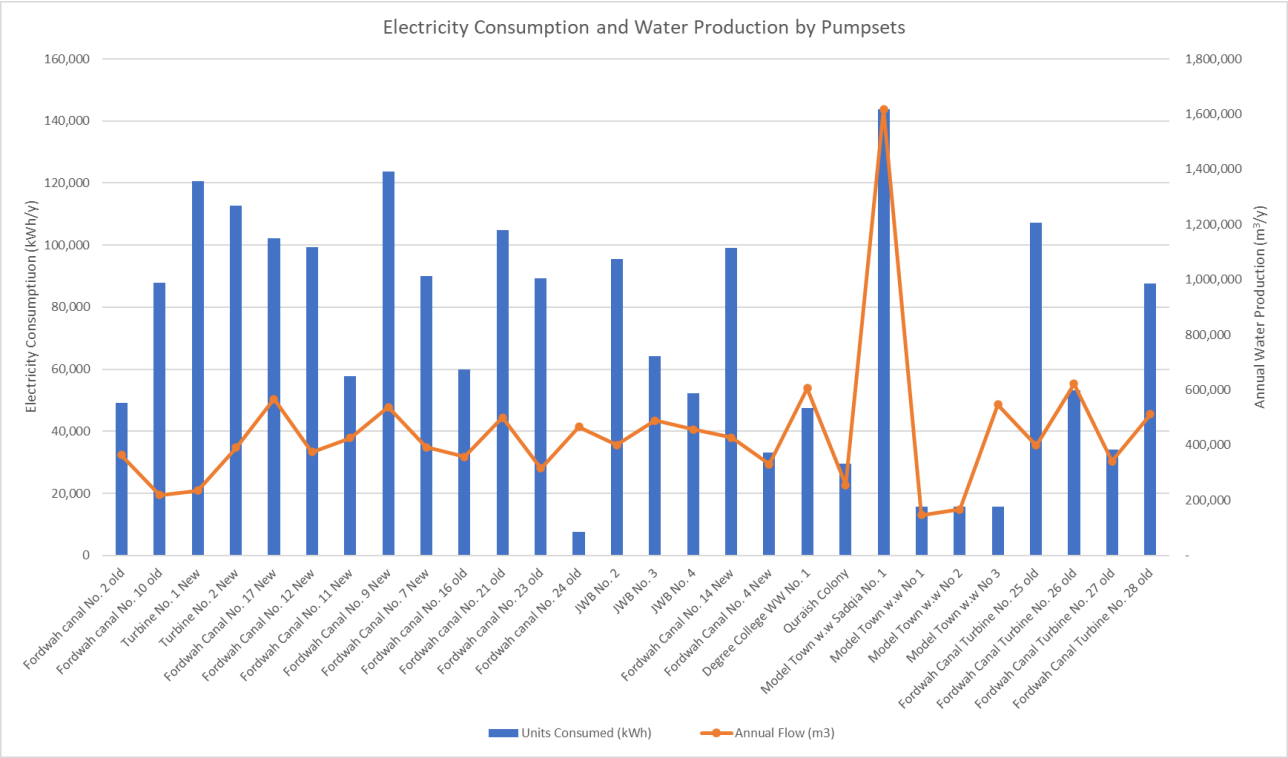
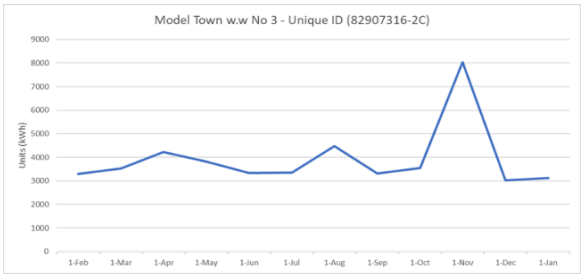


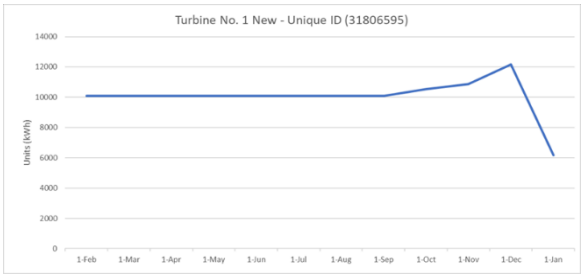
Figure 2: Electricity Consumption and Water Production by Pumpsets

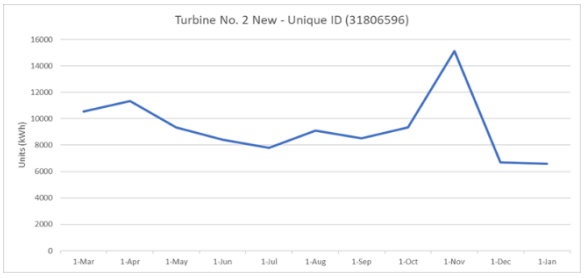
It should be noted that the values for total water production are based on the instantaneous measurement of flow during the on-site visit as the MC does not record the total water production by the pumpsets. Furthermore, only those pumpsets have been included in the above graph for which pump performance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

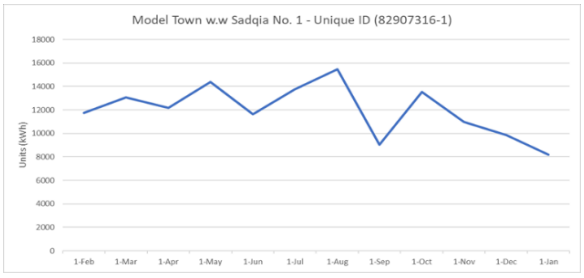
2.4.1 Monthly Energy profiles of all Potable Water Pumps and Disposal Sites

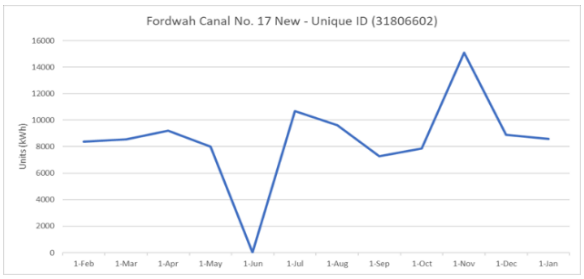
The energy consumption trends provided here are based on utility bills provided by the MC. The bills were provided by the MC for all operational sites.

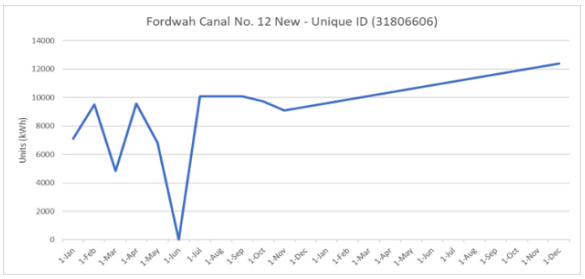


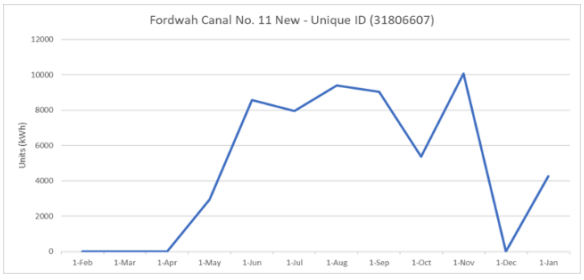


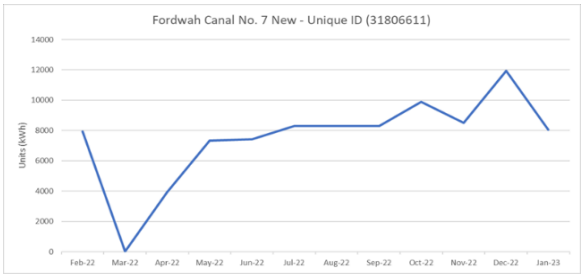


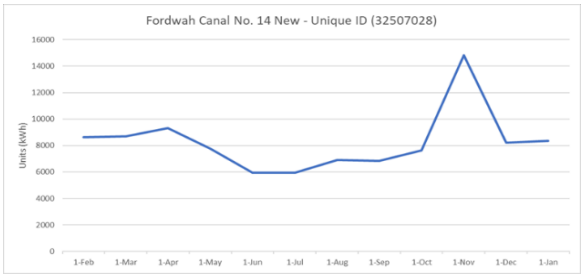


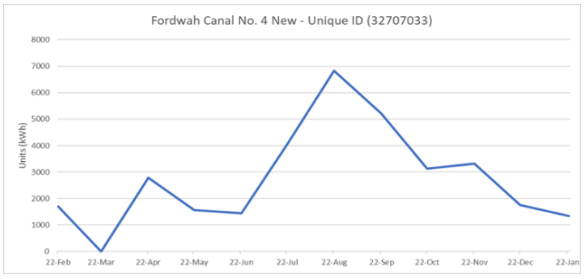

Fordwah Canal No. 17 New - Unique ID (31806602)
Units (kWh)
16000
14000
12000
10000
8000
6000
4000
2000
0
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

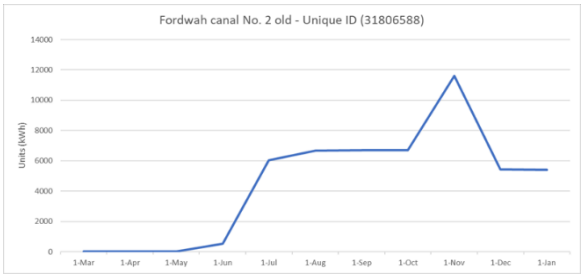

Fordwah Canal No. 12 New - Unique ID (31806606)
Units (kWh)
14000
12000
10000
8000
6000
4000
2000
0

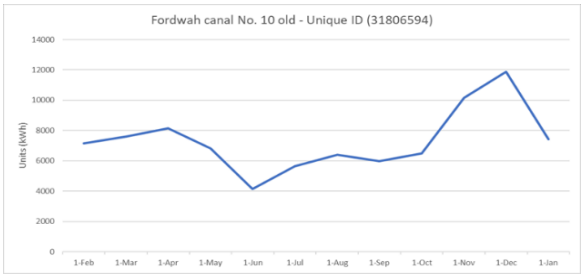

Fordwah Canal No. 11 New - Unique ID (31806607)
Units (kWh)
12000
10000
8000
6000
4000
2000
0
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

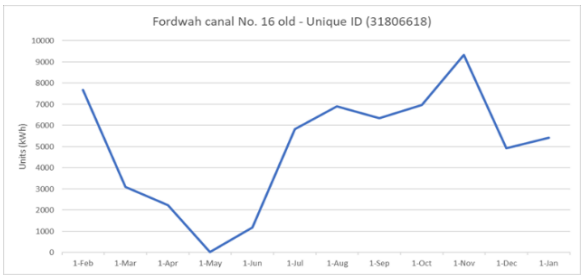

Fordwah Canal No. 7 New - Unique ID (31806611)
Units (kWh)
14000
12000
10000
8000
6000
4000
2000
0
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23

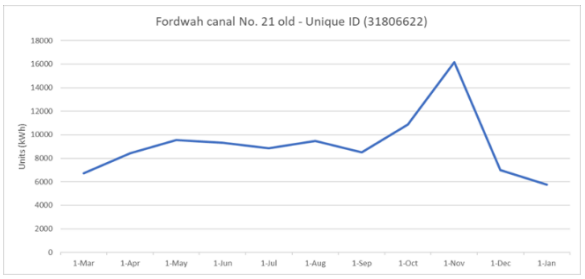

Fordwah Canal No. 14 New - Unique ID (32507028)
Units (kWh)
16000
14000
12000
10000
8000
6000
4000
2000
0
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

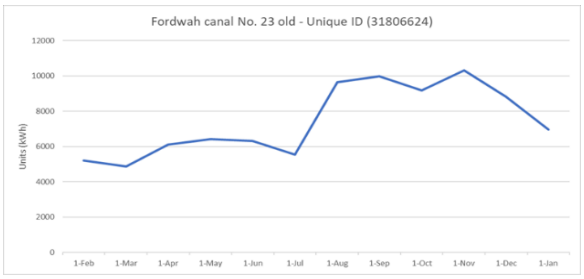

Fordwah Canal No. 4 New - Unique ID (32707033)
Units (kWh)
8000
7000
6000
5000
4000
3000
2000
1000
0
22-Feb
22-Mar
22-Apr
22-May
22-Jun
22-Jul
22-Aug
22-Sep
22-Oct
22-Nov
22-Dec
22-Jan

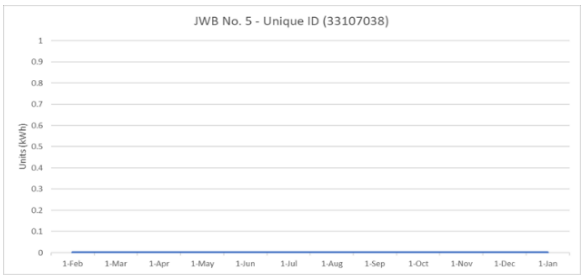

Fordwah canal No. 2 old - Unique ID (31806588)
Units (kWh)
14000
12000
10000
8000
6000
4000
2000
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

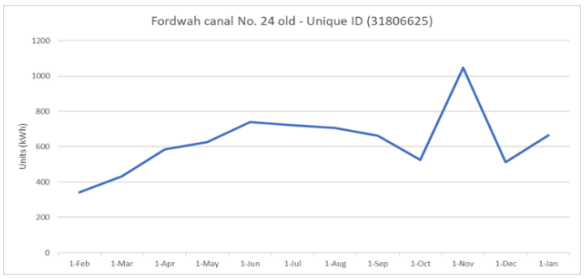

Fordwah canal No. 10 old - Unique ID (31806594)
Units (kWh)
14000
12000
10000
8000
6000
4000
2000
0
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

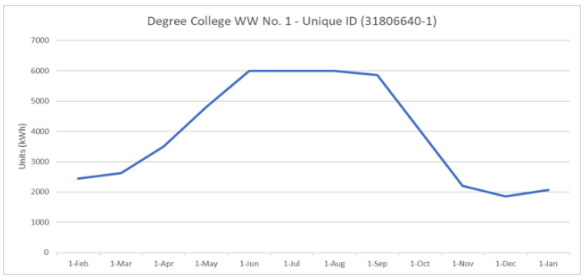

Fordwah canal No. 16 old - Unique ID (31806618)
Units (kWh)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

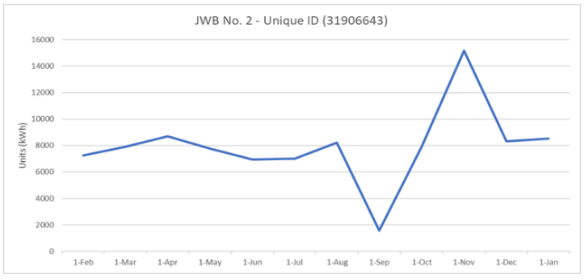

Fordwah canal No. 21 old - Unique ID (31806622)
Units (kWh)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

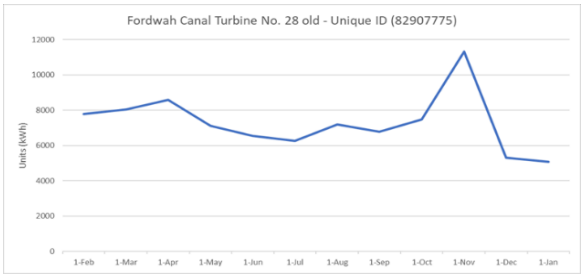

Fordwah canal No. 23 old - Unique ID (31806624)
Units (kWh)
12000
10000
8000
6000
4000
2000
0
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

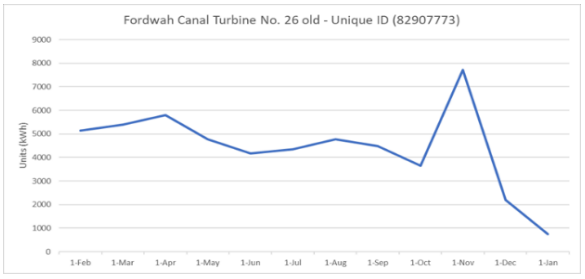

JWB No. 5 - Unique ID (33107038)
Units (kWh)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
1-Dec
1-Jan

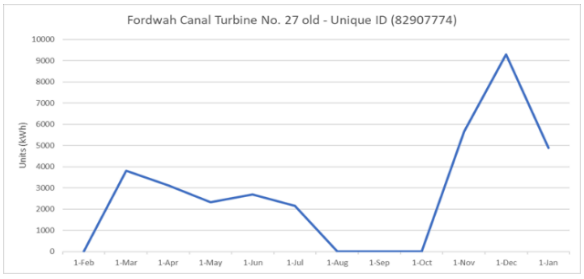


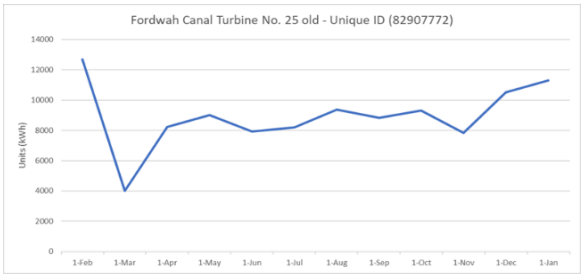


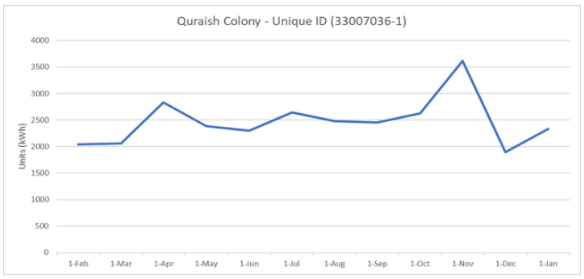


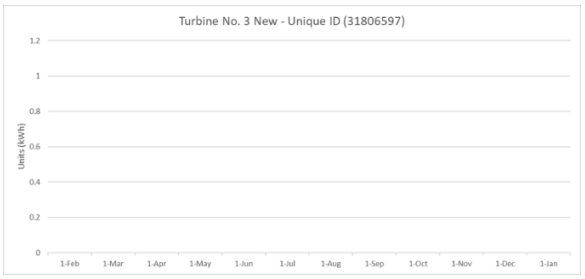












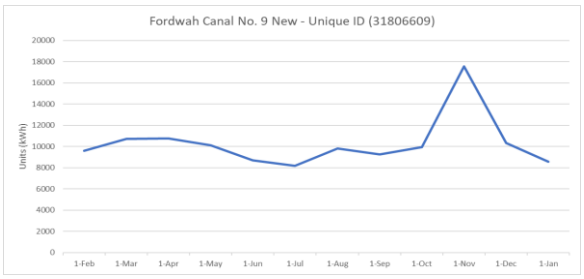


Figure 3: Energy Consumption Trend for Water Pumps

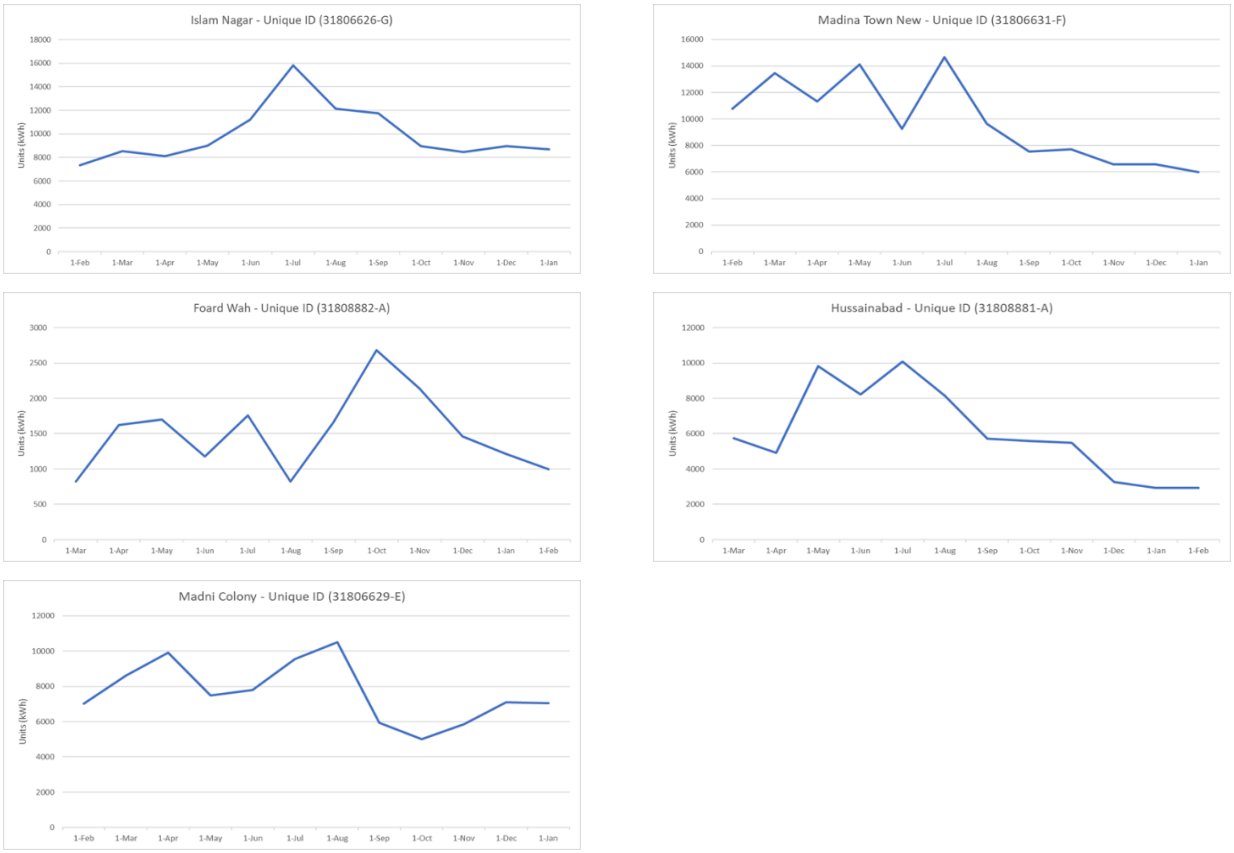


Figure 4: Energy Consumption Trend for Disposal Units

2.4.2 Performance of Water Pumping System

B Bahawalnagar MC has seventy-seven (77) tubewells for groundwater, all of which are manually operated. Performance evaluation of pumpsets could be carried out at only 29 locations due to the reasons specified under section 2. Performance analysis was carried out for the operational tubewells, by simultaneous measurement of flow and electrical consumption The list of audit equipment used by the Consultant is attached as Annexure 2. Since the Sluice valves at several pumping stations were either jammed or broken, it was not possible to determine system resistance and/or assess the pumpset performance at its duty point. Nevertheless, the purpose of the energy audit is to evaluate the energy consumption of MC's water supply network based on their actual/existing working condition. Therefore, any measurements made by altering the actual field operating mode/conditions will not be a true representation of the energy consumption of assets.

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



Figure 5: Sample pictures from field audit of pumpsets

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

Table 14: Matrix of Pumpset Assessment and Billing Data Availability

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
1	31806586	Ford wah Canal # 01 Old	Yes	No
2	31806587	Ford wah # 1 Old	Yes	No
3	31806588	Fordwah canal No. 2 old	Yes	Yes
4	31806589	Fordwah canal No. 3 old	Yes	No
5	31806590	Fordwah canal No. 5 old	Yes	No
6	31806591	Fordwah canal No. 6 old	Yes	No
7	31806592	Fordwah canal No. 7 old	Yes	No
8	31806593	Fordwah canal No. 9 old	Yes	No
9	31806594	Fordwah canal No. 10 old	Yes	Yes
10	31806595	Turbine No. 1 New	Yes	Yes
11	31806596	Turbine No. 2 New	Yes	Yes
12	31806597	Turbine No. 3 New	Yes	No
13	31806598	Fordwah Canal No. 21 New	Yes	No
14	31806599	Fordwah Canal No. 20 New	Yes	No
15	31806600	Fordwah Canal No. 19 New	Yes	No
16	31806601	Fordwah Canal No. 18 New	Yes	No
17	31806602	Fordwah Canal No. 17 New	Yes	Yes
18	31806603	Fordwah Canal No. 16 New	Yes	No
19	31806605	Fordwah Canal No. 13 New	Yes	No
20	31806606	Fordwah Canal No. 12 New	Yes	Yes
21	31806607	Fordwah Canal No. 11 New	Yes	Yes
22	31806608	Fordwah Canal No. 10 New	Yes	No
23	31806609	Fordwah Canal No. 9 New	Yes	Yes
24	31806610	Fordwah Canal No. 8 New	Yes	No
25	31806611	Fordwah Canal No. 7 New	Yes	Yes
26	31806612	Fordwah Canal No. 6 New	Yes	No
27	31806613	Fordwah Canal No. 5 New	Yes	No
28	31806614	Fordwah canal No. 15 old	Yes	No
29	31806615	Fordwah canal No. 14 old	Yes	No
30	31806618	Fordwah canal No. 16 old	Yes	Yes
31	31806619	Fordwah canal No. 17 old	Yes	No
32	31806620	Fordwah Canal No.19 (old)	Yes	No
33	31806621	Fordwah canal No. 20 old	Yes	No
34	31806622	Fordwah canal No. 21 old	Yes	Yes
35	31806623	Fordwah Canal No. 22 (old)	Yes	No

Sr. No.	Unique ID	Location	Electricity Bill Available	Assessment Carried Out
36	31806624	Fordwah canal No. 23 old	Yes	Yes
37	31806625	Fordwah canal No. 24 old	Yes	Yes
38	31906643	JWB No. 2	Yes	Yes
39	31906644	JWB No. 3	Yes	Yes
40	31906645	JWB No. 4	Yes	Yes
41	31906647	JWB No. 6	Yes	No
42	31906648	JWB No. 7	Yes	No
43	31906649	JWB No. 8	Yes	No
44	31906650	JWB No. 9	Yes	No
45	31906651	JWB No. 10	Yes	No
46	31906657	JWB No. 1	Yes	No
47	32307024	Fordwah canal No. 8 old	Yes	No
48	32507025	Fordwah canal No. 11 old	Yes	No
49	32507026	Fordwah canal No. 12 old	Yes	No
50	32507027	Fordwah canal No. 13 old	Yes	No
51	32507028	Fordwah Canal No. 14 New	Yes	Yes
52	32507029	Fordwah Canal No. 15 New	Yes	No
53	32707033	Fordwah Canal No. 4 New	Yes	Yes
54	33107038	JWB No. 5	Yes	Yes
55	31806589-1	Fordwah canal No. 4 old	Yes	No
56	31806592-1	Fordwah canal No. 7 old	Yes	No
57	31806640-1	Degree College WW No. 1	Yes	Yes
58	31806640-2	Degree College WW No. 2	Yes	No
59	3180686-1	Fordwah canal No. 0 New	Yes	No
60	32307024-1	Fordwah canal No. 8-1 old	Yes	No
61	33007036-1	Quraish Colony	Yes	Yes
62	33007036-2	Quraish Colony	Yes	No
63	33007037-1	Shahzad Nagar w.w	Yes	No
64	33007037-2	Shahzad Nagar w.w	Yes	No
65	33007037-3	Shahzad Nagar w.w	Yes	No
66	33007037-4	Shahzad Nagar w.w	Yes	No
67	82907316-1	Model Town w.w Sadqia No. 1	Yes	Yes
68	82907316-2	Model Town w.w Sadqia No. 2	Yes	No
69	82907316-2A	Model Town w.w No 1	Yes	Yes
70	82907316-2B	Model Town w.w No 2	Yes	Yes
71	82907316-2C	Model Town w.w No 3	Yes	Yes
72	82907771	Fordwah Canal Pump No. 18 old	Yes	No
73	82907772	Fordwah Canal Turbine No. 25 old	Yes	Yes
74	82907773	Fordwah Canal Turbine No. 26 old	Yes	Yes
75	82907774	Fordwah Canal Turbine No. 27 old	Yes	Yes
76	82907775	Fordwah Canal Turbine No. 28 old	Yes	Yes
77	82907776	Fordwah Canal Turbine No. 29 old	Yes	No

Table 15: Pumpset Primary Performance Parameters

Sr No.	Unique ID	Location	Rated Pump Flow m^3/hr	Measured Flow m^3/hr	Dynamic Head m	Power Consumption kW	Pump Efficiency %	Measured Power Factor	Comments
1	31806588	Fordwah canal No. 2 old	51.0	69.0	18.17	10.00	40%	0.76	Efficiency of the pumpset is unsatisfactory. Previously, no pumpset was installed at this site.
2	31806594	Fordwah canal No. 10 old	51.0	41.5	15.26	10.10	20%	0.83	Efficiency of the pumpset is unsatisfactory. Previously, this site was non-functional.
3	31806595	Turbine No. 1 New	51.0	35.7	34.81	12.93	31%	0.92	Efficiency of the pumpset is unsatisfactory. Previously, this site was non-functional.
4	31806596	Turbine No. 2 New	51.0	59.3	42.54	13.70	59%	0.74	New pump has been installed at the site. Efficiency of the pumpset is satisfactory. Previously, no pumpset was installed at the site.
5	31806602	Fordwah Canal No. 17 New	51.0	85.9	26.14	12.33	58%	0.90	New pump has been installed at the site. Efficiency of the pumpset is satisfactory. Previously, it was recommended to replace the pumpset due to the lower efficiency of 29%.
6	31806606	Fordwah Canal No. 12 New	51.0	56.7	40.92	13.47	55%	0.85	New pump has been installed at the site. Efficiency of the pumpset is satisfactory. Previously, it was recommended to replace the pumpset.
7	31806607	Fordwah Canal No. 11 New	51.0	80.6	13.79	14.50	25%	0.88	Efficiency of the pumpset is unsatisfactory. Previously, there was no motor installed at the site.
8	31806609	Fordwah Canal No. 9 New	51.0	81.4	30.24	14.60	54%	0.83	New pump has been installed at the site. Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, it was recommended to replace the pumpset.
9	31806611	Fordwah Canal No. 7 New	51.0	74.2	31.85	14.03	54%	0.79	New pump has been installed at the site. Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, no pumpset was installed at the site.
10	31806618	Fordwah canal No. 16 old	51.0	67.8	27.92	10.60	57%	0.78	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 55%.
11	31806622	Fordwah canal No. 21 old	51.0	94.7	29.35	16.00	56%	0.86	New pump has been installed at the site. Efficiency of the pumpset is satisfactory. Previously, no pumpset was installed at the site.

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
12	31806624	Fordwah canal No. 23 old	51.0	59.9	22.29	14.60	29%	0.82	Efficiency of the pumpset is unsatisfactory. Gate/sluice valve is jammed. Previously, the efficiency of the pumpset was 56%.
13	31806625	Fordwah canal No. 24 old	51.0	88.2	29.63	15.00	56%	0.82	Efficiency of the pumpset is satisfactory. Previously, the efficiency of the pumpset was 65%.
14	31906643	JWB No. 2	51.0	75.7	27.96	12.53	54%	0.84	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, efficiency of the pumpset was 53%.
15	31906644	JWB No. 3	51.0	92.6	11.05	5.85	56%	0.45	Efficiency of the pumpset is satisfactory. Previously, it was recommended to replace the pumpset due to low efficiency. i.e., 28%
16	31906645	JWB No. 4	51.0	86.6	17.07	15.23	31%	0.80	Efficiency of the pumpset is unsatisfactory. Gate/sluice valve is jammed. Previously, no motor was installed at the site.
17	32507028	Fordwah Canal No. 14 New	51.0	81.0	29.26	13.60	56%	0.85	New pumpset has been installed at the site. Efficiency of the pumpset is satisfactory. Gate/sluice valve is jammed. Previously, this pumpset was abandoned by the MC.
18	32707033	Fordwah Canal No. 4 New	51.0	62.5	30.35	10.75	57%	0.90	Efficiency of the pumpset is satisfactory. Previously, this pumpset was abandoned by the MC.
19	33107038	JWB No. 5	51.0	90.5	12.94	20.57	18%	0.84	Efficiency of the pumpset is unsatisfactory. Previously, no motor and pumpset were installed at the site.
20	31806640-1	Degree College WW No. 1	152.9	114.7	7.17	18.53	14%	0.84	Efficiency of the pumpset is unsatisfactory. Previously, efficiency of the pumpset was 22% and it was recommended to replace the pumpset.
21	33007036-1	Quraish Colony	152.9	154.4	9.28	22.83	20%	0.88	Efficiency of the pumpset is unsatisfactory. Previously, efficiency of the pumpset was 21% and it was recommended to replace the pumpset.
22	82907316-1	Model Town w.w Sadqia No. 1	203.9	306.5	9.28	36.10	25%	0.78	Efficiency of the pumpset is unsatisfactory. Previously, efficiency of the pumpset was 22%.
23	82907316-2A	Model Town w.w No 1	152.9	148.5	9.47	14.20	32%	0.68	Efficiency of the pumpset is unsatisfactory. Previously, efficiency of the pumpset was 22%.

Sr No.	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	Measured Power Factor	Comments
24	82907316-2B	Model Town w.w No 2	152.9	167.6	17.20	17.40	53%	0.72	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory. Previously, efficiency of the pumpset was 23%.
25	82907316-2C	Model Town w.w No 3	152.9	103.5	20.13	11.70	57%	0.59	Efficiency of the pumpset is satisfactory.
26	82907772	Fordwah Canal Turbine No. 25 old	51.0	75.6	21.19	8.80	58%	0.84	Efficiency of the pumpset is satisfactory.
27	82907773	Fordwah Canal Turbine No. 26 old	51.0	117.7	21.19	14.20	56%	0.88	Efficiency of the pumpset is satisfactory. Gate/sluice valve of the pumpset is not working properly.
28	82907774	Fordwah Canal Turbine No. 27 old	51.0	64.7	24.10	8.40	59%	0.79	Efficiency of the pumpset is satisfactory.
29	82907775	Fordwah Canal Turbine No. 28 old	51.0	96.8	20.18	10.80	58%	0.86	Efficiency of the pumpset is satisfactory.

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

Table 16: Pumpset Secondary Performance Parameters

Unique ID	Motor Vibration Hz	Temperature of Motor	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
31806588	79.58	47	15	-	25	Unsafe	Not ok	-	-	-	0.76	67%	Low PF
31806594	79.58	53	15	-	25	Unsafe	Not ok	-	-	-	0.83	68%	
31806595	159.15	48	15	-	25	Unsafe	OK	180	380	0.88	0.92	87%	
31806596	159.15	62	15	89	25	Safe	Not ok	200	400	0.84	0.74	92%	Low PF
31806602	63.66	62	15	89	25	Safe	Ok	200	400	0.84	0.90	83%	
31806606	13.26	59	15	89	25	Safe	OK	200	400	0.84	0.85	90%	
31806607	387.94	52	15	-	25	Safe	OK	180	380	0.88	0.88	97%	
31806609	188.09	64	15	89	25	Safe	Not ok	200	400	0.84	0.83	98%	
31806611	15.16	62	15	89	25	Safe	Ok	200	400	0.84	0.79	94%	Low PF
31806618	106.10	61	15	-	50	Unsafe	Not ok	160	380	0.84	0.78	71%	Low PF
31806622	79.58	71	15	89	50	Safe	Ok	200	400	0.84	0.86	107%	Overloaded Motor
31806624	0.00	87	15	-	25	Unsafe	Not ok	-	380	0.84	0.82	98%	
31806625	106.10	50	15	-	25	Unsafe	Not ok	150	380	0.88	0.82	101%	Overloaded Motor
31906643	159.15	33	19	-	25	Safe	Not ok	220	380	0.84	0.84	67%	
31906644	3.58	39	19	-	25	Safe	Not ok	220	380	0.84	0.45	31%	Low PF
31906645	24.49	45	19	-	25	Safe	Ok	200	380	0.84	0.80	82%	
32507028	7.96	54	15	89	25	Safe	Ok	200	400	0.84	0.85	91%	
32707033	275.87	41	15	-	25	Safe	Ok	200	380	0.83	0.90	72%	

Unique ID	Motor Vibration Hz	Temperature of Motor	Motor Rated kW	Motor Rated Efficiency	Transformer kVA	Elec. Connection	Line Leakage	Rated Head of Pump	Motor Rated Voltage V	Full Load PF	PF (Measured)	Load factor %	Observations
33107038	527.72	73	19	-	25	Safe	Ok	220	380	0.84	0.84	110%	Overloaded Motor
31806640-1	185.68	32	22	-	50	Safe	Ok	-	400	0.88	0.84	83%	
33007036-1	145.73	32	30	-	50	Safe	Ok	115	400	0.88	0.88	77%	
82907316-1	106.10	52	37	-	100	Safe	Not ok	-	400	0.88	0.78	97%	Low PF
82907316-2A	119.37	36	19	-	50	Safe	Ok	-	440	0.87	0.68	76%	Low PF
82907316-2B	79.58	38	19	-	50	Safe	Ok	-	440	0.87	0.72	93%	Low PF
82907316-2C	79.58	29	19	-	50	Unsafe	Ok	-	-	-	0.59	63%	Low PF
82907772	106.10	44	15	-	25	Safe	Not ok	200	-	0.88	0.84	59%	
82907773	53.05	65	15	-	25	Safe	Not ok	200	380	0.88	0.88	95%	
82907774	53.05	44	15	-	25	Safe	Ok	200	380	0.88	0.79	56%	Low PF
82907775	79.58	53	15	-	25	Safe	-	200	380	0.88	0.86	72%	

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

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

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
1	31806588	Fordwah canal No. 2 old	51	14.914	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	68.96	18.2	Flow at Existing Operating Conditions	10.00	40%
2	54.41	25.2	Flow nearest to duty point	9.80	45%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
2	31806596	Turbine No. 2 New	51	14.914	
Sr. No.	**Flow Meter Readings (m3/h)**	**Total Head (m)**	**Status**	**Power Consumption in KW**	**Efficiency**
1	59.306	42.5	Flow at Existing Operating Conditions	13.70	59%
2	53.34	47.5	Flow nearest to duty point	13.37	61%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
3	31806609	Fordwah Canal No. 9 New	51	14.914	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	81.4097	30.2	Flow at Existing Operating Conditions	14.6	54%
2	58.314	33.8	Flow nearest to duty point	11.14	57%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
4	31806622	Fordwah canal No. 21 old	51	14.914	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	94.65	29.3	Flow at Existing Operating Conditions	16.00	56%
2	53.54	42.0	Flow nearest to duty point	12.03	60%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
5	31806625	Fordwah canal No. 24 old	51	14.914	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	88.2	29.6	Flow at Existing Operating Conditions	15.00	56%
2	64.63	41.6	Flow nearest to duty point	14.6	59%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
6	31906643	JWB No. 2	51	18.6425	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	75.74	28.0	Flow at Existing Operating Conditions	12.53	54%
2	53.34	40.6	Flow nearest to duty point	11.57	60%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
7	32707033	Fordwah Canal No. 4 New	51	14.914	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	62.5065	30.4	Flow at Existing Operating Conditions	10.75	57%
2	56.1098	35.3	Flow nearest to duty point	10.73	59%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
8	33107038	JWB No. 5	51	18.6425	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	90.496	12.9	Flow at Existing Operating Conditions	20.57	18%
2	51.4663	34.0	Flow nearest to duty point	20.20	28%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
9	82907772	Fordwah Canal Turbine No. 25 old	51	14.914	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	75.56	21.2	Flow at Existing Operating Conditions	8.8	58%
2	57.63	26.1	Flow nearest to duty point	8.1	60%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
10	82907774	Fordwah Canal Turbine No. 27 old	51	14.914	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	64.7	24.1	Flow at Existing Operating Conditions	8.4	59%
2	56.51	29.0	Flow nearest to duty point	8.4	63%

Sr. No.	Unique ID	Location	Rated Flow (m3/hr)	Motor Capacity (kW)	
11	82907775	Fordwah Canal Turbine No. 28 old	51	14.914	
Sr. No.	Flow Meter Readings (m3/h)	Total Head (m)	Status	Power Consumption in KW	Efficiency
1	96.83	20.2	Flow at Existing Operating Conditions	10.8	58%
2	69.07	25.1	Flow nearest to duty point	9.07	61%

2.4.3 Wastewater Disposal System

The MC has seven (7) disposal station having twenty-nine (29) pumps for suction of wastewater from collecting tanks to main sewage drain. All these pumps are manual and run as per requirement.

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

Table 18: Disposal Performance Parameters

Sr No	Unique ID	Location	Rated Pump Flow	Measured Flow	Dynamic Head	Power Consumption	Pump Efficiency %	PITCO Comments
1	31806628	Karmawala	152.9	277.1	4.27	8.50	45%	Efficiency of the pumpset is satisfactory. Previously, the pump site was under construction.
2	31806626-F	Islam Nagar	305.8	398.9	7.32	17.40	54%	Efficiency of the pumpset is satisfactory.
3	31806626-G	Islam Nagar	305.8	304.9	7.32	17.00	42%	Efficiency of the pumpset is satisfactory.
4	31806629-E	Madni Colony	305.8	239.7	12.19	23.04	41%	Efficiency of the pumpset is satisfactory.
5	31806631-C	Madina Town New	305.8	515.9	4.57	15.70	48%	Efficiency of the pumpset is satisfactory. Previously, the MCU was non-operational.
6	31806631-H	Madina Town New	305.8	263.2	9.14	19.80	39%	Efficiency of the pumpset is close to the cut-off value. Therefore, the performance of the pumpset is deemed to be satisfactory.
7	31808881-E	Hussainabad	305.8	310.2	4.57	9.90	46%	Efficiency of the pumpset is satisfactory.
8	31808882-A	Foard Wah	203.9	324.7	5.18	10.86	50%	Efficiency of the pumpset is satisfactory.
9	31808882-B	Foard Wah	203.9	257.1	5.18	10.47	41%	Efficiency of the pumpset is satisfactory.
10	31808883	Model Town	152.9	202.4	7.32	11.00	43%	Efficiency of the pumpset is satisfactory.

Figure 6: Wastewater Disposal

2.4.4 Dewatering Sets

There are eight (8) dewatering sets in the MC, out of which six are functional. It is recommended to maintain O&M logbooks of dewatering sets for recording date, time, operational hours, fuel consumption, location of operation and other maintenance details on a regular basis.

Figure 7: Dewatering Sets

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

2.5 Proposed Resource Efficiency Measures- Water Pumps and Disposals

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

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

Sr No.	Unique ID	Location	Comments	Recommendation
Pumps				
1	31806588	Fordwah canal No. 2 old	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	31806594	Fordwah canal No. 10 old	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
3	31806595	Turbine No. 1 New	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
4	31806596	Turbine No. 2 New	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
5	31806607	Fordwah Canal No. 11 New	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
6	31806618	Fordwah canal No. 16 old	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
7	31806624	Fordwah canal No. 23 old	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
8	31906644	JWB No. 3	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
9	31906645	JWB No. 4	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.
10	33107038	JWB No. 5	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
11	31806640-1	Degree College WW No. 1	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
12	33007036-1	Quraish Colony	Efficiency of the pumpset is below 55%	It is recommended to replace the pumpset.
13	82907316-1	Model Town w.w Sadqia No. 1	The power factor at the site is below 0.8. Efficiency of the pumpset is below 55%	A 5 kVAr capacitor should be installed on each phase. It is recommended to replace the pumpset.
14	82907316-2A	Model Town w.w No 1	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.
15	82907316-2C	Model Town w.w No 3	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
16	82907774	Fordwah Canal Turbine No. 27 old	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
17	31806628	Karmawala	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
18	31806626-F	Islam Nagar	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
19	31806626-G	Islam Nagar	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
20	31806631-H	Madina Town New	The power factor at the site is below 0.8.	A 5 kVAr capacitor should be installed on each phase.
21	31808881-E	Hussainabad	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
22	31808882-A	Foard Wah	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
23	31808882-B	Foard Wah	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
24	31808883	Model Town	The power factor at the site is below 0.8.	A 2.5 kVAr capacitor should be installed on each phase.
General Observations				
25	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
26	General	Operating Time	Pumps should not be run during Peak electricity consumption hours.	Operational hours of pump should be scheduled keeping in mind the varying peak hours across the year to avoid peak charges. Peak hours for MEPCO during the entire year are given in Annexure 1.
27	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.
28	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 Bahawalnagar MC and gathered detailed information about streetlights including their numbers, pole/fixture types and operation details. Details of the surveyed lights are provided in the following tables.

Table 20: Inventory Detail of Streetlights

	Streetlights	MC Operated	Privately Operated
Operational Street Lights	254	254	
Non-Operational Street Lights	219	219	
Total	**473**	**473**	**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 48 light fixtures installed on PC, 38 fixtures are installed on steel structure, 249 fixtures are installed on tubular structure and 17 fixtures are installed on walls. The streetlights' structural classification is tabulated below.

Table 21: Details of Streetlight Poles

Operated by	Precast Concrete	Steel Structure	Tubular Steel	Wall	Grand Total
MC	48	38	249	17	72
Private					0

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

Table 22: Metering of Streetlights

Sr/ No	Area	Total Number of Lights	Reference Number	Distance (km)
1	Dak khana Chowk	14	28158110255801	0.342
2	Larri Adda Chowk	19		0.746
3	Manchanabad Road	62	28158110000108	1.369
4	Manchanabad Cantt Road	112	28158130010624	3.059
5	Degree College Road	34	28158110316610	3.495
6	Bahawali Chowk	46	28158110740303	4.388
7	Hussainabad Chowk	40	28158130010625	1.981
8	Jalwala Road	28	28158130010613	1.086
9	Mahajar Colony	5	28158110247302	0.132
10	Fire Brigades Road	17	14158111276705	0.690
11	Urdu Bazar	13		0.578
12	Circular Road 1	25	28158111316801	2.145
13	Circular Road 2	15	28158111317801	1.243
14	Madni Colony	14	4158110401504	1.231
15	Rafeeq Shah Chowk	24	26158110185501	2.807
16	Model Town	5	28158130090601	0.496

Out of the 473 surveyed lights in the MC, 254 lights were found to be operational. Details are given in the following table:

Table 23: Details of Operational Streetlights

Equipment Type	Wattage of Lighting Fixture	Quantity		Daily Operational Hours[5]	Electricity Consumption (kWh/yr)	
		MC	Private		MC	Private
LED	27	10		12.0	1,183	0
LED	30	50		12.0	6,570	0
LED	50	7		12.0	1,533	0
LED	60	183		12.0	48,092	0
LED	120	3		12.0	1,577	0
Mercury Bulb	150	1		12.0	657	0
Total					**59,612**	

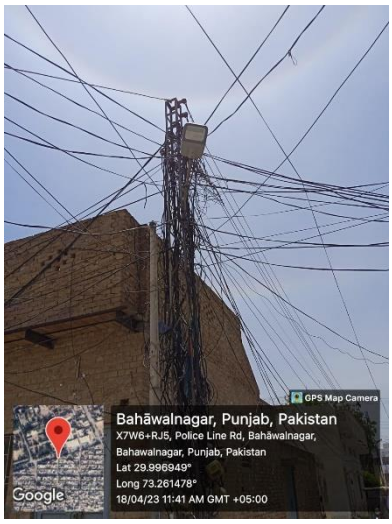


Figure 8: Pictures of Streetlights

3.2 GIS Map

GIS and yellow points denote functional streetlights.

[5] Based on Interview with Client.

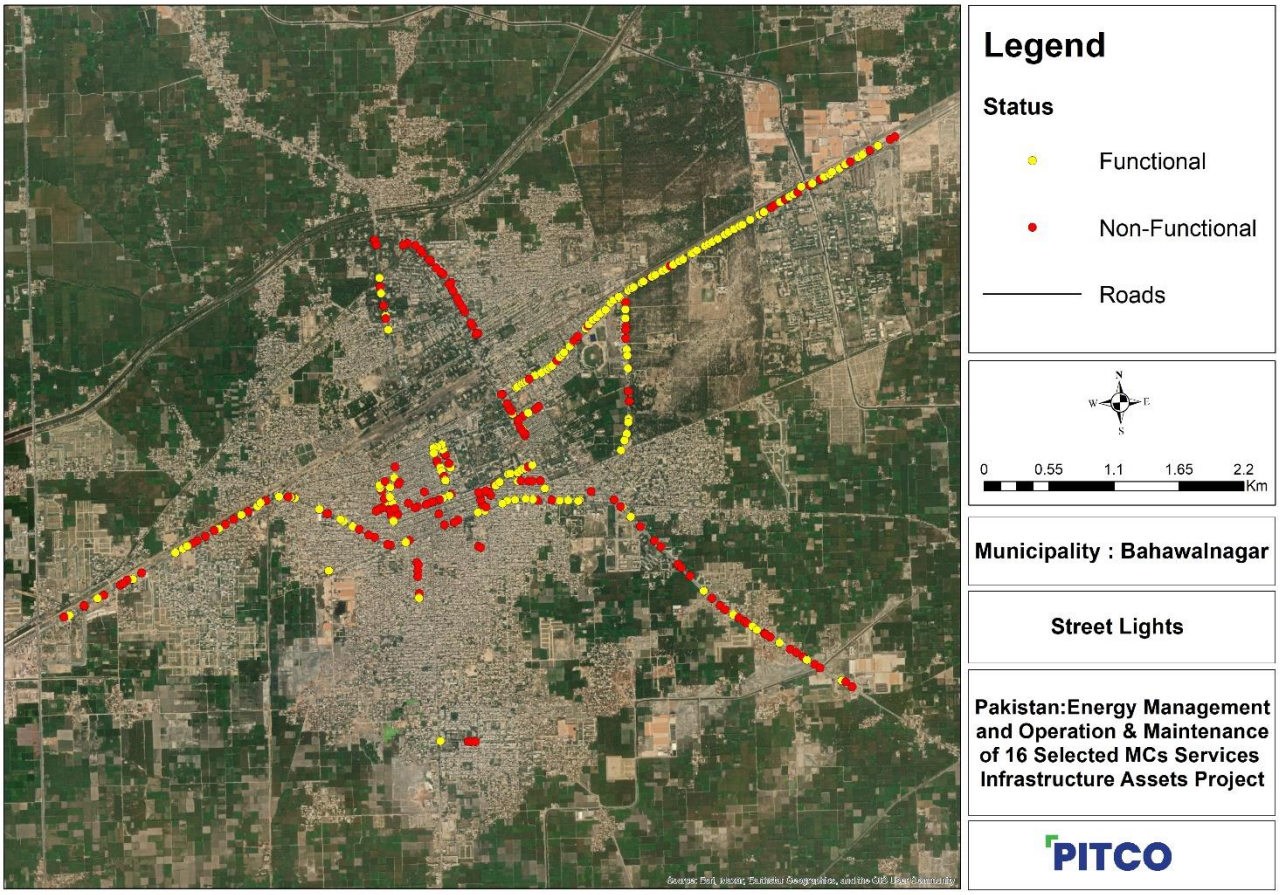


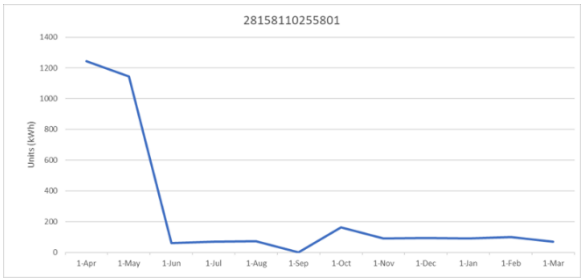
Figure 9: GIS Mapping of street lights in Bahawalnagar MC

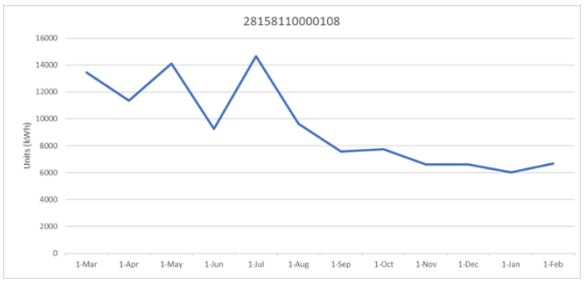
3.3 Baseline Energy Consumption Trend

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

Table 24: Baseline Energy Consumption Trend

Particulars	Unit	Value
Electrical energy consumed	kWh/y	212,832
Total number of operational lights	No.	254

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


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


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


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


28158110247302
Units (kWh)
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100
80
60
40
20
0
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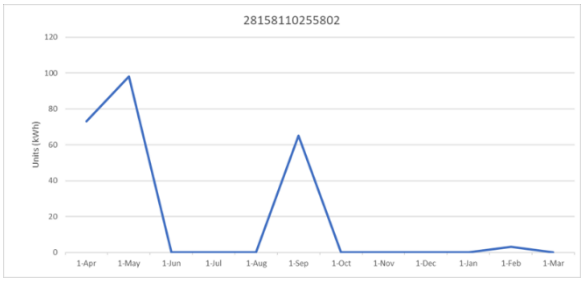
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Units (kWh)
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60
40
20
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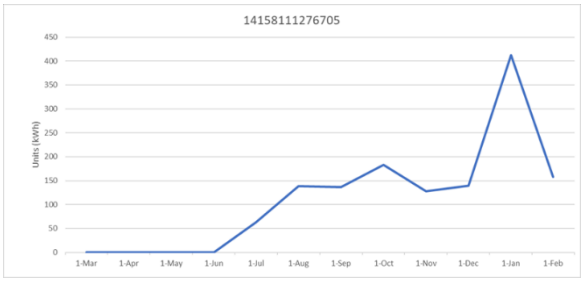
14158111276705
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300
250
200
150
100
50
0
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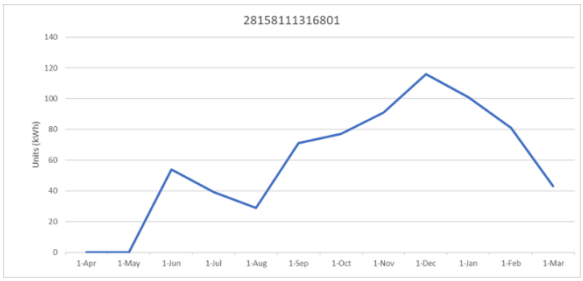
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Units (kWh)
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100
80
60
40
20
0
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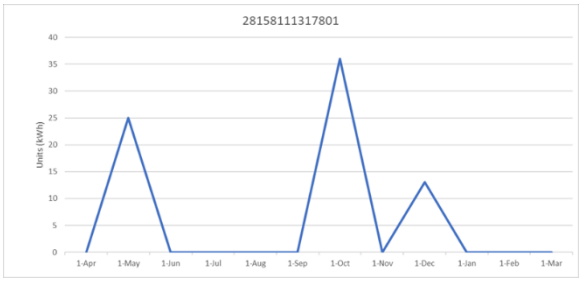
28158111317801
Units (kWh)
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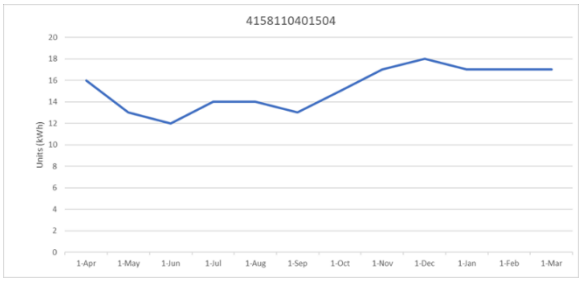
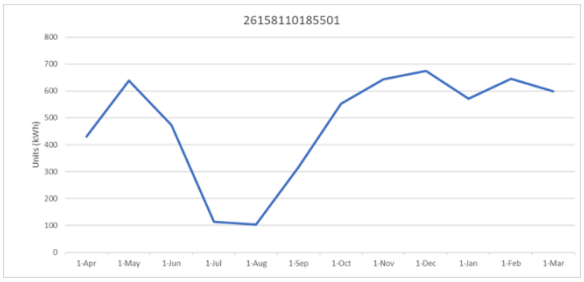
35
30
25
20
15
10
5
0
1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar


4158110401504
Units (kWh)
20
18
16
14
12
10
8
6
4
2
0
1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar


26158110185501
Units (kWh)
800
700
600
500
400
300
200
100
0
1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep 1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar


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

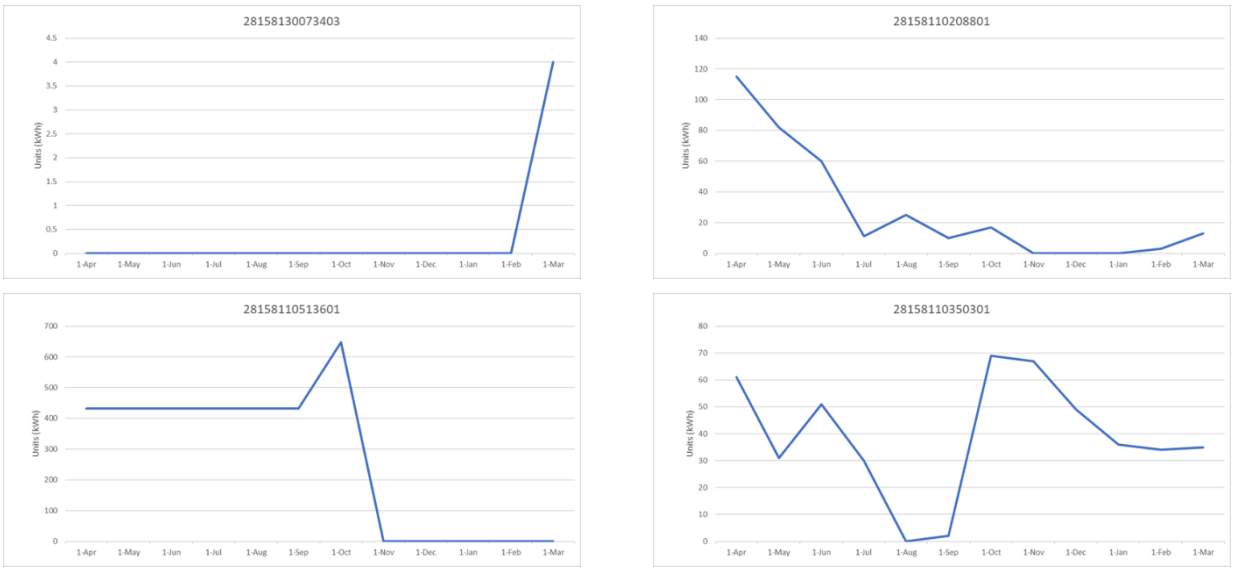


Figure 10: Energy Consumption trend of Streetlights

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	65	254	14,393	99,952	-85,559	1,043 kWh/km	3,876 kWh/km	Although the MC has undertaken replacement of inefficient streetlights withs LEDs and installed 189 new efficient LEDs, a sevenfold increase in the overall billing for streetlights has been observed. This points to potential misuse of the MC's electricity connections resulting in significantly increased billing for the MC. This needs to be further investigated together.

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 Bahawalnagar.

3.5 Observations

- All Streetlights in Bahawalnagar MC are operated by MC.
  Almost all operational streetlights are LEDs.
- Approximately 99% of the LED streetlights have a rating of less than 120 Watts.
- Bahawalnagar MC is not maintaining any record or database of streetlights.

3.6 Action plan for Energy Efficiency Measures – Streetlights

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

Table 25: Streetlights - recommendations for improvement

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

Table 26: Vehicle Inventory Detail

Sr. No.	Unique Registration Number	Vehicle Type	Make	Model	Year of Manufacturing	Type of Drive	Current allocation of vehicles	Engine No	Chassis No	Engine Capacity (hp)
1	Unregistered Vehicle 1	Truck	Hino	Dutro	2012	4WD	Transport of Solid Waste	JM13152	JHFYF20H606002793	4009
2	Unregistered Vehicle 2	Tractor front loader	Massey	MF-385	2022	4WD	Transport of Solid Waste	507105-H	85483/02/22	85HP
3	BNH-4081	Tractor	Massey	MF-240	2006	2WD	Water Bowser	53308-M	9343-95	50HP
4	Unregistered Vehicle 3	Truck	Bedford	N/A	1982	4WD	Water Bowser	N/A	N/A	4500
5	Unregistered Vehicle 4	Bolan	Suzuki	Bolan	2022	2WD	Equipment Carriage	PKT1025650	SV308PK01142157	796
6	Unregistered Vehicle 5	Truck	Faw	Tiger VH	2022	4WD	Mechanical Sweeper	D36Y5MY0108	AHFME14T4220172	130HP
7	Unregistered Vehicle 6	Truck	Faw	Tiger VH	2022	4WD	Transport of Solid Waste	D36Y5MY0106	AHFME14T4220170	130HP
8	Unregistered Vehicle 7	Truck	Faw	Tiger VH	2022	4WD	Transport of Solid Waste	D36Y5MY0120	AHFME14T4220168	130HP
9	Unregistered Vehicle 8	Truck	Faw	Tiger VH	2022	4WD	Transport of Solid Waste	D36Y5MY0119	AHFME14T4220169	130HP
10	Unregistered Vehicle 9	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386188	SR308PK490855	796
11	Unregistered Vehicle 10	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386535	SR308PK491190	796
12	Unregistered Vehicle 11	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386324	SR308PK490976	796
13	Unregistered Vehicle 12	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386282	SR308PK490955	796
14	Unregistered Vehicle 13	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386429	SR308PK491187	796
15	Unregistered Vehicle 14	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386532	SR308PK491183	796
16	Unregistered Vehicle 15	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386365	SR308PK491025	796
17	Unregistered Vehicle 16	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	PKT386196	SR308PK490865	796
18	Unregistered Vehicle 17	Tractor front loader	Massey	MF-385	2022	4WD	Transport of Solid Waste	507102-H	84483/04/22	85HP
19	Unregistered Vehicle 18	Tractor front blade	Massey	MF-385	2022	4WD	Transport of Solid Waste	507192-H	85550/04/22	85HP
20	Unregistered Vehicle 19	Rickshaw	Road Prince	RP150-LD	2017	2WD	Transport of Solid Waste	84312842	LZSHCKZ8H8001667	150
21	Unregistered Vehicle 20	Rickshaw	Road Prince	RP150-LD	2017	2WD	Transport of Solid Waste	8H-3099	14H800	150
22	Unregistered Vehicle 21	Rickshaw	Road Prince	RP150-LD	2017	2WD	Transport of Solid Waste	8H-309898	LZSHCKZJ4H8001654	150
23	Unregistered Vehicle 22	Rickshaw	Road Prince	RP150-LD	2017	2WD	Transport of Solid Waste	8H-312812	LZSHCKZ8H8001710	150
24	Unregistered Vehicle 23	Rickshaw	Road Prince	RP150-LD	2017	2WD	Transport of Solid Waste	8H-309996	14H8001722	150
25	Unregistered Vehicle 24	Rickshaw	Road Prince	RP150-LD	2017	2WD	Transport of Solid Waste	8H-311591	LZSHCKZ8H8001667	150
26	Unregistered Vehicle 25	Rickshaw	Road Prince	RP150-LD	2017	2WD	Transport of Solid Waste	8H-312707	LZSHCKZJ4H8001711	150
27	Unregistered Vehicle 26	Rickshaw	Road Prince	RP150-LD	2017	2WD	N/A	8H-309941	LZSHCKZJ4H8001609	150
28	Unregistered Vehicle 27	Rickshaw	Road Prince	RP150-LD	2017	2WD	Transport of Solid Waste	8H-310169	LZSHCKZ8H8001544	150
29	Unregistered Vehicle 28	Rickshaw	Road Prince	RP150-LD	2017	2WD	Transport of Solid Waste	8H-310347	LZSHCKZJ4H8001716	150
30	Unregistered Vehicle 29	Truck Sucker Machine	Nissan	PKB-211	2007	4WD	Suction	FE6-097531BP	PKB211G-00634-P	3400
31	Unregistered Vehicle 30	Truck Jetting Machine	Nissan	PKB-211	2007	4WD	Jetting	FE6-097535BP	PKB211G-00638-P	3400
32	BNE 6787	Tractor Trolley	Massey	MF-240	1999	2WD	Transport of Solid Waste	CE97065V557831	MTL-906/44	50HP
33	Unregistered Vehicle 31	Tractor Trolley	Fiat	NH480	2013	2WD	Transport of Solid Waste	238608-12GA	630483	55HP
34	Unregistered Vehicle 32	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	388333	PK492992	796

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)
35	Unregistered Vehicle 33	Mini-Truck Mini Tipper	Suzuki	Ravi	2022	2WD	Transport of Solid Waste	388168	PK492834	796
36	BNJ-1021	Tractor Front loader	Massey	MF-385	2011	4WD	Transport of Solid Waste	LM98570V52045U	8047310-11	85HP
37	Unregistered Vehicle 34	Tractor	Fiat	NH480	2013	2WD	Transport of solid waste Sweeper mechanical	238609-12GA	631366	55HP
38	Unregistered Vehicle 35	Tractor Front loader	Massey	MF-385	2012	4WD	Transport of Solid Waste	LM913572V502133W	G-84309/03/12	85HP
39	Unregistered Vehicle 36	Tractor Front blade	Massey	MF-385	2012	4WD	Transport of solid waste Front blade	B572U502115W	G-84307/2/12	85HP
40	Unregistered Vehicle 37	Truck	Hino	Dutro	2012	4WD	Transport of Solid Waste	JM13161CC	JHFYF20H306002802	4009
41	Unregistered Vehicle 38	Truck	Hino	Dutro	2012	4WD	Transport of Solid Waste	JM13159	JHFYF20HY06002800	4009
42	Unregistered Vehicle 39	Truck	Hino	Dutro	2012	4WD	Transport of Solid Waste	JM13157CC	JHFYF20H506002798	4009
43	BNJ-1022	Tractor Trolley	Massey	MF-240	2011	2WD	Transport of Solid Waste	CE9906365-46T	A41516/13/11	50HP
44	Unregistered Vehicle 40	Tractor Trolley	Fiat	NH640	2012	4WD	Loading / Unloading	008113-12D8	4104-10-9006	85HP
45	BNJ-1023	Tractor Trolley	Massey	MF-240	2009	2WD	Transport of Solid Waste	CE99001V5858535	40448-V-9	50HP
46	BNC-16	Car	Suzuki	Khyber	1999	2WD	N/A	N/A	N/A	1000
47	BNF-4	Car	Suzuki	Cultus	2003	2WD	Transport of staff	812064	955410	1000
48	BNE-262	Jeep	Suzuki	Potohar	2002	4WD	Transport of staff	1071815	330261	1000
49	BNA-8059	Jeep	Suzuki	Potohar	1990	4WD	Transport of staff	341682	306850	1000
50	Unregistered Vehicle 41	Mini-Truck Mini Tipper	Suzuki	Ravi	2012	2WD	Dengue Brigade	PKT221149	SR308PK325820	796
51	Unregistered Vehicle 42	Tractor	Fiat	NH480	N/A	2WD	N/A	N/A	N/A	55HP
52	Unregistered Vehicle 43	Tractor	Massey	MF-240	2001	2WD	N/A	N/A	N/A	50HP
53	Unregistered Vehicle 44	Tractor	Massey	MF-240	2001	2WD	N/A	N/A	N/A	50HP
54	Unregistered Vehicle 45	Tractor	Massey	MF-240	1992	2WD	N/A	N/A	N/A	50HP
55	Unregistered Vehicle 46	Tractor	Massey	MF-385	2001	4WD	Transport of Solid Waste	N/A	N/A	85HP
56	Unregistered Vehicle 47	Bike	Yamaha	YB-100	1990	2WD	N/A	3HHZ-010470K	8H22-0104707	100
57	Unregistered Vehicle 48	Bike	Kawasaki	N/A	N/A	2WD	N/A	N/A	N/A	100

4.2 Baseline Fuel Consumption Trend

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

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

Sr. No.	Unique Registration Number	Fuel Consumption (Idle)				Fuel Consumption (Working)				
		Start Time	End Time	Fuel Usage (Liters)	Consumption	Start Time	End Time	Distance (km)	Fuel Usage	Consumption
1	Unregistered Vehicle 1	4:35 PM	6:05 PM	3.925	2.62 Liters/hr	3:32 PM	4:32 PM		7.179	7.18 Liters/hr
2	Unregistered Vehicle 2	4:30 PM	6:00 PM	3.7	2.47 Liters/hr	3:30 PM	4:30 PM		7.07	7.07 Liters/hr
3	BNH-4081	4:45 PM	6:40 PM	1.633	0.85 Liters/hr	3:35 PM	4:45 PM		5.638	4.83 Liters/hr
4	Unregistered Vehicle 4	6:15 PM	7:15 PM	0.8	0.8 Liters/hr	4:50 PM	6:15 PM		1.99	1.4 Liters/hr
5	Unregistered Vehicle 5	10:05 AM	11:05 AM	1.085	1.09 Liters/hr	9:00 AM	10:00 AM		9.093	9.09 Liters/hr
6	Unregistered Vehicle 6	9:45 AM	10:45 AM	1.57	1.57 Liters/hr	8:45 AM	9:45 AM		9.205	9.21 Liters/hr
7	Unregistered Vehicle 19	9:45 AM	10:45 AM	0.302	0.3 Liters/hr	8:45 AM	9:45 AM		0.5	0.5 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
8	Unregistered Vehicle 29	10:00 AM	11:00 AM	2.235	2.24 Liters/hr	8:30 AM	9:50 AM		7.165	5.37 Liters/hr
9	Unregistered Vehicle 30	11:25 AM	12:25 PM	4.005	4.01 Liters/hr	10:15 AM	11:25 AM		7.68	6.58 Liters/hr
10	BNE 6787	11:32 AM	12:32 PM	1.717	1.72 Liters/hr	10:25 AM	11:30 AM		3.67	3.39 Liters/hr
11	Unregistered Vehicle 31	11:37 AM	12:37 PM	2.213	2.21 Liters/hr	10:20 AM	11:35 AM		3.525	2.82 Liters/hr

Table 28: Vehicle Fuel Consumption- logbook data

Sr. No.	Unique Registration Number	Fuel Usage on logbook (km/ltr)
1	Unregistered Vehicle 1	4.00
2	Unregistered Vehicle 2	7.00
3	Unregistered Vehicle 19	15.00
4	Unregistered Vehicle 20	15.00
5	Unregistered Vehicle 21	15.00
6	Unregistered Vehicle 23	15.00
7	Unregistered Vehicle 24	15.00
8	Unregistered Vehicle 25	15.00
9	Unregistered Vehicle 26	15.00
10	Unregistered Vehicle 27	15.00
11	BNE 6787	5.00
12	Unregistered Vehicle 31	6.00
13	BNJ-1022	5.00
14	BNJ-1023	5.00

The logbooks of remaining vehicles are not available in MC.

The MC made 11 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 1.81 liters/hour whereas the average operational fuel consumption of vehicles turned out to be 5.22 liters/hour.

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

Table 29: Fuel Cost

Description	Unit	Value
Annual Consumption of Fuel (Diesel)	Liter/y	31,116
Annual Cost of Fuel (Diesel)	PKR/y	9,116,988
Annual Consumption of Fuel (Petrol)	Liter/y	10,368
Annual Cost of Fuel (Petrol)	PKR/y	2,820,096

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 Bahawalnagar 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 Bahawalnagar has bought enough new vehicles to meet their daily demand. Based on the logbook data, the consultant cannot make any recommendation for replacement of old vehicles. A 6-month exercise should be undertaken in which the distance travelled by each vehicle, its fuel consumption, weight of waste carried (in case of waste carrying vehicles), and O&M cost should be properly logged to calculate the efficiency of the vehicles. Once this activity is completed, the inefficient vehicles should be sold in the open market through a transparent auction.

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

5 Municipal Buildings

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

5.1 GIS Map

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

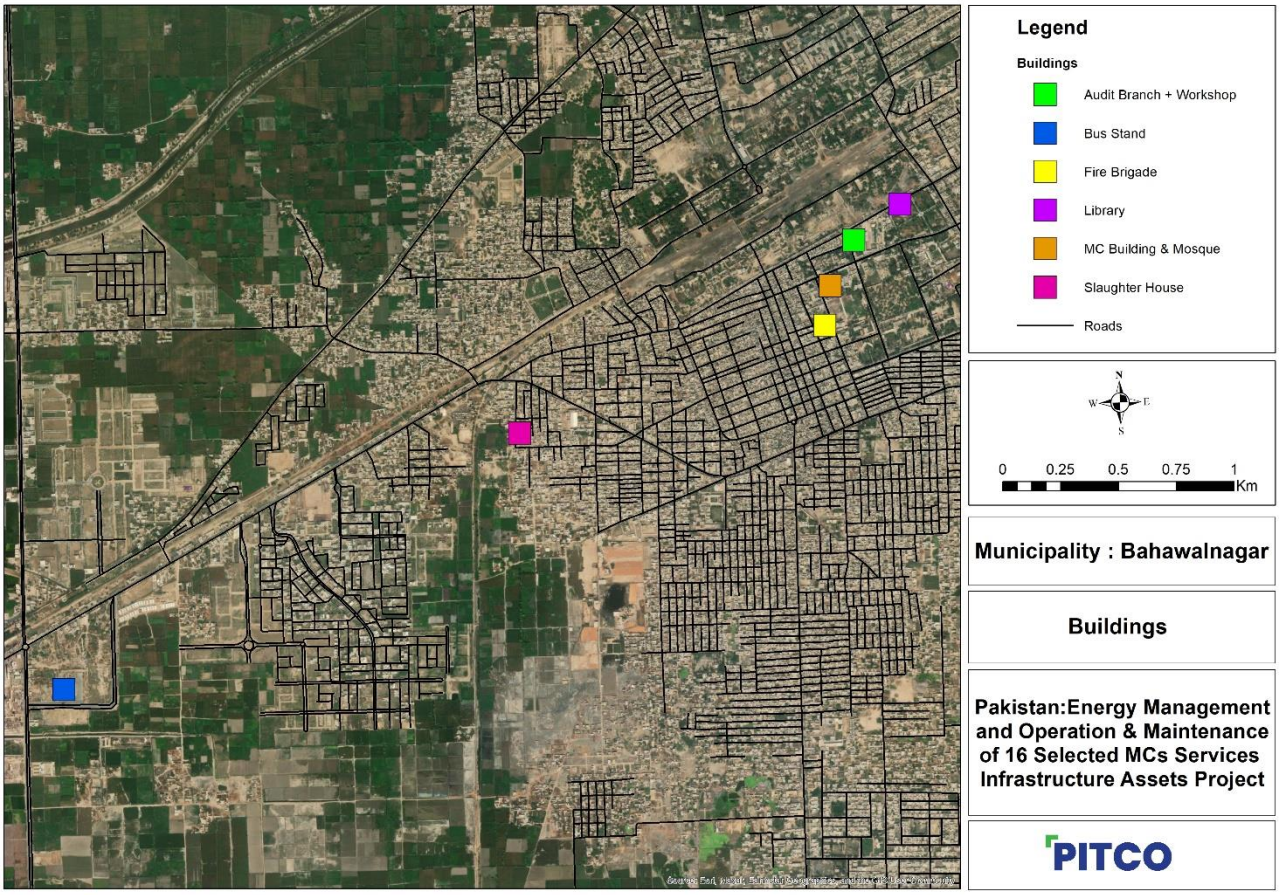


Figure 12: Map for Buildings

5.2 Building Details

Details of the MC buildings are given below.

Table 30: Buildings' Details

Sr. No.	Address	GPS	Unique ID	Ownership	Age of Building	Condition of Building	Total Area (m2)	Insulation of Building	Number of Floors
1	MC Building & Mosque	N:29.99903 E:73.25561	31806585	MC	N/A	Satisfactory	6,674	No Proper Insulation	1
2	Fire Brigade	N: 29.9975 E: 73.2553	31806585-1	MC	N/A	Satisfactory	524	No Proper Insulation	1
3	Library	N:30.002096 E:73.258863	31806585-2	MC	N/A	Un-Satisfactory	253	No Proper Insulation	1
4	Slaughter House	N:29.993749 E:73.241486	31806630	MC	N/A	Satisfactory	1,011	No Proper Insulation	1
5	Audit Branch + Workshop	N:30.000776 E:73.256734	31806585-4	MC	N/A	Satisfactory	1,666	No Proper Insulation	1
6	Bus Stand	N:29.984450 E:73.220687	31806585-5	MC	N/A	Satisfactory	15,880	No Proper Insulation	1

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

Table 31: Number of 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	Land branch	Electric Heater	1	1000	0	0	0	0
2	Superintendent office	Electric Heater	1	1000	3	3	78	234
3	Co-office	Electric Geyser	1	2000	3	3	78	468
	Total							**702**

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

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
MC Building & Mosque								
1	Account Branch	Ceiling Fan	2	80	8	8	208	266
2	Account Branch	Air Cooler	1	125	8	4	104	104
3	Account Branch 2	Ceiling Fan	1	80	8	8	208	133
4	MOF office	Ceiling Fan	1	80	8	8	208	133
5	MOF office	Inverter	1	1452	4	4	104	604
6	Gallery	Ceiling Fan	1	80	8	8	208	133
7	Doctor room	Ceiling Fan	2	80	6	8	208	200
8	Registration Branch	Ceiling Fan	2	80	8	8	208	266
9	Land Branch	Ceiling Fan	1	80	8	8	208	133
10	Map Branch	Ceiling Fan	1	80	8	8	208	133
11	Map Branch Room	Ceiling Fan	1	80	8	8	208	133
12	TTPP Branch	Ceiling Fan	1	80	8	8	208	133
13	Ware House	Ceiling Fan	1	80	2	8	208	33
14	Complaint Cell	Ceiling Fan	1	80	8	8	208	133
15	Stablishing branch	Ceiling Fan	1	80	8	8	208	133
16	Superintendent office	Ceiling Fan	1	80	8	8	208	133
17	Superintendent office	Split AC	1	1650	2	4	104	343
18	Vice Chairman office	Ceiling Fan	1	80	8	8	208	133
19	Vice Chairman office	Exhaust Fan	1	30	8	8	208	50
20	Administrative office	Bracket Fan	8	50	2	8	208	166
21	Administrative office	Split AC	1	2700	1	4	104	281
22	Administrative office	Exhaust Fan	1	30	0	0	0	0
23	Administrative office	Split AC	1	0	0	0	0	0
24	Administrative office	Split AC	1	0	0	0	0	0
25	Kitchen	Ceiling Fan	1	80	8	8	208	133
26	Kitchen	Bracket Fan	1	50	8	8	208	83
27	Co-office	Bracket Fan	3	50	8	8	208	250
28	Co-office	Inverter	1	1452	8	4	104	1,208
29	Co-office	Bracket Fan	1	50	0	0	0	0
30	Co-office	Exhaust Fan	1	30	8	8	208	50
31	Gallery	Ceiling Fan	1	80	18	8	208	300
32	Superintendent Branch	Ceiling Fan	1	80	8	8	208	133
33	Superintendent Branch	Bracket Fan	1	50	8	8	208	83
34	IT Branch	Ceiling Fan	1	80	7	8	208	116
35	Water Branch	Ceiling Fan	1	80	8	8	208	133
36	Water Supply	Ceiling Fan	2	80	8	8	208	266
37	Engineering Branch	Ceiling Fan	1	80	8	8	208	133

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

Sr. No	Name of Room	Type of Cooling Equipment	Equipment Count	Capacity in Watts	Daily operating hours[7]	No. of months used per year	Operating days per year	Annual Electricity consumption (kWh/year)
38	Engineering Branch	Air Cooler	1	125	7	6	156	137
39	Engineering Branch	Bracket Fan	1	50	8	8	208	83
40	MOI Branch	Ceiling Fan	2	80	8	8	208	266
41	MOI Branch	Split AC	1	1800	8	4	104	1,498
42	Union Office	Ceiling Fan	2	80	8	8	208	266
43	Electric Branch	Ceiling Fan	1	80	8	8	208	133
44	Gallery	Ceiling Fan	1	80	4	8	208	67
45	Meeting Hall	Bracket Fan	4	50	2	8	208	83
46	Masjid Main Hall	Ceiling Fan	17	80	5	8	208	1,414
47	Masjid Main Hall	Air Cooler	1	125	4	6	156	78
48	Masjid Main Hall	Bracket Fan	3	50	5	8	208	156
49	Masjid Main Hall	Exhaust Fan	1	30	5	8	208	31
50	Masjid outside	Ceiling Fan	15	80	5	8	208	1,248
51	Hall	Ceiling Fan	15	80	1	4	104	125
52	Watchman room	Ceiling Fan	1	80	12	8	208	200
Fire Brigade								
1	Open Area	Ceiling Fan	1	80	10	8	208	166
2	Room 1	Ceiling Fan	1	80	8	8	208	133
3	Room 1	Air Cooler	1	125	0	0	0	0
4	Room 1	Pedestal Fan	1	125	8	8	208	208
Library								
1	**Ladies Room**	Ceiling Fan	1	80	8	8	208	133
2	**Gents Room**	Ceiling Fan	1	80	0	0	0	0
3	**Gents room**	Air Cooler	1	125	0	0	0	0
4	**Office**	Ceiling Fan	1	80	4	8	208	67
5	**Office**	Air Cooler	1	125	0	0	0	0
Slaughter House								
1	**Doctor room**	Ceiling Fan	1	80	10	8	208	166
2	**Hall 2**	Ceiling Fan	1	80	8	8	208	133
3	**Hall 3**	Ceiling Fan	1	80	8	8	208	133
Bus Stand								
1	**Bus Stand Mosque**	Ceiling Fan	8	80	4	8	208	**1**
2	**Ladies waiting room**	Ceiling Fan	8	80	6	8	208	**2**
3	**Washroom**	Exhaust fan	1	30	4	12	312	**3**
Audit branch + workshop								
1	**Open Area**	Pedestal Fan	1	125	10	6	156	**1**
2	**Open Area**	Air Cooler	1	125	8	6	156	**2**
3	**Watchman room**	Ceiling Fan	1	80	14	8	208	**3**
4	**Audit office**	Ceiling Fan	1	80	8	8	208	**4**
5	**Audit office**	Split AC	1	0	0	0	0	**5**
6	**Audit office**	Bracket Fan	1	50	0	0	0	**6**
7	**Gallery**	Ceiling Fan	1	80	8	8	208	**7**

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)
8	**RDD Director office**	Ceiling Fan	1	80	8	8	208	**8**
9	**RDD Director office**	Split AC	1	1800	8	8	208	**9**
10	**Record room**	Ceiling Fan	1	80	8	8	208	**10**
11	**Record room**	Air Cooler	1	125	6	8	208	**11**
12	**Record room**	Split AC	1	1800	8	8	208	**12**
13	**Record room**	Bracket Fan	1	50	8	8	208	**13**
14	**Record room**	Pedestal Fan	1	125	8	8	208	**14**
1	**Open Area**	Pedestal Fan	1	125	10	6	156	**1**
2	**Open Area**	Air Cooler	1	125	8	6	156	**2**
3	**Watchman room**	Ceiling Fan	1	80	14	8	208	**3**
	Total Annual kWh							**22,514**

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

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Energy consumption (kWh/year)
MC Building & Mosque							
1	**Account Branch**	CFL	1	25	8	312	62
2	**Account Branch**	LED	1	50	8	312	125
3	**Account Branch**	Zero Bulb	1	12	8	312	30
4	**Account Branch 2**	LED	4	7	8	312	70
5	**Account Branch 2**	LED	1	45	8	312	112
6	**Account Branch 2**	LED	1	12	8	312	30
7	**MOF Office**	LED	4	7	8	312	70
8	**MOF Office**	LED	1	12	8	312	30
9	**Gallery**	LED	1	12	8	312	30
10	**Doctor Room**	LED	6	10	6	312	112
11	**Doctor Room**	LED	2	12	6	312	45
12	**Darbar inside**	CFL	1	25	0	312	0
13	**Darbar inside**	LED	1	18	6	312	34
14	**Darbar inside**	Zero Bulb	4	12	6	312	90
15	**Darbar inside**	LED	1	12	0	312	0
16	**Registration branch**	CFL	1	25	8	312	62
17	**Registration branch**	LED	3	12	8	312	90
18	**Land branch**	LED	2	25	8	312	125
19	**MOP Branch**	LED	2	25	8	312	125
20	**MOP Branch room**	LED	1	25	8	312	62
21	**Gallery**	ILB	1	100	0	312	0
22	**Gallery**	CFL	1	24	0	312	0
23	**Gallery**	LED	1	12	12	312	45

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

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Energy consumption (kWh/year)
24	**Ware House**	Tubelight	3	40	2	312	75
25	**Complaint Cell**	LED	4	7	8	312	70
26	**Establishment branch**	LED	3	12	8	312	90
27	**Establishment branch**	LED	1	12	0	312	0
28	**Superintendent office**	LED	4	18	8	312	180
29	**Vice Chairman office**	ILB	2	200	0	312	0
30	**Vice Chairman office**	LED	2	50	8	312	250
31	**Administrative office**	CFL	6	24	8	312	359
32	**Administrative office**	LED	1	12	2	312	7
33	**Administrative office**	Tubelight Panel	4	72	0	312	0
34	**Administrative office**	CFL	20	24	0	312	0
35	**Administrative office**	LED	2	50	8	312	250
36	**Administrative office**	CFL	1	12	8	312	30
37	**Kitchen**	ILB	1	100	0	312	0
38	**Kitchen**	CFL	1	24	8	312	60
39	**Co-office**	Tubelight	1	40	0	312	0
40	**Co-office**	CFL	1	24	8	312	60
41	**Co-office**	LED	4	50	8	312	499
42	**Gallery**	LED	1	12	8	312	30
43	**Store**	Tubelight	1	40	1	312	12
44	**Sanitation branch**	LED	3	12	8	312	90
45	**IT branch**	LED	4	7	7	312	61
46	**Water store branch**	LED	1	25	8	312	62
47	**Water supply**	LED	1	12	0	312	0
48	**Engineering branch**	ILB	1	200	0	312	0
49	**Engineering branch**	CFL	1	45	8	312	112
50	**Engineering branch**	LED	1	50	8	312	125
51	**MOI branch**	LED	2	50	8	312	250
52	**MOI branch**	LED	1	30	8	312	75
53	**MOI branch**	LED	1	12	8	312	30
54	**Union Office**	ILB	1	200	1	312	62
55	**Union Office**	LED	2	45	8	312	225
56	**Union Office**	LED	4	7	8	312	70
57	**Electric branch**	LED	2	12	8	312	60
58	**Gallery**	LED	3	12	8	312	90
59	**Meeting Hall**	Tubelight Panel	18	72	1	312	404
60	**Open Area**	LED	2	30	12	312	225
61	**Masjid Main Hall**	LED	26	12	2	312	195
62	**Masjid Main Hall**	LED	11	10	2	312	69
63	**Masjid Main Hall**	LED	4	7	2	312	17
64	**Masjid Outside**	LED	7	12	6	312	157
65	**Wazu Area**	Tubelight	1	40	0	312	0
66	**Wazu Area**	LED	7	12	12	312	314

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Energy consumption (kWh/year)
67	**Hall**	LED	13	12	1	312	49
68	**Watchman Room**	CFL	1	24	0	312	0
69	**Watchman Room**	LED	1	12	8	312	30
Fire Brigade							
1	**Open Area**	LED	3	12	12	312	135
2	**Washroom**	ILB	2	100	2	312	125
3	**Room 1**	ILB	1	100	0	312	0
4	**Room 1**	LED	1	12	8	312	30
Library							
1	**Gents Room**	Tubelight	1	40	0	312	0
2	**Office**	ILB	1	100	2	312	62
3	**Office**	Tubelight	2	40	0	312	0
4	**Office**	CFL	1	25	0	312	0
Slaughter House							
1	**Doctor Room**	LED	2	18	10	312	112
2	**Hall 1**	ILB	7	100	8	312	1,747
3	**Hall 2**	ILB	5	60	8	312	749
4	**Hall 3**	ILB	2	60	8	312	300
5	**Hall 3**	LED	1	12	8	312	30
6	**Hall 3**	ILB	4	100	8	312	998
7	**Pump Room**	ILB	1	100	2	312	62
8	**Open Area**	LED	2	18	10	312	112
Audit branch + workshop							
1	**Open Area**	ILB	2	200	0	312	0
2	**Open Area**	CFL	4	25	0	312	0
3	**Open Area**	LED	1	12	12	312	45
4	**Watchman Room**	LED	2	12	12	312	90
5	**Washroom**	LED	1	7	12	312	26
6	**Audit Room**	LED	1	18	8	312	45
7	**Gallery**	LED	2	12	0	312	0
8	**Gallery**	LED	1	18	12	312	67
9	**Washroom**	LED	1	18	0	312	0
10	**ADD Director Office**	LED	1	18	8	312	45
11	**Record Room**	CFL	2	25	8	312	125
12	**Record Room**	LED	1	18	8	312	45
Bus Stand							
1	**Mosque**	Tubelight	4	40	0	312	0
2	**Mosque**	LED	1	12	12	312	45
3	**Ladies waiting room**	Tubelight	4	40	0	312	0
4	**Ladies waiting room**	LED	1	12	12	312	45
5	**Washroom**	Tubelight	1	40	0	312	0
6	**Washroom**	LED	1	12	0	312	0
7	**Office DSP Room**	Tubelight	2	40	0	312	0

Sr. No	Name of Room/ Location	Type of Lighting Equipment	Count of Equipment	Capacity in Watts	Daily operating hours[8]	Operating days per year	Annual Energy consumption (kWh/year)
8	**Class room**	Tubelight	2	40	0	312	0
9	**Rest Area**	Tubelight	2	40	0	312	0
10	**Rest Area**	LED	2	12	4	312	30
11	**Clerk office**	Tubelight	2	40	0	312	0
12	**Clerk office**	LED	1	12	8	312	30
13	**Clerk office**	Tubelight	1	40	0	312	0
14	**Gallery**	Tubelight	8	40	0	312	0
15	**Gallery**	LED	1	18	8	312	45
16	**Gallery**	LED	2	12	8	312	60
17	**Ticket office**	ILB	1	100	12	312	374
18	**Ticket office**	Tubelight	2	40	0	312	0
19	**Ticket office 2**	ILB	1	100	12	312	374
20	**Ticket office 2**	CFL	1	24	0	312	0
21	**Ticket office 3**	Tubelight	1	40	0	312	0
22	**Ticket office 4**	Tubelight	1	40	0	312	0
23	**Ticket office 4**	LED	1	12	8	312	30
24	**Ticket office 5**	LED	1	12	8	312	30
25	**Ticket office 6**	Tubelight	1	40	0	312	0
26	**Ticket office 7**	Tubelight	1	40	0	312	0
27	**Ticket office 8**	Tubelight	1	40	0	312	0
28	**Ticket office 8**	LED	1	12	8	312	30
29	**Kitchen**	Tubelight	1	40	0	312	0
30	**Outside Gallery**	Tubelight	8	40	0	312	0
31	**Outside Gallery**	CFL	1	24	8	312	60
32	**Outside Gallery**	LED	14	12	8	312	419
33	**Outside Gallery**	LED	10	50	10	312	1,560
						Total Annual kWh	**14,176**

5.3 Baseline Energy Consumption Trend

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

Table 34: Energy consumption in Office Buildings

SI No.	Description	Unit	Value[9]
1	Annual Electricity Consumption	kWh	62,990
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	6	57,473	48,838	8,635	8.29 kWh/m2	7.05 kWh/m2	Bus Stand building and Audit Branch building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these building has not been considered in the overall energy consumption and KPI calculations. Furthermore, there are no electricity units in the electricity bill of Slaughter House for this assessment period and there was no electricity bill for Fire Brigade building during the last assessment so, for the purpose of this comparison, their energy consumption are also not considered in the overall energy consumption and KPI calculations.

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

Table 35: Cooling Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Office and Mosque	Ceiling Fan	62	0	80
MC Office and Mosque	Bracket Fan	19	0	22
MC Office and Mosque	Exhaust Fan	1	0	4
MC Office and Mosque	Air Cooler	5	0	3
MC Office and Mosque	Split AC	7	0	5
MC Office and Mosque	Inverter	-	-	2
Library	Ceiling Fan	3	0	3
Library	Air Cooler	1	0	2

Table 36: Lighting Equipment Comparison

Building Name	Initial Audit (2019)			Recent Audit (2023)
	Type of Cooling Equipment	Count	Proposed Replacements	Count
MC Office and Mosque	LED	84	0	150
MC Office and Mosque	CFL	32	32	35
MC Office and Mosque	Tube light	15	15	6
MC Office and Mosque	Zero Bulb	-	-	5
MC Office and Mosque	Incandescent light bulb	-	-	6
MC Office and Mosque	Tube light Panel	-	-	22
Library	Tube light	4	4	3
Library	Incandescent light bulb	3	3	1
Library	CFL	-	-	1

Table 37: Annual Units (kWh) Comparison

Building Name	Initial Audit (2019) kWh	Recent Audit (2023) kWh	Comments
MC Office and Mosque	55,325	48,559	Bus Stand building and Audit Branch building were not included in the previous assessment, therefore, for the purpose of this comparison, the energy consumption of these building has not been considered in the overall energy consumption and KPI calculations. Furthermore, there are no electricity units in the electricity bill of Slaughter House for this assessment period and there was no electricity bill for Fire Brigade building during the last assessment so, for the purpose of this comparison, there energy consumptions are also not considered in the overall energy consumption and KPI calculations.
Library	2,148	279	
Overall	**57,473**	**48,838**	

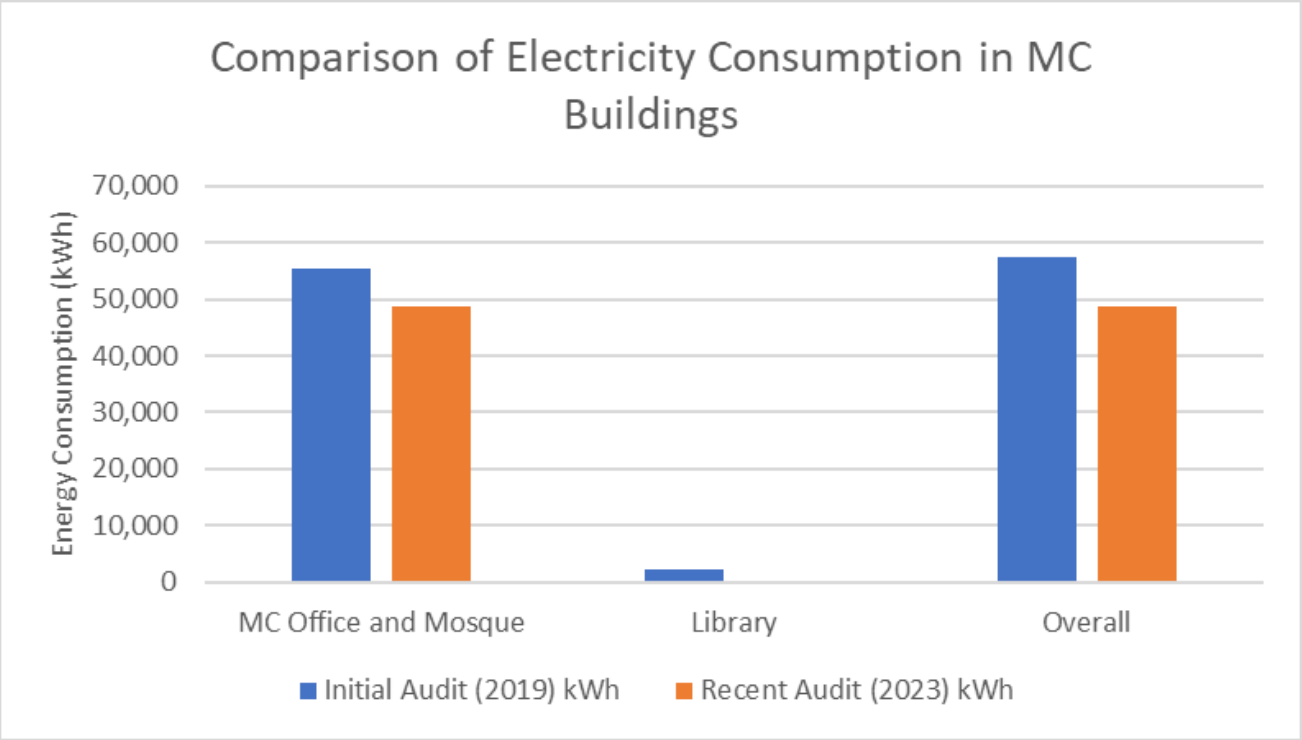


Figure 13:Comparison of Electricity Consumption in MC Buildings

5.4 Maintenance Logs of Buildings

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

6 Solar Assessment for MC Bahawalnagar

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

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

Main MC Building & Mosque, Slaughter House, Audit Branch & Workshop and Bus Stand, have Three Phase 400V electrical connection whereas, Fire Brigade and Library have single phase 220V electrical connection. As single-phase connections are not eligible for net metering, therefore, the Consultant has only carried out detailed assessment of system size requirement for the three phase connection buildings only. However, if the system requirement of any site with single-phase connection exceeds above 5 kW based on the historical electricity bill, the Consultant has provided the detailed assessment of available solar system capacity. Metering details of each building is presented below.

Table 38: Metering details at MC Bahawalnagar

Sr. No.	Building Name	Unique ID	Billing Reference Number	Sanctioned Load (kW)	Tariff Category
1	Main MC Building & Mosque	31806585	28158110204007 (3ϕ)	16	A-3a (66)
2	Fire Brigade	31806585-1	14158111276705 (1ϕ)	1	G-1 (72)
3	Library	31806585-2	28158111080400 (1ϕ)	0.7	A-3a (66)
4	Slaughter House	31806630	27158110786501 (3ϕ)	60	B2b (12)T
5	Audit Branch & Workshop	31806585-4	28158110971803 (3ϕ)	5.3	A-3a (66)
6	Bus Stand	31806585-5	29158120497044 (3ϕ)	14.92	A-3a (66)

6.1 Main MC Office Building & Mosque

The project site i.e. Main Office Building is located near Baldia road, Bahawalnagar, Punjab, Pakistan while the geographical co-ordinates of location are 29.99903°N (latitude) and 73.25561°E (longitude).

Figure 14: Front view of MC Office Building & Mosque

Figure 15: Aerial view of MC Office Building & Mosque

6.1.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of MC Office Building & Mosque is 48,559 kWh with the peak electricity consumption of

7,176 kWh in October 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 39: Solar System Requirement

Sr. No.	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	28158110204007	48,559	4,047	7,176	36

6.1.2 Roof Assessment

As per the Consultant's assessment, the total area of the Main MC Building & Mosque is 71,838 ft^2 whereas, the total area of rooftop available for the solar installation is 11,597 ft^2. The area assumed for system installation is clear roof space area, which is exclusive of shading areas due to any obstructions like water tank, parapet wall, any nearest heighted building, mumty room, air vents, sky lights and trees.

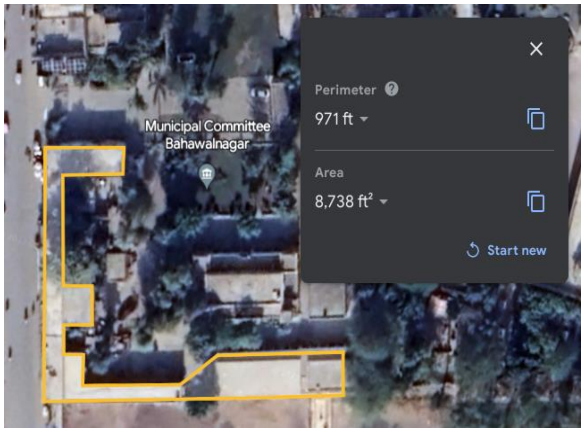


Figure 16: Top View of Main MC Office building Section-A

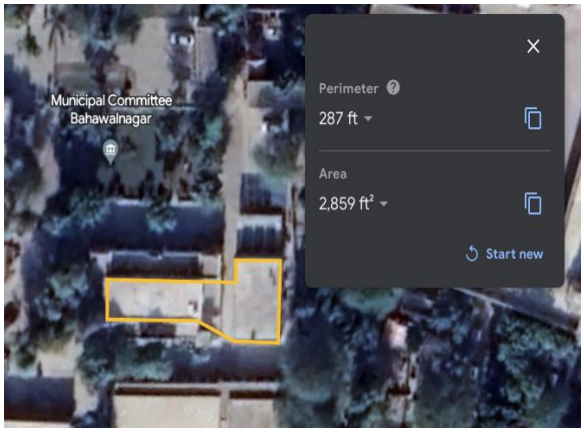


Figure 17: Top View of Main MC Office building Section-B

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

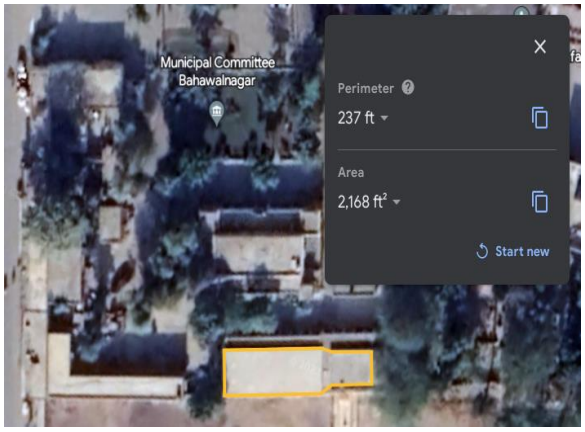


Figure 18: Location for Solar Installation - A

Figure 19: Location for Solar Installation - B

Figure 20: Location for Solar Installation - C

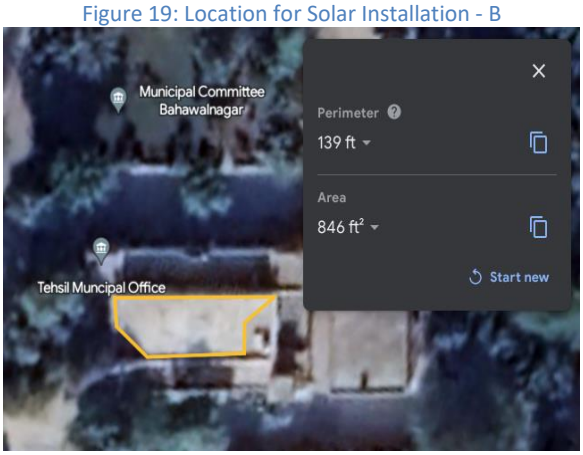


Figure 21: Location for Solar Installation - D

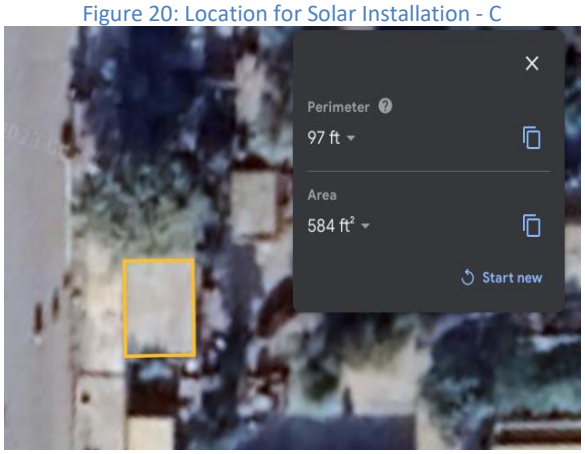


Figure 22: Location for Solar Installation - E

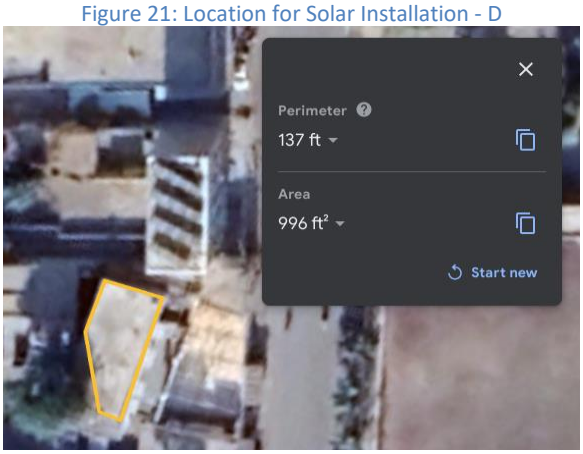


Figure 23: Location for Solar Installation - F

Table 40: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Location – C	Location – D	Location – E	Location – F	Total
Area availability (ft²)	2,168	1,202	1,140	846	584	996	6,936
Solar system capacity (kW)	22	12	11	8	6	10	69

6.2 Fire Brigade

The project site i.e. Fire Brigade is located near Tehsil Bazaar Road, Bahawalnagar, Punjab, Pakistan while the geographical co-ordinates of location are 29.9975°N (latitude) and 73.2553°E (longitude).

Figure 24: Front view of Fire Brigade

Figure 25: Aerial view of Fire Brigade

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 this electrical connection is 2,115 kWh with the peak electricity consumption of 412 kWh in January 2023. The annual energy consumption for Fire Brigade cannot be accurately determined as this meter is shared with streetlight. Based on the historical billing, the Consultant has estimated the solar system requirement of this electrical connection, which is presented below in the following table.

Table 41:Solar System Requirement

Sr. No.	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	14158111276705	2,115	176	412	2

Note: Based on the analysis of the historical electricity billing data, it is identified that the solar system requirement for this connection is only **2 kW**[10], based on the size of solar system requirement, it is not recommended to install the solar system at this site.

6.3 Library

The project site i.e. Library is located near Eid Gah Road, Bahawalnagar, Punjab, Pakistan while the geographical co-ordinates of location are 30.001992°N (latitude) and 73.258827°E (longitude).

[10] This is the solar system requirement for the Fire Brigade building and streetlight connection.

Figure 26: Front view of Library

Figure 27: Aerial view of 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 279 kWh with the peak electricity consumption of 74 kWh in October 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 42: Solar System Requirement

Sr. No.	Meter Reference Number	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	28158111080400	279	23	74	0.20

Note: Based on the analysis of the historical billings it is identified that the system requirement for this site is **0.2 kW** with a single-phase connection furthermore as building is connected to the national grid through a single-phase electricity connection, it is not recommended to install the solar system at this site.

6.4 Slaughterhouse

The project site i.e. Slaughter House is located near Madina town Bahawalnagar, Punjab, Pakistan while the geographical co-ordinates of location are 29.99363°N (latitude) and 73.24094°E (longitude).

Figure 28: Front View of the Slaughterhouse

Figure 29: Aerial view of the Slaughterhouse

6.4.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that currently, MC is not receiving the bills against this electrical connection therefore, it is not possible for the Consultant to calculate the solar system requirement based on the historical billing.

6.4.2 Roof Assessment

As per the Consultant's assessment, the total area of the Slaughterhouse is 10,882 ft^2 whereas, the total area of rooftop available for the solar installation is 1,367 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 30: Top View of the building

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

Figure 31: Location for Solar Installation

Table 43: System Size Calculation with Respect to Area

Parameters	Location
Area availability (ft²)	1,367
Solar system capacity (kW)	13

6.5 Audit Branch & Workshop

The project site i.e. Audit Branch & Work shop is located near Eid Gah Road, Bahawalnagar, Punjab, Pakistan while the geographical co-ordinates of location are 30.000776°N (latitude) and 73.256734°E (longitude).

Figure 32: Front View of Audit Branch & Work Shop

Figure 33: Aerial View of Audit Branch & Work Shop

6.5.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Audit Branch & Work shop 6,287 kWh with the peak electricity consumption of 820 kWh in August 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 44:Solar System Requirement

Sr. No.	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	28158110971803	6,287	523	820	5

6.5.2 Roof Assessment

As per the Consultant's assessment, the total area of the Audit Branch & Work shop is 17,933 ft^2 whereas, the total area of rooftop available for the solar installation is 3,630 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.

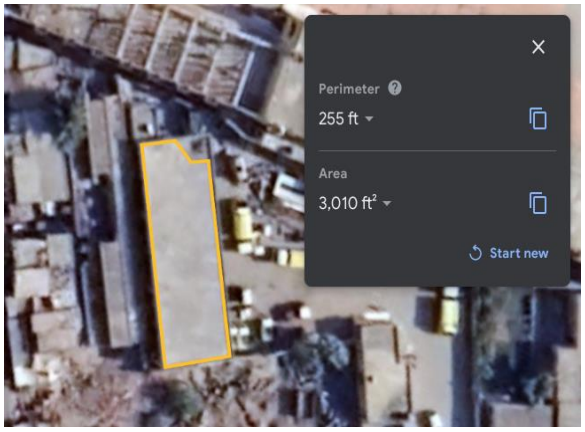


Figure 34: Top view of Audit Branch & Workshop Section-A

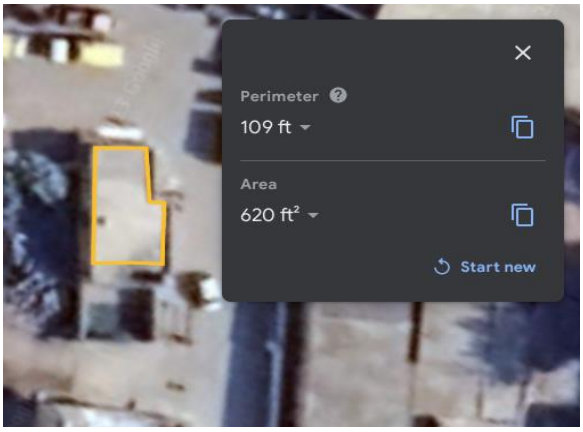


Figure 35: Top view of Audit Branch & Workshop Section-B

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

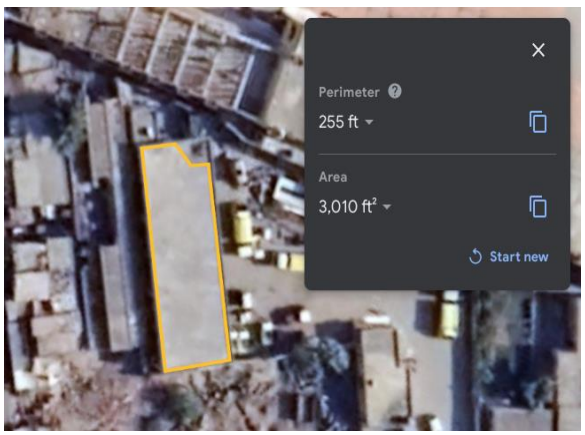


Figure 36: Location for Solar Installation – A

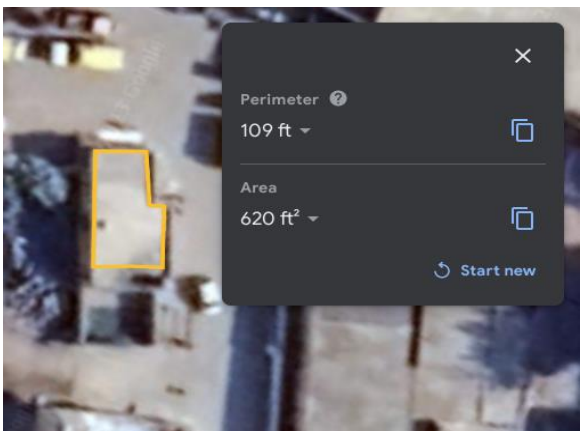


Figure 37: Location for Solar Installation – B

Table 45: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Total
Area availability (ft^2)	3,010	620	3,630
Solar system capacity (kW)	30	6	36

6.6 Bus Stand

The project site i.e. Bus Stand Building is located near New Bus Stand, Bahawalnagar Bypass, Bahawalnagar, Punjab, Pakistan, while the geographical co-ordinates of location are 29.984450°N (latitude) and 73.220687°E (longitude).

Figure 38: Front view of Bus Stand

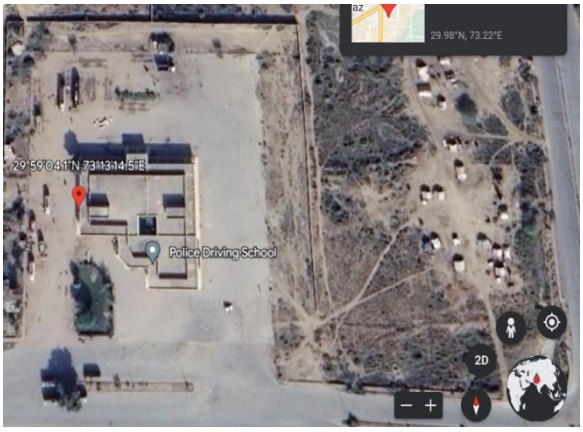


Figure 39: Aerial view of Bus Stand

6.6.1 Solar System Requirement

Based on the analysis of energy bills from March 2022 to February 2023, it is identified that the annual energy consumption of Bus Stand is 7,865 kWh with the peak electricity consumption of 1,047 kWh in November 2022. Based on the annual energy consumption, the Consultant has estimated the solar system requirement of the building, which is presented below in the following table.

Table 46:Solar System Requirement

Sr. No.	Meter Reference No	Annual Energy Consumption (kWh)	Average Energy Consumption (kWh/month)	Peak Energy Consumption kWh/month	Solar system requirement (kW)
1	29158120497044	7,865	655	1,047	6

6.6.2 Roof Assessment

As per the Consultant's assessment, the total area of the Bus Stand is 170,931 ft^2 whereas, the total area of rooftop available for the solar installation is 22,101 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.

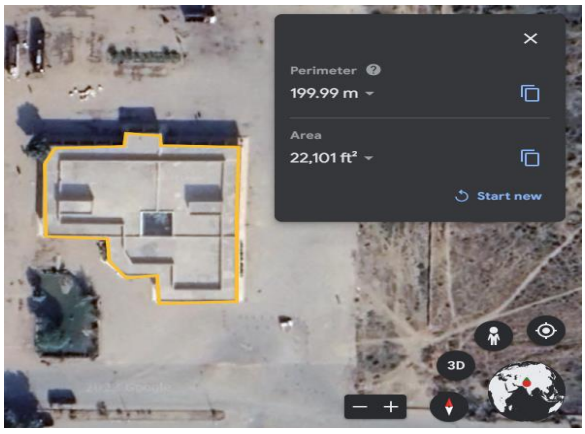


Figure 40: Top View of Bus Stand

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.

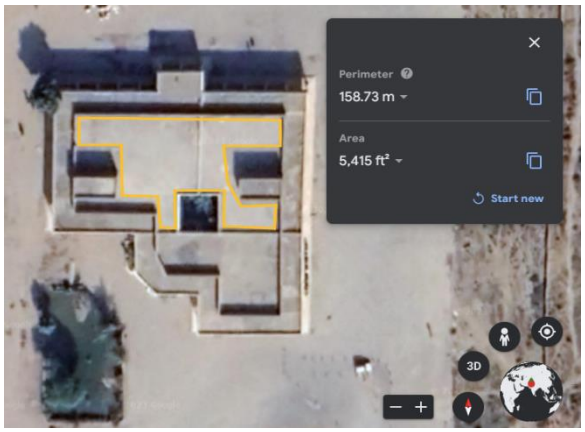


Figure 41: Location for Solar Installation – A

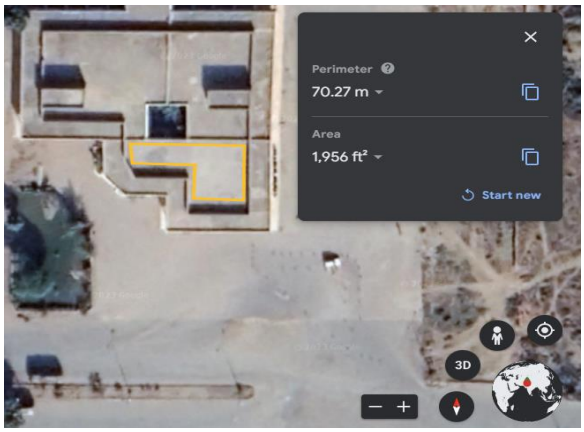


Figure 42: Location for Solar Installation – B

Table 47: System Size Calculation with Respect to Area

Parameters	Location – A	Location – B	Total
Area availability (ft²)	5,415	1,956	7,371
Solar system capacity (kW)	54	19	73

6.7 Net Metering Consideration

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

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

- Any three phase consumers (residential, commercial and industrial) will be considered eligible for the net metering system.
- Only plants installed and commissioned by AEDB registered vendors/consultants shall be eligible for net metering.
- Any empty space on the roof or facades of buildings, car parking, garages, factory or industrial buildings or sheds or similar buildings or at land within own premise of the consumer or any other suitable area where utility meter exists, is acceptable by the utility.
- Interconnection standards shall comply with the interconnection rules and standards set by the Utility or other relevant governing authority.
- 150% on the customer's sanctioned load is specified as the maximum permissible generator size (installed output DC capacity).
- The maximum output DC capacity of the installed RE system for Net Metering cannot be more than 1 MW.
- Load flow study for the facility having capacity up to 250kW is not required.
- The NOC by Electrical Inspector is not required for Net Metering of a system below 250 kW capacity.

- In case the kWh supplied by Distribution Company exceed the kWh supplied by Distributed Generator, the Distributed Generator shall be billed for the net kWh in accordance with the Applicable Tariff.
- The tariff payable by the Distribution Company shall only be the off-peak rate of the respective consumer category of the respective month.

- The equipment installed for net metering shall be capable of accurately measuring the flow of electricity in two directions.
- The net meter shall conform to the specifications mentioned in Net metering regulation or approved by relevant authority (Utility or NEPRA).
- A Distributed Generator shall be responsible for all costs associated with Interconnection Facilities up to the Interconnection Point including metering installation
- A variation of ±5%in Voltage and ±1% in frequency is permissible to the nominal voltage and frequency respectively
- The Distributed Generator will furnish and install a manual disconnect device that has a visual break to isolate the Distributed Generation Facility from the Distribution facilities
- The grid connected inverters and generators shall comply with Underwriter Laboratories UL 1741 standard (Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources) which addresses the electrical interconnection design of various forms of generating equipment, IEEE 1547 2003, IEC 61215, EN
- The Distributed Generator shall not have any right to utilize Distribution Company's Interconnection Facilities for the sale of electricity to any other person.

6.7.1 Net-metering application procedure

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

- Any person who meets the requirements of a Distributed Generator as defined under the regulations 2(k) is eligible for submitting application. Regulation 2(k) states the definition of a Distributed Generator as “a Distribution Company’s 3 Phase 400V or 11 kV consumer i.e: domestic, commercial or industrial and who owns and/or operates the Distributed Generation **Facility and** is responsible for the rights and regulations related to the agreement and licensed by the Authority under these regulations”.
- Application to Distribution Company along with necessary documents shall be submitted by intending Distributed Generator.
- Within five working days of receiving an Application, the Distribution Company shall acknowledge its receipt and inform the Applicant whether the Application is completed in all respect. Provided that in case of any missing information or documents the Applicant shall provide the same to Distribution Company within seven working days of being informed by Distribution Company.
- Upon being satisfied that the Application is complete in all respect, the Distribution Company shall perform an initial review (20 days) to determine whether the Applicant qualifies for Interconnection Facility or may qualify subject to additional requirements.
- In case the initial review reveals that the proposed facility is not technically feasible, the Distribution Company shall return the Application and communicate the reasons to the Applicant within three working days after the completion of initial review.

- For connections up to 250 kW, no technical feasibility study is needed. Power Ministry, GOP has directed DISCOs to carry out relevant technical studies and approve the connections at sub-division level. If the DISCO is satisfied that the Applicant qualifies as a DG, then the DISCO and DG will enter into an agreement.
- The DISCO office will send the copy of the Agreement between DISCO and DG to NEPRA along with application for issuance of Generation License (GL). NEPRA will issue GL within forty (40) hours of submission of application by DISCOs.
- After the Agreement. DISCO will issue the Connection Charge Estimate, if any, to the Applicant for the proposed interconnection facility up to the interconnection point including net metering installation (it is the Applicant's choice to purchase Net Meter from DISCO or open market)
- The Applicant shall make the payment of Connection Charge Estimate within twenty days of its issuance.
- Within Thirty (30) days of payment by Applicant, the DISCO office will install and commission the proposed interconnection facility after the confirmation of GL license to the DG by NEPRA.

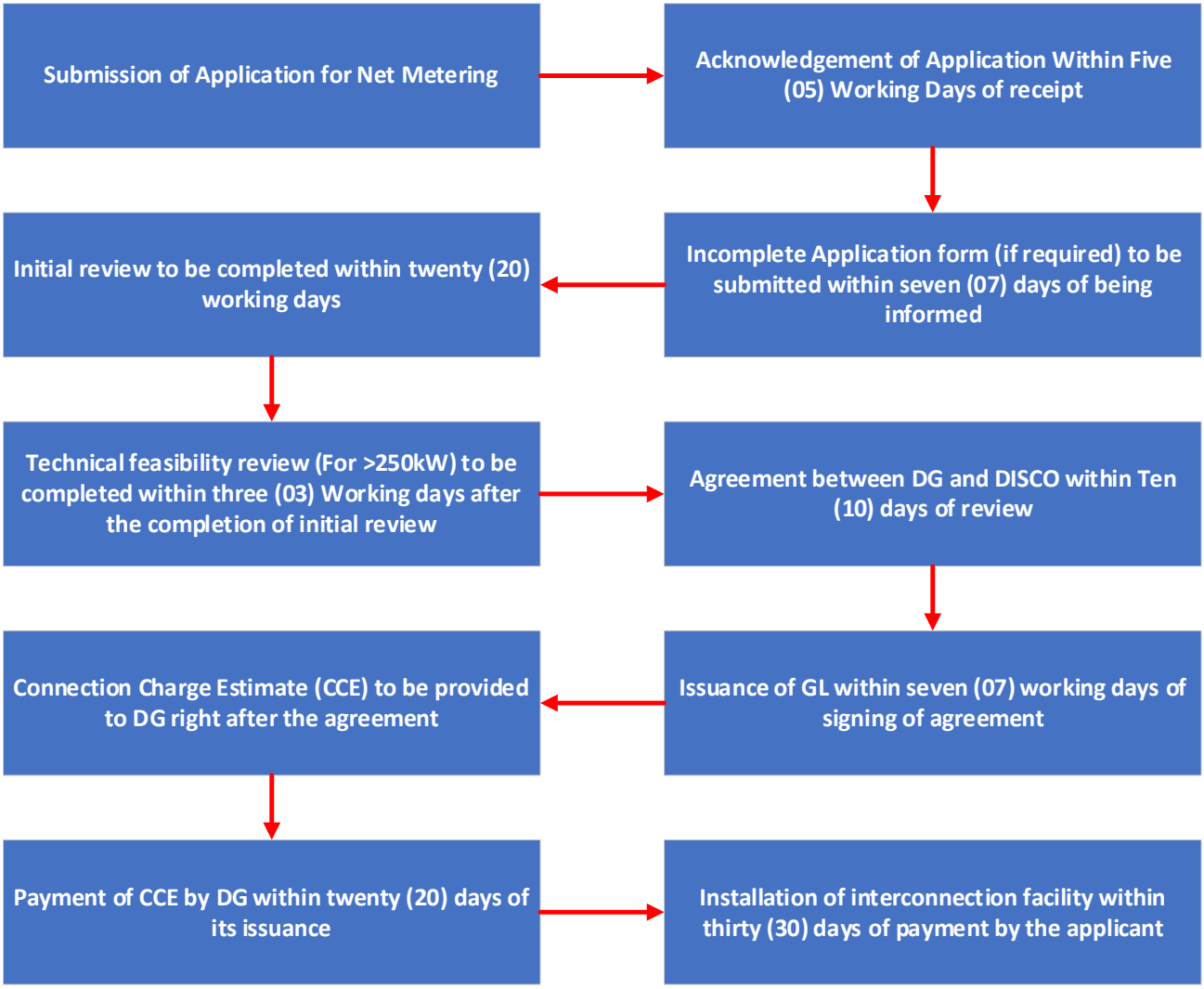


Figure 43: Pakistan Net Metering Application Process

The Consultant strongly recommends that net metering facility be utilized in the PV system design for municipal buildings. The basis of this recommendation is based on the nature of the loads. During the day,

solar can supplement the electronic, lighting, and cooling loads while exporting the excess energy to the Grid.

7 Recommended Energy Efficiency Measures

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

7.1 Energy Efficiency Measures for Water Pumps & Wastewater Disposal System

7.1.1 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Fordwah canal No. 2 old - Unique ID: 31806588)

Study & Investigation

The savings are calculated based on the network averages.

Recommended Action

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

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

Saving Assessment

Table 48: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	15
Measured Flow	m^3/h	69
Measured Head	m	18.2
Measured Motor Power	kW	10.00
Pump Efficiency	%	40.2%
Existing Operational Hours	h	16.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	7.8
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	16.0
Pump Operational Days	days	330
Efficiency	%	78%
Annual Water Generation from proposed pump	m^3	269,123

Parameters	Unit	Values
Energy Required per m^3 by Existing Pump Network to Supply abovementioned quantity of water	(kWh/m^3)	0.22
Energy Required by Existing Pump Network to Supply abovementioned quantity of water	kWh	58,412
Energy Required by Proposed Pump to Supply abovementioned quantity of water	kWh	41,342
Saving Potential	kWh/y	17,070
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,742
Investment	US $	3,594
Simple Payback Period	months	16

7.1.2 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Fordwah canal No. 10 old - Unique ID: 31806594)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 20%.

Recommended Action

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

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

Saving Assessment

Table 49: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	15
Measured Flow	m^3/h	41
Measured Head	m	15.3
Measured Motor Power	kW	10.10
Pump Efficiency	%	20%
Existing Operational Hours	h	16.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	7.8
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	13.0
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	53,328
Energy Required by Proposed Pump	kWh/y	33,636
Saving Potential	kWh/y	19,692

Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	3,163
Investment	US $	3,594
Simple Payback Period	months	14

7.1.3 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Turbine No. 1 New - Unique ID: 31806595)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 31%.

Recommended Action

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

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

Saving Assessment

Table 50: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	180
Design Motor Power of Existing Pump	kW	15
Measured Flow	m^3/h	36
Measured Head	m	34.8
Measured Motor Power	kW	12.93
Pump Efficiency	%	31%
Existing Operational Hours	h	20.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	7.8
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	14.0
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	85,360
Energy Required by Proposed Pump	kWh/y	36,154
Saving Potential	kWh/y	49,206
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	7,902
Investment	US $	3,594
Simple Payback Period	months	5

7.1.4 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Fordwah Canal No. 11 New - Unique ID: 31806607)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 25%

.

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 51: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	180
Design Motor Power of Existing Pump	kW	15
Measured Flow	m^3/h	81
Measured Head	m	13.8
Measured Motor Power	kW	14.50
Pump Efficiency	%	25%
Existing Operational Hours	h	16.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	7.8
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	25.3
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	76,560
Energy Required by Proposed Pump	kWh/y	65,412
Saving Potential	kWh/y	11,148
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,790
Investment	US $	3,594
Simple Payback Period	months	24

7.1.5 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Fordwah canal No. 23 old - Unique ID: 31806624)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 29%.

Recommended Action

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

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

Saving Assessment

Table 52: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	15
Measured Flow	m^3/h	60
Measured Head	m	22.3
Measured Motor Power	kW	14.60
Pump Efficiency	%	29%
Existing Operational Hours	h	16.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	7.8
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	18.8
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	77,088
Energy Required by Proposed Pump	kWh/y	48,544
Saving Potential	kWh/y	28,544
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	4,584
Investment	US $	3,594
Simple Payback Period	months	9

7.1.6 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (JWB No. 4 - Unique ID: 31906645)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 31%.

Recommended Action

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

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

Saving Assessment

Table 53: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	200
Design Motor Power of Existing Pump	kW	19
Measured Flow	m^3/h	87
Measured Head	m	17.1
Measured Motor Power	kW	15.23
Pump Efficiency	%	31%
Existing Operational Hours	h	16.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	7.8
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	27.2
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	80,432
Energy Required by Proposed Pump	kWh/y	70,274
Saving Potential	kWh/y	10,158
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,631
Investment	US $	3,594
Simple Payback Period	months	26

7.1.7 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (JWB No. 5 - Unique ID: 33107038)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 18%.

Recommended Action

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

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

Saving Assessment

Table 54: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	51
Design Head of Existing Pump	ft	220
Design Motor Power of Existing Pump	kW	19
Measured Flow	m^3/h	90
Measured Head	m	12.9
Measured Motor Power	kW	20.57
Pump Efficiency	%	18%
Existing Operational Hours	h	16.0
Proposed Pump Flow	m^3/h	51
Proposed Head	m	40
Power Consumption of Proposed Pump	kW	7.8
Motor Size of Proposed Pump	hp	15.0
Operational Hours of Proposed Pump	h	28.4
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	108,592
Energy Required by Proposed Pump	kWh/y	73,401
Saving Potential	kWh/y	35,191
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	5,652
Investment	US $	3,594
Simple Payback Period	months	8

7.1.8 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Degree College WW No. 1 - Unique ID: 31806640-1)

Study & Investigation

Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 14%.

Recommended Action

Replacement of Pump with new PECO 10WC 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 55: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	153
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	22
Measured Flow	m^3/h	115
Measured Head	m	7.2
Measured Motor Power	kW	18.53
Pump Efficiency	%	14%
Existing Operational Hours	h	16.0
Proposed Pump Flow	m^3/h	153
Proposed Head	m	34
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	12.0
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	97,856
Energy Required by Proposed Pump	kWh/y	64,957
Saving Potential	kWh/y	32,899
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	5,284
Investment	US $	4,151
Simple Payback Period	months	9

7.1.9 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Quraish Colony - Unique ID: 33007036-1)

Study & Investigation

E Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 20%.

Recommended Action

Replacement of Pump with new PECO 10WC 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 56: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	153
Design Head of Existing Pump	ft	115
Design Motor Power of Existing Pump	kW	30
Measured Flow	m^3/h	154
Measured Head	m	9.3
Measured Motor Power	kW	22.83
Pump Efficiency	%	20%
Existing Operational Hours	h	5.0
Proposed Pump Flow	m^3/h	153
Proposed Head	m	34
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	5.0
Pump Operational Days	days	330
Efficiency	%	78%
Energy Required by Existing Pump	kWh/y	37,675
Energy Required by Proposed Pump	kWh/y	27,340
Saving Potential	kWh/y	10,335
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	1,660
Investment	US $	4,151
Simple Payback Period	months	30

7.1.10 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Model Town w.w Sadqia No. 1 - Unique ID: 82907316-1)

Study & Investigation

E Efficiency of existing water pumpset was tested by simultaneous measurements of flow, head & power and was found out to be 25%.

Recommended Action

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

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

Saving Assessment

Table 57: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	204
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	37
Measured Flow	m^3/h	306
Measured Head	m	9.3
Measured Motor Power	kW	36.10
Pump Efficiency	%	25%
Existing Operational Hours	h	16.0
Proposed Pump Flow	m^3/h	204
Proposed Head	m	32
Power Consumption of Proposed Pump	kW	18.6
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	24.1
Pump Operational Days	days	330
Efficiency	%	85%
Energy Required by Existing Pump	kWh/y	190,608
Energy Required by Proposed Pump	kWh/y	147,961
Saving Potential	kWh/y	42,647
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	6,849
Investment	US $	4,657
Simple Payback Period	months	8

7.1.11 High Priority Energy Efficiency Measure: Replacement of Pumpset

Description

Replacement of Pumpset at (Model Town w.w No 1 - Unique ID: 82907316-2A)

Study & Investigation

The savings are calculated based on the network averages.

Recommended Action

Replacement of Pump with new PECO 10WC 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 58: Saving & cost benefit for pumpset replacement

Parameters	Unit	Values
Design Flow of Existing Pump	m^3/h	153
Design Head of Existing Pump	ft	
Design Motor Power of Existing Pump	kW	19
Measured Flow	m^3/h	149
Measured Head	m	9.5
Measured Motor Power	kW	14.20
Pump Efficiency	%	31.7%
Existing Operational Hours	h	3.0
Proposed Pump Flow	m^3/h	153
Proposed Head	m	34
Power Consumption of Proposed Pump	kW	16.4
Motor Size of Proposed Pump	hp	30.0
Operational Hours of Proposed Pump	h	3.0
Pump Operational Days	days	330
Efficiency	%	78%
Annual Water Generation from proposed pump	m^3/y	151,382
Energy Required per m^3 by Existing Pump Network to Supply abovementioned quantity of water	(kWh/m^3)	0.22
Energy Required by Existing Pump Network to Supply abovementioned quantity of water	kWh	32,857
Energy Required by Proposed Pump to Supply abovementioned quantity of water	kWh	16,241
Saving Potential	kWh/y	16,615
Cost of Power (Grid)	US $/kWh	0.16
Saving Potential	US $	2,668
Investment	US $	4,151
Simple Payback Period	months	19

7.1.12 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 59: 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	Fordwah canal No. 2 old	31806588	2.5	3.0	50	150
2	Turbine No. 2 New	31806596	2.5	3.0	50	150
3	Fordwah Canal No. 7 New	31806611	2.5	3.0	50	150
4	Fordwah canal No. 16 old	31806618	2.5	3.0	50	150
5	JWB No. 3	31906644	2.5	3.0	50	150
6	JWB No. 4	31906645	2.5	3.0	50	150
7	Model Town w.w Sadqia No. 1	82907316-1	5.0	3.0	50	150
8	Model Town w.w No 1	82907316-2A	2.5	3.0	50	150
9	Model Town w.w No 2	82907316-2B	2.5	3.0	50	150
10	Model Town w.w No 3	82907316-2C	2.5	3.0	50	200
11	Fordwah Canal Turbine No. 27 old	82907774	2.5	3.0	50	250
12	Karmawala	31806628	2.5	3.0	50	300
13	Islam Nagar	31806626-F	5.0	3.0	50	350
14	Islam Nagar	31806626-G	2.5	3.0	50	400
15	Madina Town New	31806631-H	5.0	3.0	50	450
16	Hussainabad	31808881-E	2.5	3.0	50	500
17	Foard Wah	31808882-A	2.5	3.0	50	550
18	Foard Wah	31808882-B	2.5	3.0	50	600
19	Model Town	31808883	2.5	3.0	50	650
Total						**5600**

7.1.13 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 106 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 60: Financial analysis of installation of Smart Meters

Parameters	Unit	Values
Water Monitoring Saving	%	1.00%
Annual Water consumption (Baseline)	m^3/y	12,938,513
Annual Water consumption (post-implementation)	m^3/y	12,809,128
Annual Water saving per year	m^3/y	129,385
Estimate of Investment (including the cost of the server)	US$	106,000

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 473 streetlights are being operated by the municipality. Out of these, 219 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 44: 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 61: Financial Analysis of Replacement of Non-functional Streetlights

Parameters	Unit	Value
Number of non-functional streetlights	#	219
Number of non-functional streetlights (>20 feet)	#	62
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	157

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Total cost LED installation	PKR	11,356,703
Proposed number of photocell switches	#	16
Cost of photocell switches	PKR	1,000
Total cost of photocell switches	PKR	16,000
Upfront investment cost	PKR	11,372,703
Upfront investment cost	US$	40,588
Annual Operating Electricity unit	kWh/yr	34,208
Annual Operating Cost	PKR/yr	1,539,351
Annual maintenance cost	PKR/yr	1,440,000
Monthly O&M Cost	PKR/month	248,279
Monthly diesel cost for operating fork lifter for two days	PKR/month	20,000
Monthly cost of renting Fork Lifter for two days	PKR/month	80,000
Miscellaneous Cost	PKR/month	20,000
Monthly maintenance cost	PKR/month	120,000

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

Project

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

Study & Investigation

During the assessment it was observed that there are 473 streetlights operated by municipality out of which 254 are operational. 253 of the operational streetlights were LEDs so they are not recommended for replacement.

Recommended Action

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

Saving Assessment

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

Table 62: Financial Analysis of Replacement of Inefficient functional Streetlights

Parameters	Unit	Value
Number of functional streetlights	#	1
Number of functional streetlights (>20 feet)	#	0
Wattage of proposed LED lights	Watt	50
Cost of LED light with fittings	PKR	53,873
Number of non-functional streetlights (<20 feet)	#	1

Parameters	Unit	Value
Wattage of proposed LED lights	Watt	30
Cost of LED light with fittings	PKR	51,061
Upfront investment cost	PKR	51,061
Upfront investment cost	US$	182
Annual Operating Electricity unit	kWh/yr	131
Annual Electricity Consumption of Existing Lights	kWh/yr	657
Financial Savings	US$/yr	84
Payback	months	26

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 63: Replacement of inefficient equipment at office buildings

Sr. No	Type of Equipment	Equipment count	Individual Capacity (Watts)	Total Capacity (Watts)	Baseline Energy Consumption (kWh/year)	Proposed Equipment	Wattage of Proposed Equipment	Overall Wattage of Proposed Equipment	Projected Energy Consumption (kWh/year)	Individual Cost of Proposed Equipment (PKR)	Overall Cost of Proposed LEDs/Inverters
MC Building & Mosque											
1	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
2	CFL	1	25	25	62	LED Bulb 13 Watts	13	13	32	350	350
3	Tubelight	3	40	120	300	LED Rod 20 Watts	20	60	150	2,900	8,700
4	CFL	6	24	144	359	LED Bulb 13 Watts	13	78	195	350	2,100
5	CFL	1	12	12	30	LED Bulb 8 Watts	8	8	20	330	330
6	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
7	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
8	Tubelight	1	40	40	100	LED Rod 20 Watts	20	20	50	2,900	2,900
9	CFL	1	45	45	112	LED Bulb 20 Watts	20	20	50	830	830
10	ILB	1	200	200	499	LED Bulb 20 Watts	20	20	50	830	830
11	Tubelight Panel	18	72	1296	3,235	LED Panel 36 Watt	36	648	1,617	6,200	111,600
Fire Brigade											
12	ILB	2	100	200	499	LED Bulb 13 Watts	13	26	65	350	700
Library											
13	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
Slaughter House											
14	ILB	7	100	700	1,747	LED Bulb 13 Watts	13	91	227	350	2,450
15	ILB	5	60	300	749	LED Bulb 8 Watts	8	40	100	330	1,650
16	ILB	2	60	120	300	LED Bulb 8 Watts	8	16	40	330	660
17	ILB	4	100	400	998	LED Bulb 13 Watts	13	52	130	350	1,400
18	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
Audit branch + workshop											
19	CFL	2	25	50	125	LED Bulb 13 Watts	13	26	65	350	700
Bus Stand											
20	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
21	ILB	1	100	100	250	LED Bulb 13 Watts	13	13	32	350	350
22	CFL	1	24	24	60	LED Bulb 13 Watts	13	13	32	350	350
	Total										**138,000**

Recommended Action

It is recommended to replace all inefficient equipment.

Saving Assessment

Table 64: 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	10,356
Average Operational Hours for Building Cooling Equipment	Hours/day	3,050
Energy consumption of inefficient Equipment	kWh/yr	7,306
Energy consumption of Proposed Equipment	kWh/yr	45
Energy Savings	kWh/yr	1,173
Unit cost of electricity	PKR/kWh	493
Annual cost savings	USD	5
Upfront Investment (including change in fixtures)	USD	312
Payback Period	Months	8

8 Investment Estimate (including Material Specification/Quantities)

8.1 Potable Water Pump

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

8.1.1 Investment Estimate (including Material Specification/Quantities) for PECO 8 MC /7 Stages, 15hp Motor

Pump Size	8 MC /7 Stages		
Capacity	51 m3/hr	Max. O.D bowl	7.5 Inches
Speed	1450 rpm	I.D tubewell	-
Pump Input	15 HP	Length of suction pipe	
Prime Mover (SEM/DE)	15 HP	Length of bowl assembly	
		Length of column pipe	
		Length of top pipe	1 Ft
		Total length of column	1 Ft

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

Pump assembly of	7	stages with flow type impellers				
Column assembly of	4	inshces I.D with flanged joins		each 10 ft length	0	Sets
				and one top set	1	feet length
				column shaft dia	25	mm
Discharge head inch	4					with prelubrication tank
Electric Motor vertical hollow shaft 15 HP/4 Pole						included
DWT 8M C						included
Discharge head 4 " with top shaft						included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	860,684
Sales Tax @ 17%	Rs:	146,316
Total Cost of Pumpset	Rs:	1,007,000

8.1.2 Investment Estimate (including Material Specification/Quantities) for PECO 10 WC /3 Stages, 30hp Motor

Pump Size		10 WC /3 Stages			
Capacity		152.9 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		0
			Length of top pipe		1 Ft
			Total length of column		1 Ft

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

Pump assembly of	4	stages with flow type impellers				
Column assembly of	5	inshces I.D with flanged joins		each 10 ft length	0	Sets
				and one top set	1	feet length
				column shaft dia	30	mm
Discharge Head Inch	6					with prelubrication tank
Electric Motor vertical hollow shaft 30 HP/4 Pole						included
DWT 10 WC						included
Discharge head 6 " with top shaft						included

Price of pumping unit as specified above

Price/Unit Rs	Rs:	965,290
Sales Tax @ 17%	Rs:	197,710
Total Cost of Pumpset	Rs:	1,163,000

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

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

Material Specifications

Pump Assembly

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

Column Pipe assembly

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

Component parts of each pumping unit

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

Price of pumping unit as specified above

Price/Unit Rs	Rs:	557,692
Sales Tax @ 17%	Rs:	94,808
Total Cost of Pumpset	Rs:	1,305,000

8.2 Investment Estimate (including Material Specification/Quantities) Streetlights

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

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 50W	50	7000 Lm	140 Lm/Watt	62	53,873	3,340,126
2	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	157	51,061	8,016,577
3	Accessories	Photocell switch				16	1,000	16,000
Lumpsum Price (PKR)								**11,372,703**
Lumpsum Price (USD)								**40,588**

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

Sr. No.	Type	Model	Wattage	Luminous flux	Luminous Efficiency	Quantity Proposed	Unit Cost (PKR)	Total Cost (PKR)
1	LED	LED Cobra-head 30W	30	4200 Lm	140 Lm/Watt	1	51,061	51,061
Lumpsum Price (PKR)								**51,061**
Lumpsum Price (USD)								**182**

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	30	390	350	10,500
2	LED Rod 20 Watts	20	4	80	2,900	11,600
3	LED Bulb 8 Watts	8	8	64	330	2,640
4	LED Bulb 20 Watts	20	2	40	830	1,660
5	LED Pannel 36 Watt	36	18	648	6,200	111,600

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
		Lumpsum Price (PKR)				**138,000**
		Lumpsum Price (USD)				**493**

9 Summary of Energy Efficiency Measures

MC Bahawalnagar's annual energy consumption is 3,885,741 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$ 45,183** with an estimated investment of **US$ 195,129**
- Reduce electricity consumption by approx. **281,337 kWh**
- Reduce GHG Emissions by **141 tCO_2/y**

10 Annexures

Annexure 1: PEAK / OFF PEAK TIMINGS of MEPCO

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

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