INVESTMENT GRADE ENERGY AUDIT REPORT

Jaunpur Nagar Palika Parishad, Uttar Pradesh

Submitted by

Energy Efficiency Services Limited

Submitted To

Jaunpur Nagar Palika Parishad

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ACKNOWLEDGMENT

We are sincerely thankful to the Ministry of Urban Development, Government of India for including energy audits to achieve energy efficiency under the reforms of Atal Mission for Rejuvenation and Urban Transformation (AMRUT). We are also extremely thankful to the "Department of Urban Development (DUD) Uttar Pradesh" for taking up the reform on priority basis with Energy Efficiency Services Limited (EESL) and signing the agreement on 09th Feb 2017 for preparation of Investment Grade Energy Audit (IGEA) reports for its AMRUT Mission and Smart Mission for Cities & Towns. We acknowledge the support and guidance provided by the following Central and State Government officials:

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- Shri Jasbir Singh (CEA – 20533), CII
- Shri Kiran Y, CII
- Shri Gnanendra Reddy D, CII

On Behalf of Energy Efficiency Services Limited
Signature

Mr. Tarun Tayal

Executive Summary

Background of the Project

The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) was launched by Prime Minister of India in June 2015 with the objective of providing basic services (e.g. water supply, sewerage, urban transport) to households and build amenities in cities which will improve the quality of life for all.

To facilitate market transformation and replicate Municipal Energy Efficiency Programme on a large scale in India, Ministry of Urban Development (MoUD), Government of India signed a Memorandum of Understanding (MoU) with Energy Efficiency Services Limited (EESL), a joint venture under Ministry of Power, Government of India on 28th September 2016 under AMRUT. This will enable replacement of inefficient pump sets in Public Water Works & Sewerage Systems (PWW&SS) with energy efficient pump sets with no upfront cost to the Municipal Bodies. The investment will be recovered in form of fixed annuity.

Energy audit and optimizing energy consumption are mandatory reforms under AMRUT. EESL and "Department of Urban Development (DUD) Uttar Pradesh", Government of Uttar Pradesh have jointly entered into an agreement on 9th Feb, 2017 in order to provide an overarching framework to facilitate engagement between State Government and various ULBs (covered under AMRUT) of Uttar Pradesh. Under this agreement, EESL is undertaking the project to replace old inefficient pump sets by energy efficient pump sets in Jaunpur, City of Uttar Pradesh.

Description of Facilities

Jaunpur is a city and a municipal board in Jaunpur district of the state of Uttar Pradesh. It is situated in the North-West part of Varanasi Division. Its area extends from 24.240N to 26.120N latitude and between 82.70E and 83.50E longitudes. Its attitude varies from 261 ft to 290 ft. above M.S.L. (Mean Sea Level). The topography of the district is mainly a flat plain with shallow river-balleys. Gomti and Sai are its main parental rivers.

The rivers Gomthi and Basuhi divide the district into nearly four equal landmasses. The soils are mainly sandy, loamy and clayey. The temperatures of the district of Jaunpur lie between a minimum of 4.3°C and a maximum of 44.6°C. Average annual rainfall is 987 mm. The geographical area of the district is 4038 sq.km.

The water demand of Jaunpur city is met from the below two main water sources:

1. River water from Gomthi River (Raw water Pumping Station)
2. Underground water (Jalkal Pumping station and tube wells)

At present, Jaunpur city has only one water Treatment Plant (WTP) in Jalkal Pumping station where Raw water Pumped from Raw water Pump House is Treated and supplied to the city. During Low River water level/additional water requirements, Underground water is utilized to cater the water demands in the Jaunpur city.

1. Jaunpur Raw water pumping station

The Raw water Pumping Station receives raw water from Gomthi River through Intake well. The Raw water from the River is pumped to the Water Treatment plant i.e. Jalkal Pumping Station through a Pipeline. Pump sets at Jaunpur Raw water Pumping Station are operated based upon the level of water in the Gomthi River. The average operating hours for all the pump sets is approximately 20-22 hours per day, pertaining to the water availability.

2. Jalkal Pump House

Jalkal Pump House is a Water Treatment Plant which receives raw water from raw water pump house through a pipe line from Gomthi River. The Raw Water is collected through a channel and then supplies to water treatment plant. The treated water from the plant is stored in the underground reservoir i.e. (2 No's of CWR's) at Jalkal Pumping Station. The water Stored in the Reservoir is then supplied to overhead storage tank using pumping systems installed at Jalkal Pumping station.

3. Submersible Pumps

Submersible pumps are located at different places in the city which supplies water from bore wells to the end users through Over Head storage Tanks / Direct Supply. Description of facility and water storage capacity is provided in the table below.

Description of Facility and water storage capacity

S. No	Facility Name & Location	Source of water	Number of pumps	MLD Capacity	Type of Storage	Number of/ Reservoir/Clarifier	No. of OHT
1	Raw Water Pump House	Gomthi River	4	NA	Intake well	-	-
2	Jalkal Pump House	Raw water Pump house	4	13	Clear water Reservoir	2	1
3	Submersible Pumps	Underground	53	NA	OHT/Direct Supply	-	6

Summary of Performance Evaluation of Pump sets

Based on the measurement and analysis carried out during the energy audit, the pump and pump set efficiencies for the pumping stations have been estimated. The summary of results is provided in the table below.

Pump range and Efficiency evaluation metrics:

Sl. No	Pump Reference	Pump Type	Pump Capacity (kW)	Weighted average pump efficiency	Weighted average pump set efficiency
	Jalkal Pumping Station				
1	Pump 1 (60HP)	Centrifugal	45	40.63 %	36 %
2	Pump 2 (30HP)	Centrifugal	22.5	40.47%	36 %
3	Pump 3 (60HP)	Centrifugal	45	37.42 %	33%
4	Pump 4 (30HP)	Centrifugal	22.5	41.28 %	37 %
	Submersible Pumps				
5	Misirpur	Submersible	11.25	44.19%	38%
6	Sarailatta	Submersible	22.5	12.81%	11 %
7	Bhagat Singh Park	Submersible	18.75	24.53%	21 %
8	Hindi Bhawan	Submersible	22.5	30.31%	26 %
9	Khasanpur	Submersible	22.5	36.34%	31 %
10	Pachiatia	Submersible	18.75	34.7%	29 %
11	Sipah	Submersible	18.75	31.82%	27 %
12	Sagar Chungi	Submersible	22.5	34.61%	29 %
13	Purani Bazar	Submersible	22.5	29.9%	26 %
14	Jeeta Patti	Submersible	18.75	32.11%	27 %
15	Naigang No.1	Submersible	18.75	44.27%	38 %
16	Naigang No.2	Submersible	18.75	33.15 %	28 %
17	Line Bazar	Submersible	18.75	38.67 %	33 %
18	SP Bungalow	Submersible	18.75	33.16 %	28 %
19	Polytechnic 1	Submersible	18.75	37.52 %	32 %
20	Jalkal Main Gate	Submersible	18.75	31.04 %	26 %
21	Mufti Mohalla	Submersible	18.75	40.51 %	34 %
22	Chand Mari	Submersible	18.75	7.82%	7 %
23	Tutipur	Submersible	18.75	33.35%	28 %
24	Jalkal Campus near JE Residence	Submersible	22.5	52.29%	44 %
25	Bhosa Gudam	Submersible	18.75	46.07%	39%
26	Ruhutta	Submersible	18.75	45.21%	38%
27	DM Residence	Submersible	18.75	50.42 %	43 %

Sl. No	Pump Reference	Pump Type	Pump Capacity (kW)	Weighted average pump efficiency	Weighted average pump set efficiency
28	English Club	Submersible	18.75	10.68 %	9 %
29	Kharka Colony	Submersible	22.5	33.65%	29 %
30	Naigang No.3	Submersible	22.5	39.66%	34 %
31	Polytechnic 2	Submersible	22.5	52.63%	45 %
32	Khasanpur	Submersible	7.5	54.42%	46 %
33	Bhaurajipur	Submersible	7.5	52.15%	44 %
34	Chitarsari	Submersible	7.5	13.24%	11%
35	Makhadum Shah	Submersible	7.5	40.06%	34%
36	Achala Devi Ghat	Submersible	7.5	31.87%	27 %
37	Sipah	Submersible	7.5	30.89%	26 %
38	Matapur	Submersible	7.5	14.31%	12 %
39	Sakarmandi	Submersible	7.5	23.16%	20 %
40	Chakpyarali	Submersible	7.5	51.05%	43%
41	Jogiyapur	Submersible	7.5	39.22%	33%
42	Miyanpur	Submersible	7.5	57.2%	48%
43	Rasulabad	Submersible	7.5	32.13%	27%
44	Raj Colony	Submersible	7.5	34.63%	29%
45	Raja Sahab Pokra	Submersible	7.5	45.92%	39 %
46	Bodkarpur	Submersible	7.5	38.19%	32 %
47	Premrejpur	Submersible	7.5	58.71%	50 %
48	Ballochtola	Submersible	7.5	26.54%	23 %

Performance Indicators

Along with estimation of efficiency of pump sets, performance indicators such as specific energy consumption was also evaluated for pumps of Jalkal Pumping Station and Submersible Pumping Stations. Details of performance indicators and other operating parameters is provided in the tables below

Performance Indicators of pump sets of Jaunpur City:

Pump House	Pump Reference	Operating Pattern	Total head (m)	Measured power consumption (kW)	Pumping quantity (m3/hour)	Estimated annual operating hours (hour/annum)	Estimated quantity pumped per annum (KL)	Estimated annual power consumption (kWh/annum)	Estimated SEC (Kwh/MLD	Pump efficiency (%)	Pump set efficiency (%)
Jalkal Pumping Station	Pump-1	Pumps 1& 3 (Running) Pumps 2&4 (Stand - by)	19	51.48	362	2190	792780	112741.2	142.38	40.63 %	36 %
	Pump-2		19	22.04	154	2190	337260	48267.6	142.98	40.47%	36 %
	Pump-3		19	37.85	245	2190	536550	82891.5	154.62	37.42 %	33%
	Pump 4		19	20.07	143	2190	313170	43953.3	140.11	41.28 %	37 %
Total (A)							**1979760**	**287853.6**			
Submersible Pumps	Misirpur	Working	24	21.67	126	3650	459900	79095.5	172.30	44.19%	38%
	Sarailatta	Working	30	20.10	26	3650	94900	73365	761.36	12.81%	11 %
	Bhagat Singh Park	Working	17	20.22	87	3650	317550	73803	231.35	24.53%	21 %
	Hindi Bhawan	Working	19	24.72	119	3650	434350	90228	208.14	30.31%	26 %
	Khasanpur	Working	33	18.62	63	3650	229950	67963	295.24	36.34%	31 %
	Pachiatia	Working	24	26.72	118	3650	430700	97528	227.21	34.7%	29 %
	Sipah	Working	21	26.63	120	3650	438000	97199.5	221.06	31.82%	27 %
	Sagar Chungi	Working	26	26.29	106	5840	619040	153533.6	249.04	34.61%	29 %
	Purani Bazar	Working	19	21.99	106	3650	386900	80263.5	207.98	30.63%	26 %
	Jeeta Patti	Working	23	25.48	109	3650	397850	93002	233.26	32.11%	27 %
	Naigang No.1	Working	25	23.49	126	3650	459900	85738.5	186.69	44.27%	38 %
	Naigang No.2	Working	24	31.90	133	3650	485450	116435	240.42	33.15 %	28 %
	Line Bazar	Working	23	22.59	117	3650	427050	82453.5	193.81	38.67 %	33 %
	SP Bungalow	Working	19	22.63	122	3650	445300	82599.5	185.40	33.16 %	28 %
Submersible Pumps	Polytechnic 1	Working	21	22.24	119	7300	868700	162352	186.19	37.5 %	32 %
	Jalkal Main Gate	Working	26	22.83	84	3650	306600	83329.5	272.15	31.04 %	26 %

Pump House	Pump Reference	Operating Pattern	Total head (m)	Measured power consumption (kW)	Pumping quantity (m3/hour)	Estimated annual operating hours (hour/annum)	Estimated quantity pumped per annum (KL)	Estimated annual power consumption (kWh/annum)	Estimated SEC (Kwh/MLD	Pump efficiency (%)	Pump set efficiency (%)
	Mufti Mohalla	Working	25	21.51	105	3650	383250	78511.5	204.41	40.51 %	34 %
	Chand Mari	Working	12	9.27	19	3650	69350	33835.5	500.36	7.82%	7 %
	Tutipur	Working	25	25.82	104	5840	607360	150788.8	247.25	33.35%	28 %
	Jalkal Campus near JE Residence	Working	37	24.88	108	7300	788400	181624	229.56	52.29%	44 %
	Bhosa Gudam	Working	30	19.04	90	7300	657000	138992	211.02	46.07%	39%
	Ruhutta	Working	41	21.81	75	5840	438000	127370.4	292.28	45.21%	38%
	DM Residence	Working	22	19.86	138	3650	503700	72489	144.22	50.42 %	43 %
	English Club	Working	26	4.96	6	7300	43800	36208	771.38	10.68 %	9 %
	Kharka Colony	Working	24	21.43	90	7300	657000	156439	238.11	33.65%	29 %
	Naigang No.3	Working	26	22.08	103	7300	751900	161184	213.40	39.66%	34 %
	Polytechnic 2	Working	27	17.34	103	3650	375950	63291	167.55	52.63%	45 %
	Khasanpur	Working	23	5.93	43	3650	156950	21644.5	138.10	54.42%	46 %
	Bhaurajipur	Working	19	6.16	51	3650	186150	22484	120.10	52.15%	44 %
	Chitarsari	Working	27	4.65	7	3650	25550	16972.5	663.02	13.24%	11%
	Makhadum Shah	Working	19	3.94	25	3650	91250	14381	156.78	40.06%	34%
	Achala Devi Ghat	Working	23	6.70	28	3650	102200	24455	238.94	31.87%	27 %
	Sipah	Working	20	6.91	33	3650	120450	25221.5	206.33	30.89%	26 %
	Matapur	Working	29	6.14	9	3650	32850	22411	663.07	14.31%	12 %
	Sakarmandi	Working	29	4.35	11	3650	40150	15877.5	412.32	23.16%	20 %
	Chakpyarali	Working	18	4.16	36	3650	131400	15184	115.95	51.05%	43%
	Jogiyapur	Working	25	5.61	27	3650	98550	20476.5	208.63	39.22%	33%
	Miyanpur	Working	20	4.74	42	3650	153300	17301	114.15	56.78%	48%
	Rasulabad	Working	28	6.47	23	3650	83950	23615.5	287.00	32.13%	27%
	Raj Colony	Working	14	4.49	33	3650	120450	16388.5	136.34	34.63%	29%
Submersible Pumps	Raja Sahab Pokra	Working	17	3.84	32	3650	116800	14016	121.80	45.92%	39 %
	Bodkarpur	Working	21	5.20	28	3650	102200	18980	183.18	38.19%	32 %
	Premrejpur	Working	16	4.22	45	3650	164250	15403	92.86	58.71%	50 %
	Ballochtola	Working	24	10.19	34	3650	124100	37193.5	296.97	26.54%	23 %
Total (B)							**13928400**	**3061627**			

Pump House	Pump Reference	Operating Pattern	Total head (m)	Measured power consumption (kW)	Pumping quantity (m3/hour)	Estimated annual operating hours (hour/annum)	Estimated quantity pumped per annum (KL)	Estimated annual power consumption (kWh/annum)	Estimated SEC (Kwh/MLD	Pump efficiency (%)	Pump set efficiency (%)
Total (A+B)							15908160	3349481			

Summary of Project Cost Benefit Analysis

The energy saving has been calculated on the basis of energy audit activity conducted at Pumping stations in Jaunpur City. Consequently, feasibility of individual projects has been discussed with ULB officials and different pump manufactures. The energy saving of this project has been calculated on the basis of the technical information shared by the manufacturers (for the recommended equipment) and operating information shared by pumping station personnel. The estimated energy saving is provided in the table below:

Summary of Energy efficiency measures identified during the audit

Sl. No	Energy Efficiency Measures (EEM)	Annual Energy Savings (kWh/Annum)	Investment Cost (Rs. Lakhs)	Monetary Energy Cost Saving (Rs. Lakhs)	Payback Period (Months)
	Pumping system				
Jalkal Pumping Station					
1	Replacement of existing Pump 1 with energy efficient Pump	65899	2.41	5.24	6
2	Replacement of existing Pump 3 with energy efficient Pump	15607	1.72	1.24	17
3	Replacement of existing Pump 2 with energy efficient Pump	36039	2.41	2.87	10
4	Replacement of existing Pump 4 with energy efficient Pump	11308	1.72	0.9	23
Submersible Pumps					
5	Replacement of existing pump at Bhagat Singh Park with energy efficient pump	31944	4.17	2.17	23
6	Replacement of existing pump at Hindi Bhawan with energy efficient pump	38873	4.23	2.64	19
7	Replacement of existing pump at Khasanpur tube well with energy efficient pump	28272	4	1.92	25
8	Replacement of existing pump at Pachiatia Singh Park with energy efficient pump	42299	4.39	2.88	18

Sl. No	Energy Efficiency Measures (EEM)	Annual Energy Savings (kWh/Annum)	Investment Cost (Rs. Lakhs)	Monetary Energy Cost Saving (Rs. Lakhs)	Payback Period (Months)
9	Replacement of existing pump at Sipah with energy efficient pump	45888	4.23	3.12	16
10	Replacement of existing pump at Sagar Chungi with energy efficient pump	65161	4.39	4.43	12
11	Replacement of existing pump at Purani Bazar with energy efficient pump	42903	3.87	2.92	16
12	Replacement of existing pump at Jeeta Patti with energy efficient pump	45253	4.23	3.08	16
13	Replacement of existing pump at Naigang No.2 with energy efficient pump	61251	4.39	4.17	13
14	Replacement of existing pump at SP Bungalow with energy efficient pump	40740	4.17	2.77	18
15	Replacement of existing pump at Polytechnic 1 with energy efficient pump	82247	4.17	5.59	9
16	Replacement of existing pump at Jalkal Main Gate with energy efficient pump	28094	4.39	1.91	28
17	Replacement of existing pump at Mufti Mohalla with energy efficient pump	23294	4.39	1.58	33
18	Replacement of existing pump at Tutipur with energy efficient pump	75244	4.24	5.12	10
19	Replacement of existing pump at Kharka Colony with energy efficient pump	63233	4.23	4.3	12
20	Replacement of existing pump at Chitarsari with energy efficient pump	9406	0.78	0.64	15
21	Replacement of existing pump at Makhadum Shah with energy efficient pump	5934	0.9	0.40	27
22	Replacement of existing pump at Achala Devi Ghat with energy efficient pump	9556	0.95	0.65	18
23	Replacement of existing pump at Sipah with energy efficient pump	4834	1	0.33	36
24	Replacement of existing pump at Matapur with energy efficient pump	14834	0.78	1.01	9
25	Replacement of existing pump at Sakarmandi with energy efficient pump	8302	0.78	0.56	17
26	Replacement of existing pump at Rasulabad with energy efficient pump	8522	0.9	0.58	19
27	Replacement of existing pump at Raj Colony with energy efficient pump	5286	0.78	0.36	26
28	Replacement of existing pump at Bodkarpur with energy efficient pump	6822	0.7	0.46	18
29	Replacement of existing pump at Ballochtola with energy efficient pump	14292	1.12	0.97	14

Sl. No	Energy Efficiency Measures (EEM)	Annual Energy Savings (kWh/Annum)	Investment Cost (Rs. Lakhs)	Monetary Energy Cost Saving (Rs. Lakhs)	Payback Period (Months)
	Sub – Total (A)	**931337**	**80.38**	**64.81**	**15**
	Auxiliary Loads				
	Jalkal Pumping Station				
30	Replacement of existing luminaries (T-8,& CFL) with LED	3109	0.07	0.25	4
	Sub Total (B)	**3109**	**0.07**	**0.25**	**4**
	Jalkal Pumping Station				
31	Installation of APFC to improve power factor	-	0.85	3	4
	Sub Total (C)	**-**	**0.85**	**3**	**4**
	Net Total (A + B + C)	**934,446**	**81.30**	**68.06**	**14**

Under maintenance pump sets, which were not repaired during energy audit period, were not taken up for measurement, analysis and subsequent implementation in this report.

Implementation of the energy efficiency measures on pumping system may result in annual energy savings of 9,31,337 kWh per year which is 44.6% of the existing electricity consumption. This energy saving is equivalent to 80.09 toe and results in reduction of 763.69 tCO_2 per year.

Apart from pumping system, opportunities for electricity and cost savings were identified in auxiliary systems such as lighting and ceiling fan. ULB may implement recommendation identified for auxiliary systems which may result in annual energy savings of 3,109 kWh per year.

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Project Financials and proposed Business Model

Total Project cost (CAPEX)

The following are the key components considered while arriving at the total project cost:

i. Cost of pump, motor and other accessories (like NRV and gate valve), discovered through a transparent bidding process;

ii. Cost of dismantling, installation and commissioning including testing charges, discovered through a transparent bidding process;

iii. Project Establishment and Supervision charges of EESL at 5 % of total cost of equipment including installation;

iv. Cost of preparation of IGEA, as per actual tendered cost, plus EESL's service charge at 15%;

v. All applicable goods and services tax as on actual basis; and

vi. Capitalized interest during the Project Implementation Period.

Details of project capital cost is provided in the table below:

Project Capital Cost

Capital Cost Related assumption	Unit	Value
Number of Pumps	*No.*	29
Total Cost of Equipment including installation, commissioning and testing	*INR lakhs*	80.39
Cost of pump including motor	*INR lakhs*	60.35
Cost of NRV	*INR lakhs*	5.48
Cost of Gate valve	*INR lakhs*	7.25
Cost of Web based dashboard	*INR lakhs*	2.23
Installation and Commissioning Cost including testing charges	*INR lakhs*	5.09
EESL's administrative and establishment charge	*%*	5
Cost of preparation of IGEA report including EESL service charges and applicable GST	*INR lakhs*	6.79
Total Project Cost w/o Capitalized interest	*INR lakhs*	91.19
Commissioning Details		
Total Months for Commissioning	*months*	9
Capitalized interest	*INR lakhs*	5.11
Total Project Cost	*INR lakhs*	96.31

Operating Costs (OPEX)

The following are the key components considered while arriving at the operating cost for the project

i. Project Establishment and Supervision charges of EESL at 4% of total project cost, with annual escalation of 5%; and

ii. Actual incurred Repair & Maintenance charges, discovered through a transparent bidding process.

Details about project operating cost is provided in the table below.

Project Operating Cost

Operational Details	Unit	Value
EESL's administrative and establishment charges	%	5%

Financing Terms and other tax related assumptions

The following are the key financial assumptions used in developing the model. Financing terms and tax related assumptions are provided in the table below:

Financing terms and tax related assumptions

Parameters	Unit	Value
Term of the project	*years*	7
Financing Details		
Debt Percentage	%	70%
Cost of Debt	%	11%
Equity Percentage	%	30%
Cost of Equity (post- tax)	%	16%
Tax Details		
Corporate Tax		34.61%
Goods and Services Tax		18%

Output - Annuity Payment to EESL

Based on the cost parameters and assumptions mentioned above, the annuity payment to EESL was computed. Details of annuity payment to EESL are provided in the table below.

Annuity payment to EESL

Year		1	2	3	4	5	6	7	Total
Calculations of annuity payment									
Total Debt to be repaid	*INR lakh*	16.65	15.59	14.53	13.47	12.41	11.35	10.29	94.29
Principal Repayment	*INR lakh*	9.63	9.63	9.63	9.63	9.63	9.63	9.63	67.41
Interest	*INR lakh*	7.02	5.96	4.90	3.84	2.78	1.72	0.66	26.88
Total Equity Repayments	*INR lakh*	10.82	9.81	8.80	7.79	6.78	5.77	4.76	54.52
Recovery of equity investment	*INR lakh*	4.13	4.13	4.13	4.13	4.13	4.13	4.13	28.89
Return on equity	*INR lakh*	6.69	5.68	4.67	3.66	2.65	1.64	0.63	25.62
R&M Charges	*INR lakh*	0.00	1.21	2.01	2.41	2.81	3.01	3.22	14.67
EESL's administrative and establishment charge	*INR lakh*	3.85	4.04	4.25	4.46	4.68	4.92	5.16	31.36
Annuity Payment to EESL	*INR lakh*	31.32	30.64	29.58	28.13	26.69	25.05	23.43	194.85
Goods and Services Tax on annuity payment	*INR lakh*	5.64	5.52	5.33	5.06	4.80	4.51	4.22	35.07
Annuity Payment to EESL incl. all applicable taxes	*INR lakh*	36.96	36.16	34.91	33.19	31.49	29.56	27.65	229.92
ULB Savings									
Total Savings	*INR lakh*	64.81	65.27	65.65	65.94	66.15	66.27	66.27	460.36

Profit to ULB	*INR lakh*	27.86	29.10	30.74	32.75	34.66	36.71	38.62	230.44
% of savings with ULBs	*%*								50.06

Sensitivity analysis

The sensitivity analysis has been conducted to determine the impact of change in capital cost and change in savings on the percentage of monetary share of accrued savings retained by the ULB. Project sensitivity analysis is provided in the table below.

Project sensitivity analysis

Change in Capital Cost	% of savings retained by the utility
-10%	54.67 %
-5%	52.37 %
0%	50.06 %
5%	47.75 %
10%	45.44 %
Change in Interest(ROE, Interest, D/E ratio)	**% of savings retained by the utility**
-10%	44.51 %
-5%	47.43 %
0%	50.06 %
5%	52.43 %
10%	54.60 %

Key facts of IGEA

Key facts of the project are as follows:

Particular	Unit	Value
Total number of pump sets as per LOA	Nos.	61
Total number of pump sets under maintenance	Nos.	13
Total number of pump sets audited	Nos.	48
Total numbers of pumps sets considered for replacement	Nos.	29
Estimated present annual energy consumption (for 29 pump sets)	kWh	20,87,326
Estimated annual energy consumption with proposed EEPS (for 29 pump sets)	kWh	11,55,988
Percentage energy saving potential	%	44.6 %
Total project cost (including IGEA cost and capitalized interest)	Rs. Lakhs	55.68

Pre – implementation annual energy consumption (baseline) and post implementation annual energy consumption will be estimated based proposed Measurement and Verification (M & V methodology

Rated and operating parameters of pump sets to be installed under this project along with other accessories are provided in the table below:

Key facts of pump sets to be replaced under this project

Pump Identification		Rated parameters			Operating parameters (individual operation)				Accessories to be installed		
Pump house	Pump Reference	Flow (m3/ hour)	Head (m)	Motor rating (kW)	Flow (m3/hr)	Total head (m)	Actual power consumption (kW)	Pump set efficiency (%)	NRV to be installed (Yes/No)	Gate valve to be installed (Yes/No)	Apparatus for Web based dashboard (Yes/No)
Jalkal Pumping Station	Pump-1	270	-	45	362	19	51.48	36 %	Yes	Yes	Yes
	Pump-2	135	-	22.5	154	19	22.04	36 %	Yes	Yes	Yes
	Pump-3	270	-	45	245	19	37.85	33%	Yes	Yes	Yes
	Pump-4	135	-	22.5	143	19	20.07	37 %	Yes	Yes	Yes
Submersible Pumps	Bhagat Singh Park	78	-	18.75	87	17	20.22	21 %	Yes	Yes	Yes
	Hindi Bhawan	72	-	22.5	119	19	24.72	26 %	Yes	Yes	Yes
	Khasanpur	78	-	22.5	63	33	18.62	31 %	Yes	Yes	Yes
	Pachiatia	90	-	18.75	118	24	26.72	29 %	Yes	Yes	Yes
	Sipah	72	-	18.75	120	21	26.63	27 %	Yes	Yes	Yes
	Sagar Chungi	72	-	22.5	106	26	26.29	29 %	Yes	Yes	Yes
	Purani Bazar	78	-	22.5	106	19	21.99	26 %	Yes	Yes	Yes
	Jeeta Patti	78	-	18.75	109	23	25.48	27 %	Yes	Yes	Yes
	Naigang No.2	60	-	18.75	133	24	31.90	28 %	Yes	Yes	Yes
	SP Bungalow	60	-	18.75	122	19	22.63	28 %	Yes	Yes	Yes
	Polytechnic 1	72	-	18.75	119	21	22.24	32 %	Yes	Yes	Yes
	Jalkal Main Gate	90	-	18.75	84	26	22.83	26 %	Yes	Yes	Yes
	Mufti Mohalla	90	-	18.75	105	25	21.51	34 %	Yes	Yes	Yes
	Tutipur	90	-	18.75	104	25	25.82	28 %	Yes	Yes	Yes
	Kharka Colony	60	-	22.5	90	24	21.43	29 %	Yes	Yes	Yes
Submersible Pumps	Chitarsari	30	-	7.5	7	27	4.65	11%	Yes	Yes	Yes
	Makhadum Shah	30	-	7.5	25	19	3.94	34%	Yes	Yes	Yes
	Achala Devi Ghat	30	-	7.5	28	23	6.70	27 %	Yes	Yes	Yes

Atal Mission for Rejuvenation and Urban Transformation

Nagar Palika Parishad Jaunpur

EESL

Pump Identification		Rated parameters			Operating parameters (individual operation)				Accessories to be installed		
Pump house	Pump Reference	Flow (m3/ hour)	Head (m)	Motor rating (kW)	Flow (m3/hr)	Total head (m)	Actual power consumption (kW)	Pump set efficiency (%)	NRV to be installed (Yes/No)	Gate valve to be installed (Yes/No)	Apparatus for Web based dashboard (Yes/No)
	Sipah	30	-	7.5	33	20	6.91	26 %	Yes	Yes	Yes
	Matapur	30	-	7.5	9	29	6.14	12 %	Yes	Yes	Yes
	Sakarmandi	30	-	7.5	11	29	4.35	20 %	Yes	Yes	Yes
	Rasulabad	30	-	7.5	23	28	6.47	27%	Yes	Yes	Yes
	Raj Colony	30	-	7.5	33	14	4.49	29%	Yes	Yes	Yes
	Bodkarpur	30	-	7.5	28	21	5.20	32 %	Yes	Yes	Yes
	Ballochtola	30	-	7.5	34	24	10.19	23 %	Yes	Yes	Yes

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ABBREVIATIONS

JNPP	Jaunpur Nagar Palika Parishad
AMRUT	Atal Mission Rejuvenation and Urban Transformation
APFC	Automatic Power Factor Control
BEP	Best Efficiency Points
BPS	Booster Pumping Stations
CEA	Certified Energy Auditor
CII	Confederation of Indian Industry
DSM	Demand Side Management
EC	Energy Conservation
EE	Energy Efficiency
EEM	Energy Efficiency Measure
EESL	Energy Efficiency Services Limited
FY	Financial Year
GST	Goods and Services Tax
HT	High Tension
HSC	Horizontal Split Casing
IGEA	Investment Grade Energy Audit
kVA	Kilo Volt Ampere
kW	Kilowatt
kWh	kilowatt Hour
LED	Light Emitting Diode
LT	Low Tension
MEEP	Municipal Energy Efficiency Programme
MoUD	Ministry of Urban Development
MoU	Memorandum of Understanding
OHT	Over Head Tank
O&M	Operation and Maintenance
PF	Power Factor
PS	Pumping Station
PWW&SS	Public Water Works & Sewerage Systems
RPM	Rotations Per Minute
R&M	Repair & Maintenance
ROE	Return on Equity
SEC	Specific Energy Consumption
SHPSC	State level High Powered Steering Committee
SLTC	State Level Technical Committee
SPS	Sewerage Pumping Station
STP	Sewerage Treatment Plant
DUD	Department of Urban Development
TOE	Tonne of oil equivalent
ULB	Urban Local Body
UM	Under Maintenance
VFD	Variable Frequency Drive
WTP	Water Treatment Plant
WDS	Water Distribution Station

1 Introduction

1.1 Background of the Project

The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) was launched by Prime Minister of India in June 2015 with the objective of providing basic services (e.g. water supply, sewerage, urban transport) to households and build amenities in cities which will improve the quality of life for all.

To facilitate market transformation and replicate Municipal Energy Efficiency Programme on a large scale in India, MoUD, Government of India signed a MoU with Energy Efficiency Services Limited (EESL), a joint venture under Ministry of Power, Government of India on 28th September, 2016 under AMRUT. This will enable replacement of inefficient pump sets in Public Water Works & Sewerage Water Systems with energy efficient pump sets at no upfront cost to the Municipal Bodies. The investment will be recovered in form of fixed annuity.

Energy audit and optimizing energy consumption are mandatory reforms under AMRUT. EESL and Department of Urban Development (DUD), Government of Uttar Pradesh have jointly entered into an agreement on 9th February, 2017 in order to provide an overarching framework to facilitate engagement between state government and various ULBs (covered under AMRUT) of Uttar Pradesh. Under this agreement, EESL is undertaking the project to replace old inefficient pump sets by energy efficient pump sets in Jaunpur. City of Uttar Pradesh

According to MoUD, energy audits for improving energy use is one of the mandated reforms under the AMRUT and this initiative would help the cities significantly. “This will substantially reduce costs of operation of water supply schemes and public lighting that will ultimately benefit the citizens. EESL will be promoting use of energy efficiency programs across the country and will ensure supply of latest technologies under these municipal programs".

Energy cost accounts for 40 to 60 % of cost only for water supply in urban areas and energy efficiency interventions can reduce this cost by 20 to 40 %, depending on the type and age of pump sets being used for bulk water supply. By becoming energy efficient, ULB’s can reap annually up to 4,800 MU and Rs.3,200 Crores besides avoiding the need for 3,300 MW of power.

Necessary interventions would be undertaken by EESL without any financial burden on ULB as cost of the proposed Municipal Energy Efficiency Programs would be borne out of annuity. MoU states that performance contracting offers a mechanism for ULB to finance these projects without upfront investment.

As per the MoU, EESL will develop overall strategy for taking up energy efficiency projects in urban areas by implementation of energy efficient pump sets in public water works and sewage systems.

EESL will provide or arrange project funding for implementation as required and will procure energy efficient equipment and materials in a transparent manner besides ensuring repair and maintenance services for the goods replaced and installed by it. EESL is in the process of implementing energy efficient pumps for 500 cities under AMRUT scheme of Government of India. After the agreement between Department of Urban Development (DUD) and EESL was signed successfully on 09th February 2017, EESL initiated an open tendering process for hiring Energy Auditing Agency through competitive bidding. Based on the bidding evaluation, CII – Godrej GBC was selected for doing the energy audit for Jaunpur city. EESL has engaged CII for preparation of (IGEA) reports for Public Water Works and Sewerage Systems (PWW&SS) with an objective to replace inefficient pump sets with efficient ones vide its work order Ref: EESL/06/2016-17/Energy Audit/Uttar Pradesh/LoA 1617390/10269 dated 28th March, 2017.

1.2 Stakeholders Involved

There are many stakeholders involved in AMRUT. Their roles and responsibilities are already defined by the MoUD and other technical committee. Generally, the MoUD, EESL, ULB and Department of Urban Development (DUD) have major role to execute under AMRUT.

MoUD: The MoUD committee may co-opt any representative from any Government Department or organization as Member or invite any expert to participate in its deliberations. Key roles of MoUD include:

i. Allocation and release of funds to the States/UTs/Mission Directorate.
ii. Overall monitoring and supervision of the Mission.
iii. Advise to the State/UT/implementing agencies on innovative ways for resource mobilization, private financing and land leveraging.
iv. Confirm appointment of organizations, institutions or agencies for third party monitoring.

Department of Urban Development (DUD): Department of Urban Development (DUD) was setup to ensure the proper implementation and monitoring of the centrally assisted programme. Department of Urban Development (DUD) provides technical support to districts/towns to achieve their targets and also help in monitoring the state training plan. They also provide guidance and supervise the programme implementation through visits to the project sites.

ULB: At the City level, the ULB will be responsible for implementation of the Mission. The Municipal Commissioner will ensure timely preparation of all the required documents. The ULBs will ensure city level approvals of IGEA and bid documents and forward these to the State level Technical Committee (SLTC)/ State level High Powered Steering committee (SHPSC) for approvals. The ULB will also be responsible for building coordination and collaboration among stakeholders for timely completion of projects without escalation of project cost.

SLTC: SLTC may co-opt member(s) from other State Government Departments/Government organizations and may also invite experts in the field to participate in its deliberations.

EESL: Ministry of Power has set up Energy Efficiency Services Limited (EESL), a Joint Venture of NTPC Limited, PFC, REC and POWERGRID to facilitate implementation of energy efficiency projects. It will promote energy efficiency programmes across the country and will ensure supply of energy efficient equipment under this municipal programme. Necessary interventions would be undertaken by EESL without any financial burden on ULBs as cost of the proposed Municipal Energy Efficiency Programmes would be borne out of annuity payments. EESL has been doing various Energy Efficient Programmes, list of same is provided below:

1. Domestic Appliances Programme (LED Bulbs, LED Tube lights, Fans, etc.)
2. Street Lighting National Programme
3. Agricultural Demand Side Management
4. Municipal Energy Efficiency Programme
5. Atal Jyoti Yojana (Solar LED Street Lights)

Energy Auditing Agency – CII – Sohrabji Godrej Green Business Centre: EESL has engaged CII for preparation of IGEA reports for public water works in Jaunpur, Uttar Pradesh with an objective to replace inefficient pump sets with energy efficient ones. CII had conducted energy audit activity at Jaunpur City and had made IGEA with financial projections for ULB.

Pump Suppliers and Manufacturers: EESL has selectively taken on-board range of pump manufacturers and enquired with them regarding the necessary specifications of the products which can be used in line with the defined criteria according to EESL. All these manufacturers are rated manufacturers and comply with the quality and standards of their products.

1.3 Objective of the IGEA

Energy costs account for 40 to 60% of cost for water supply in urban areas and energy efficiency interventions can reduce this cost by 20 to 40 %, depending on the type and age of pump sets being used for Public Water Works and Sewerage Systems (PWW&SS). The MoUD with support from EESL has designed framework project for Energy Efficiency in cities of India while giving priority to AMRUT and smart cities. The objective of this project and IGEA report is to provide maximum information for creating baseline and analysis of current energy and utilization of Public water works systems.

This project is to be co-implemented by EESL and the objectives of this project are as under:

- To create increased demand for EE investments by adopting a ULB approach to facilitate the development of customized EE products and financing solutions in ULB.
- To raise the quality of EE investment proposals from a technical and commercial perspective.
- To expand the use of existing guarantees mechanisms for better risk management by EESL to catalyze additional commercial finance for energy efficiency.
- To establish a monitoring and evaluation system for the targeted ULB.

Scope of Work of Detailed Energy Audit

The general scope of work for detailed energy audits under IGEA as per Schedule 'A' is as follows:

- Discussion with Key personnel and Site visits of the facility
    - Initial discussions with Key personnel such as Commissioner, Chief Officer, Electrical / Mechanical engineer and pump operators to explain the objectives of the project, benefits of energy efficiency, and the approach that will be followed in Energy Audit.
    - Purpose of these discussion will be to ensure that key personnel of ULB have adequate understanding of the project.
    - Visiting all the facilities within the scope of project by identified agency to ascertain the availability of data and system complexity.
    - Identified agency will formulate a data collection strategy.
- Data Collection
    - Current energy usage (month wise) for all forms of energy for the last three years (quantity and cost)
    - Mapping of process
    - ULB and pumping station profile including name of station, years in operation, total water quantity pumped in last three years
    - List of major pumping equipment and specifications
- Analysis
    - Energy cost and trend analysis
    - Energy quantities and trend analysis
    - Specific consumption and trend analysis
    - Pumping costs trend analysis
    - Scope and potential for improvement in energy efficiency
- Detailed process mapping to identify major areas of energy use
- To identify all areas for energy saving (with or without investment) in the following areas:
    - Electrical: Power factor management, transformer loading, power quality tests, motor load studies, lighting load, electrical metering, monitoring and control system
    - Water usage and pumping efficiencies (including water receipt, storage, distribution, utilization, etc.), pump specifications, break down maintenance
- Classify parameters related to EE Enhancements such as estimated quantum of energy saving, investment required, time frame for implementation, payback period and to classify the same in order of priority

- Undertake detailed financial analysis of the investments required for EE enhancements
- Design "Energy Monitoring System" for effective monitoring and analysis of energy consumption, energy efficiency.
- Correlate monthly pumping quantity data with electricity consumption for a period of last three years of normal operation for individual sections of the overall pumping station
- Recommend a time bound action plan for implementation
- The broad content of the IGEA report should be as follows:
    - **Executive summary:** Provides brief description of the facilities covered, measures evaluated, analysis methodology, results and a summary table presenting the cost and savings estimates for each recommended measure. It also includes a summary of the recommended measures and costs as well as the financial indicators of the Project.
    - **Background:** Background about the ULB and the project.
    - **Facility Description:** Details of the existing facilities targeted, such as water treatment & supply systems, sewage treatment and handling systems.
    - **Energy Scenario:** Energy consumption details of all facilities included in the audit and their energy sources.
    - **Baseline parameters and Adjustments:** Methodology followed in establishing the baseline parameters and criteria.
    - **Data Collection**: List the various types of data collected and their sources.
    - **System mapping**: Describe the methodology followed for system mapping and include the maps and process flow diagrams in the report.
    - **List of Potential EEMs:** A list of all identified measures with estimates of the savings and payback periods on investments, and a summary of the selected EEMs chosen for further development.

1.4 Methodology adopted for Energy Audit

A detailed energy audit was conducted at all the pumping stations falling under Jaunpur Nagar Palika Parishad on 4th – 13th April 2017. The energy audit team of CII comprised of BEE certified energy auditors/managers and pump experts. During the field visit, adequate number of portable energy audit instruments were used to carry out measurements of pump sets efficiency parameters. In addition to this, design and operational data was collected from logbooks, equipment manuals and pump manufacturers. Discussions were held with various technical and operating staffs of the ULB to understand the system and pump sets operations and requirements completely. The energy audit study mainly focused on the evaluation of operational efficiency/performance of the pump sets already installed in the premise from the energy conservation point of view.

The methodology planned for accomplishing the above scope of work was divided into three phases as detailed below:

Phase 1: Inception

- Conduct kick-off meeting
- Pilot visit to a few sites to ascertain the availability of data, measurements points and system complexity

- Discussed and finalized the methodology for data collection as per job card.

- **Phase 2: Detailed energy audit**
  - Initial meeting with concerned staff of ULB at each site to brief them regarding the project
  - Walk-through of the site along with pumping station/site personnel to understand the site conditions and equipment involved
  - Assessment of data availability (historical data/technical data sheets of major equipment/maintenance practices/cost details/electricity bills, etc.) and placing request for required data
  - Finalization of measurement points and support required from ULB staff
  - Conducting measurements and data collection with support from ULB staff
    - Energy auditing instruments used during project are listed below:
      - Power analyser: For electrical parameters (V, A, kW, kVA, kWh, kVAh, PF, Hz and THD)
      - Ultrasonic flow meter: For water flow measurement
      - Ultrasonic thickness gauge: For pipeline thickness measurement
      - Digital pressure gauges: For suction and discharge pressure measurement
      - Lux meter: For lighting intensity measurement
    - Filling & signing of job cards
    - Parallel activities of noting observations on the following:
      - SLD (Site Layout Diagram) & PID
      - Operation & Maintenance practices
      - Instrumentation in place and
      - Existing practices to monitor energy consumption.

- **Phase 3: Analysis and IGEA report preparation**
  - Compilation and analysis of data collected from site
  - Performance assessment of the equipment
  - Conceptualization and development of energy cost reduction projects
  - Cost benefit analysis
  - Review of adequacy of instrumentation for energy efficiency monitoring and
  - Submission of IGEA report to ULB/ SLTC for approval.

2 Interaction with Facilities/ Key Personnel

The energy auditing team interacted for work proceeding and reporting with stakeholders for efficient information exchange. The kick off meeting was held with Junior Engineer, Jalkal Pumping Station on 04th April 2017 for discussing the data/information required, methodology to be followed and support required from the ULB. The ULB appointed its staff to provide support and information during energy audit. CII has provided day wise reporting to appointed staff of ULB regarding work status. Based on the work experience with ULB, inception report was submitted to EESL.

The following important issues were discussed and appropriate guidance was provided to the team members. During the kick-off meeting and pre-site visit at Jalkal Pumping Station on 4th April 2017, the following points were discussed:

- Support from the ULB will be given to the CII team for conducting energy audit
- Energy audit will be conducted by CII team in presence of EESL personnel and nodal official of ULB.
- Observations will be discussed with the appointed official of ULB and EESL
- CII can communicate with ULB official regarding scheduling of sites for audit
- Support will be provided by ULB to obtain various data to create baseline of energy consumption, quantity of water pumped, etc.
- The letter of site activity conducted should be collected by CII after finishing the site work
- CII will regularly report the ULB official by informing the status of work and work schedule
- The site work completion letter should contain the information of pumps measured and those under maintenance
- CII will report the status of work on a daily basis to project-coordinator of EESL
- CII will submit the job card to EESL after completion of site work
- Signature of authorized personnel should be obtained on the job card in case of non-availability of data

EESL also appointed their staff to monitor audit works and to provide support and guidance for better quality of work flow. The appointed staff from EESL have been trained for the information exchange and to provide maximum support for the site to be ready for energy audit. The appointed staff of EESL held periodic discussion with CII team members regarding the observation of energy audit and feasibility of EE projects at ULB.

2.1 Interaction with Pump Manufacturers

Some of the reputed pump manufacturers were selectively contacted regarding the costing and feasibility of different pump sets. The discussion with pump set manufacturers included the following points:

- Technical Feasibility of the suggested energy efficiency measures were discussed with the vendors.
- Commercial terms of EEM such as cost of equipment, auxiliary systems, and installation cost etc. were discussed with the vendors for assessing financial viability of EEM.

3 Project area and Facility description

3.1 General information about the city

The district of Jaunpur is situated in the North-West part of Varanasi Division. Its area extends from 24.240N to 26.120N latitude and between 82.70E and 83.50E longitudes. Its attitude varies from 261 ft to 290 ft. above M.S.L. (Mean Sea Level). The topography of the district is mainly a flat plain with shallow river-balleys. Gomti and Sai are its main parental rivers. Besides these, Varuna, Basuhi, Pili. Mamur and Gangi are the smaller rivers here. The rivers Gomti and Basuhi divide the district into nearly four equal landmasses. The soils are mainly sandy, loamy and clayey. Jaunpur district is often affected by the disaster of floods. The temperatures of the district of Jaunpur lie between a minimum of 4.30C and a maximum of 44.60C. Average annual rainfall is 987 mm. The geographical area of the district is 4038 sq.km. As per the previous Census, the population of Jaunpur city is provided in the table 1.

Table 1: Population of Jaunpur city[1]

Census Year	Population (Nos.)
2001	3,911,679
2011	4,494,204

3.2 Accessibility to city from Metro cities & State capital

Rail

Jaunpur is well-connected with all major cities of India thanks to Indian Railways. It has four major railway stations: Jaunpur City Railway Station (JOP) and Jaunpur Junction (JNU), Shahganj Junction (SHG), Janghai Junction, Kerakat railway station (KCT).

Road

Jaunpur is well-connected to Lucknow, Gorakhpur, Varanasi, Allahabad and other cities like Azamgarh, Mirzapur, Janghai, Sultanpur, Kerakat, Ghazipur etc. NH-56, SH-36 are the roadways connecting all major cities to Jaunpur

Air

Airport is located 41 km from the Jaunpur city. The nearest airport with regularly scheduled flights is at Varanasi City.

3.3 Pumping Stations in the Jaunpur city

Water demand of Jaunpur city is met from the following two sources available in the Jaunpur City:

1. Gomthi River
2. Under Ground water

[1] Source: http://www.census2011.co.in/census/district/565-jaunpur.html

At present, Jaunpur city have only one Raw water Pump House, water treatment plant (Jalkal Pumping Station) and 53 Submersible Pumps in the city. The pictorial representation of the entire pumping station is provided in figure 1.

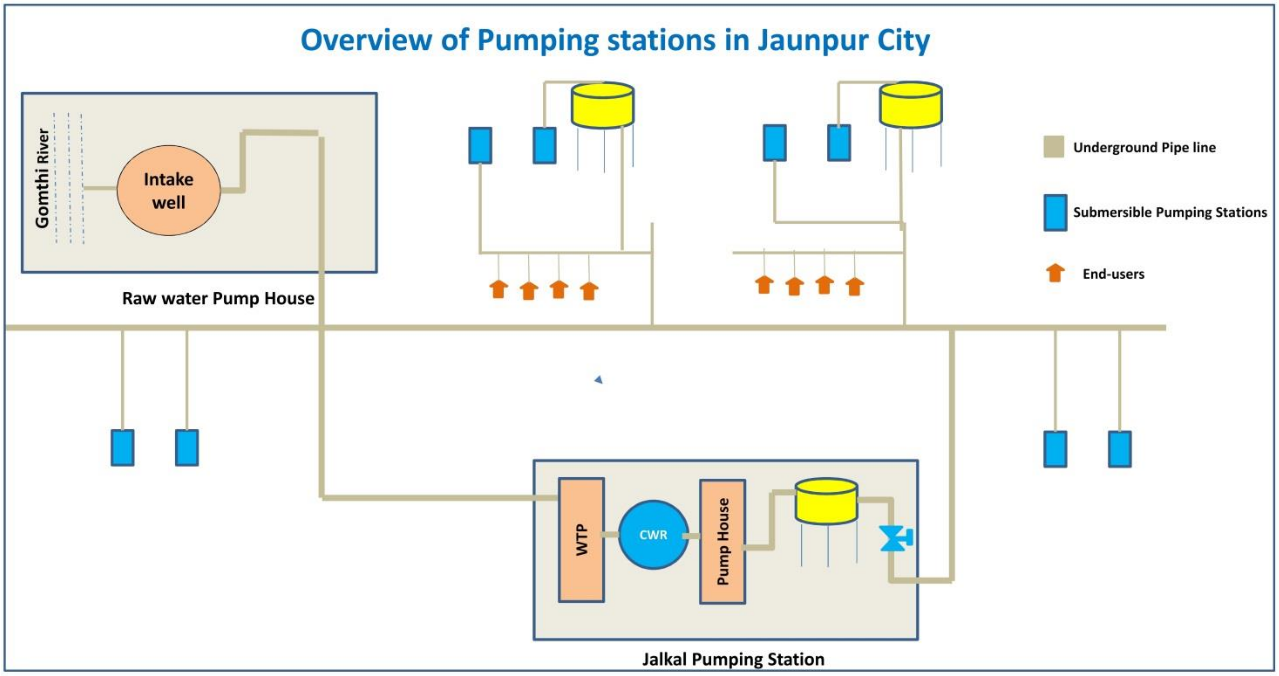


Figure 1 Overview of Pumping stations in Jaunpur city

The details of the water pumping stations are provided in the table 2.

Table 2: Details of Pumping stations in the city

S. No	Name& Location of water Plant	Capacity (MLD)	Type of the facility (Raw water/ WTP/Booster)	Source of water	Distribution/Delivery area
1	Raw Water Pump House	NA	Raw water	Gomthi River	Jalkal Pump House
2	Jalkal Pump House	NA	WTP	Raw water	End-users
3	Submersible Pumps	NA	Bore well	Under ground	End-users

Raw water Pumping Station: The water from Gomthi River is collected at Raw Water Pumping station. The water from this Pumping Station is transferred to Jalkal Pumping Station using 4 nos. of pumps. Pump sets at raw water Pump House are operated based upon the level of water flowing in the river.

Jalkal Pumping Station: Jalkal Pumping Station is a Water Treatment Plant which receives raw water from Gomthi River through a canal and a pipeline from raw water Pump House. For raw water intake, there are two channels, the treated water from filter plant is stored in the Clear Water Reservoirs. Treated water is then supplied to overhead storage tanks using pumping systems installed at Pumping Station.

Miscellaneous Pumping Stations: Bore wells are located at various locations in the city to supply water to the near-by Areas. The water from all these stations are Pumped as direct supply or to the Over Head Storage Tanks.

3.4 Historical Water Pumped and Energy Consumption Analysis

Last 12 months electricity bills of pumping stations were provided by ULB and analyzed for evaluation of SEC. Whereas historical data about water flow of Pumping Stations in Jaunpur City is not available.

Table 3: Historical water pumped and energy consumption data for last three years

Description	Water flow (kL /Annum)	Energy consumption (kWh/Annum)	Specific energy consumption (kWh/kL)
Raw Water Pump House			
Jan-14 to Dec-14	Not available		Not available
Jan-15 to Dec-15	Not available	222402*	Not available
Jan-16 to Dec-16	Not available		Not available
Jalkal Pump House			
Jan-14 to Dec-14	Not available		Not available
Jan-15 to Dec-15	Not available	178848*	Not available
Jan-16 to Dec-16	Not available		Not available
Submersible Pumps			
Jan-14 to Dec-14	Not available	1494804*	Not available
Jan-15 to Dec-15	Not available		Not available
Jan-16 to Dec-16	Not available		Not available

Note:

- 12 months electricity bills were provided for raw water pump house and Jalkal Pump House.
- 12 months Electricity Bills were provided for 18 submersible pumps only. For remaining submersible pumps, electricity bills were not available at ULB and Discoms and the undertaking has been attached in the annexure.
- Locations for which Electricity bills of submersible pumps are available – Misirpur, Sarailatta, Bhagat Singh Park, Hindi Bhawan, Khanaspur, Pachatia, Sadar Chungi, Ahaiyapur, Purani Bazar, Naigang No.1, Naigang No.2, Polytechnic 1, Mufti Mohalla, Bhusa Godam, Kharkha Colony, Naigang No.3, Polytechnic 2, Dhaigarh Tola

3.5 Power Failure Data

The last year power failure data for pumping stations is not available at the ULB provided in table 4.

Table 4: Historical power failure data

Description	Power failure in Hours
March -16	Not Available

Description	Power failure in Hours
April -16	Not Available
May -16	Not Available
June – 16	Not Available
July -16	Not Available

3.6 Rainfall and Climate data

Rainfall and climate data of Jaunpur City is provided in table 5.

Table 5: Rainfall and Climate data of Jaunpur City[2]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Temp (°C)	23	27	33	38	38	36	33	33	33	33	30	25
Avg. Temp (°C)	16	20	25	30	32	31	30	29	29	27	23	18
Min Temp (°C)	9	12	17	21	25	26	26	26	25	21	15	11
Avg. Rain (mm)	17.2	19.2	5.9	4	29.8	169.5	303	353.1	187.1	53.8	4.3	31.9
Avg. rainy days	3	3	10	1	24	29	30	25	29	14	4	6

3.7 Ground Water Profile

In present scenario, complete water demand of Jaunpur city is being met through ground water and Gomthi River as a source of water. Data regarding net ground water availability of Jaunpur district is provided in table 6.

Table 6: Ground Water Profile[3]

Assessment Unit/ District	Net Annual Ground Water Availability (ha m)	Existing Gross Ground Water Draft for all uses (ha m)	Total Annual Ground water Recharge (ha m)	Net Annual Ground Water Availability for Irrigation (ha m)	Stage of Ground water Development	Area in the Basin (Sq.Km)
Jaunpur	137992.06	107250.75	151073.62	24189.11	77.72	4038

3.8 Reservoir Levels at Different Seasons

Jaunpur city has been witnessing different seasons and accordingly the water treatment plants take appropriate actions of conserving the water in the reservoirs available to them. The data regarding the water level of the reservoir for different seasons are not available at ULB and so it is not provided here.

[2] https://www.worldweatheronline.com/jaunpur-weather/uttar-pradesh/in.aspx
[3] http://www.cgwb.gov.in/District_Profile/UP/Jaunpur.pdf

Table 7: Reservoir levels at different seasons

Different seasons	Reservoir level
Summer	NA
Winter	NA
Monsoon	NA

3.9 Water Cost Estimation

During energy audit, data regarding various operation and maintenance expenses borne by ULB was collected for estimating water cost. Details of expenditure by ULB during last year and estimated water cost is provided in the table 8.

Table 8: Water cost estimation

Particular	Units	Values
Energy cost (Electricity)	Rs. Lakhs	10429720
Repair & Maintenance	Rs. Lakhs	NA
Operation (man power & raw material)	Rs. Lakhs	NA
Miscellaneous cost (Cost of major replacement)	Rs. Lakhs	NA
Total cost	Rs. Lakhs	10429720
Annual water pumped to City (estimated)	kL	9317720
Water cost	Rs./kL	1.12*

* The water cost is estimated as an aggregate of those 19 (18 submersible pumps and 1 pumping stations) pumps whose electricity bills were provided and flow was measured during site visit.

4 Pumping Stations Performance Evaluation

Jaunpur city is getting the drinking water supply from Gomthi River through Raw water Pump house and Jalkal Pumping Station. Details of connected load at raw water Pump House and Jalkal pumping stations, layout and results of performance assessment are provided in subsequent sections of this chapter.

4.1 Connected load at pumping stations

Based on the data collected from the Pumping stations in Jaunpur City, details of connected load at raw water pump house and Jalkal pumping station are provided in the Table 9:

Table 9: Connected load details for pumping stations in Jaunpur City

S.No	Type of Load	Rated Capacity (KW)	Raw water Pump House	Jalkal Pumping Station	Submersible Pumping stations				
					20 HP	15 HP	25 HP	30 HP	10 HP
Water Pump Set									
1	Pump set	22.5	3	2	-	-	-	-	-
2	Pump set	45	1	2	-	-	-	-	-
3	Submersible Pump	18.75	-	1	-	-	12	-	-
4	Submersible Pump	22.5	-	1	-	-	-	12	-
5	Submersible Pump	15	-	-	1	-	-	-	-
6	Submersible Pump	11.25	-	-	-	2	-	-	-
7	Submersible Pump	7.5	-	-	-	-	-	-	24
Auxiliary Load									
8	Tube light (T-12)	0.045	3	10	1	-	1	1	1
9	Ceiling fan	0.075	-	8	-	-	-	-	-
10	CFL	0.075	1	11	-	-	-	-	-
11	Sodium vapor Lamp	0.25	2	-	1	-	1	1	-
12	Exhaust Fan	0.06	-	1	-	-	-	-	-
Total Connected Load of Pumping Station (kW)			**113.2**	**178.2**	**15.3**	**22.5**	**19.1**	**270**	**180**

Based on above, total connected load of Raw water Pumping station and Jalkal pumping station is estimated to be 113.2 kW and 178.2 kW, respectively and connected load of all submersible pumping stations of capacity 20 HP, 15 HP, 25 HP, 30 HP, 10 HP, is estimated to be 15.3 kW, 22.5 kW, 19.1 kW, 270.3 kW and 180 kW respectively.

4.2 Raw Water Pump House

4.2.1 Overview of existing systems

Raw water Pump House comprises of a water Intake, a pipe line from Gomthi River. Intake water pumping system supplies raw water to the WTPs of Jaunpur i.e. Jalkal Pumping Station. The source of electrical energy of raw water pump house is grid electricity from Purvanchal Vidyut Vitaran Nigam Limited (UP PUVVNL), Uttar Pradesh. The site layout diagram for raw water Pump House is provided in figure 2.

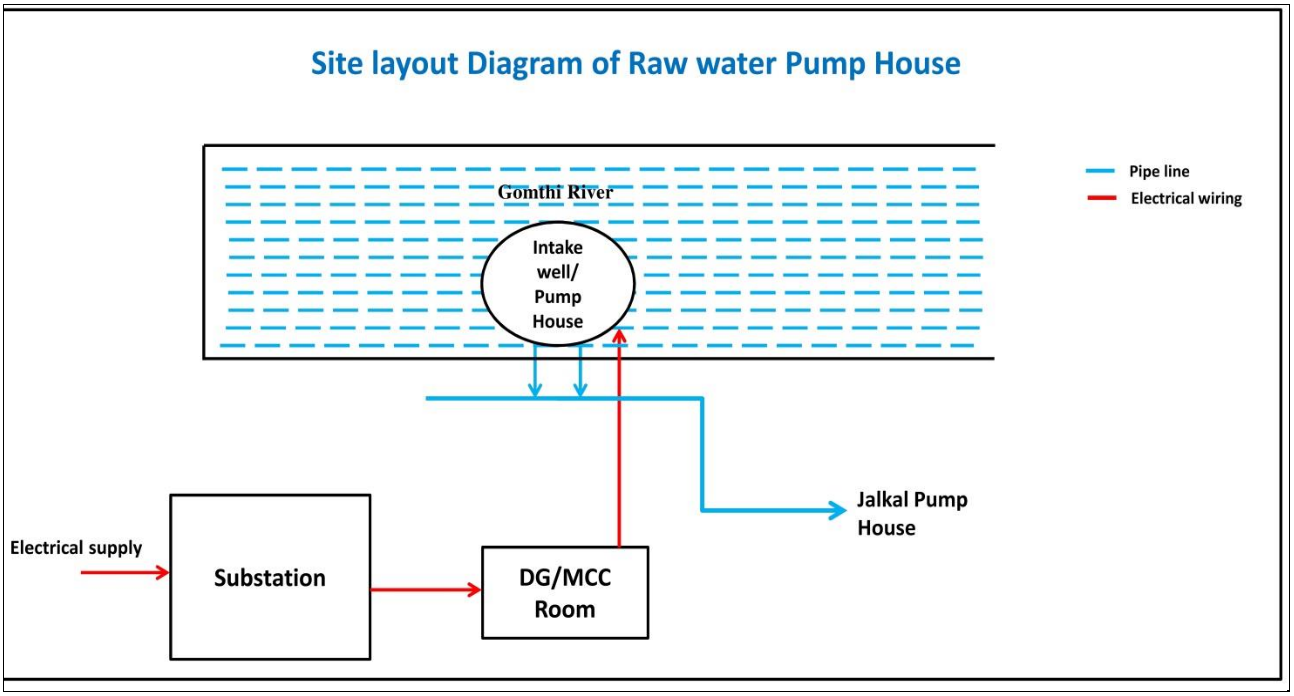


Figure 2 Site Layout Diagram for Raw water Pump House

4.2.2 Electricity supply

Raw water Pump House is getting electricity supply from PUVVNL from HT supply of 11 kV feeder which is transformed to LT level using 125 kVA, (11/0.433 kV) step down transformer. During energy audit, it was observed that transformer Name plate details are not found. Raw water Pump House has also installed diesel generator set for providing power back up in case of grid power supply interruptions. The Single Line Diagram (SLD) of raw water Pump House is provided in figure 3.

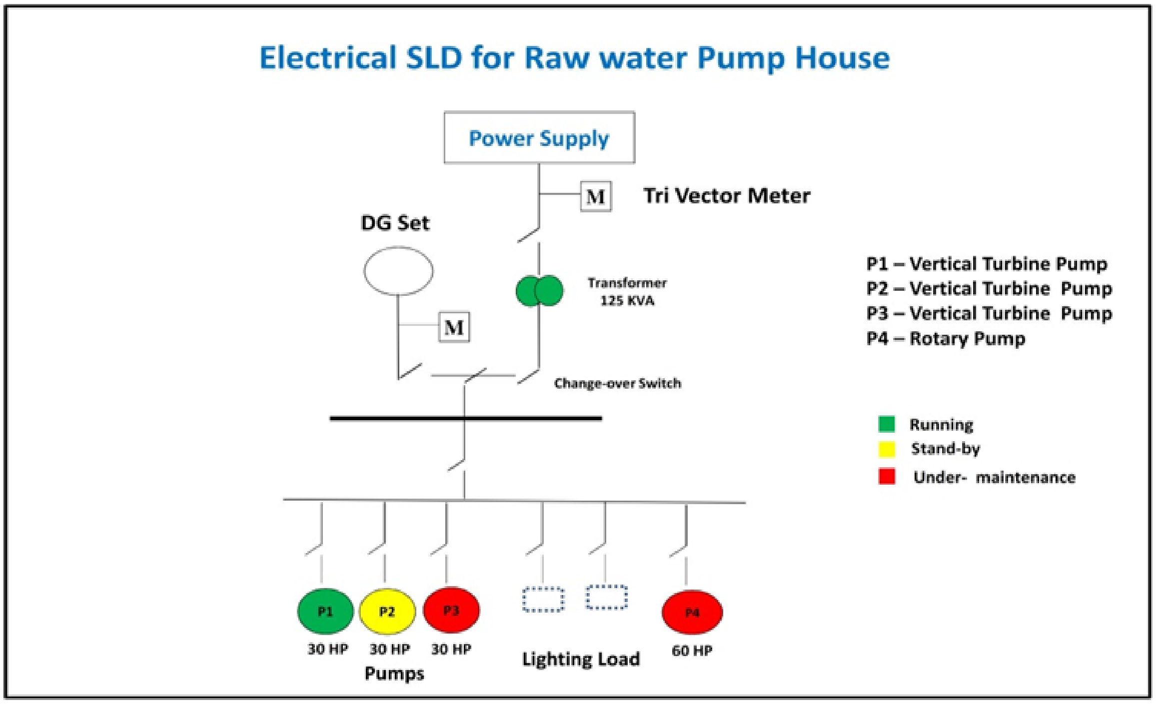


Figure 3 Single line diagram for the Raw water Pump House

4.2.3 Tariff structure

Raw water Pump House is getting supply from one LT feeder and meters installed at plant premises. As per UP PUVVNL tariff order 2016, the tariff for raw water Pumping station will fall under Public Water works Details of tariff for Public water works and state tube wells are provided in the table 10.

Table 10: Tariff structure for Raw water Pump House

Description	Raw water Pump House Energy Meter
Meter serial number	-
Power supply	0.440 kV line
Contract Demand	-
Energy charges	Rs. 7.95 Per kWh
Fixed/demand charge	Rs. 230 Per kW/month
(Basis :UP PUVVNL Tariff Order for FY 2015-16)	

4.2.4 Electricity Bill Analysis

During energy audit, electricity bill of the raw water Pump House for last 12 months are collected from Nagar Palika Parishad, Jaunpur. Details of monthly annual electricity consumption, annual electricity cost is provided in the figure 4.

Note: Details of month wise electricity bills are provided in Annexure – 4

Table 11: Energy cost and energy consumption detail for Raw water Pump House

Period of energy bill	Energy consumption (kWh/Annum)	Percentage Increase of energy consumption over previous year (%)	Energy cost (Rs./Annum)
Jan-14 to Dec-14			
Jan-15 to Dec-15			
Jan-16 to Dec-16			

Note: Details of month wise electricity bill is provided in Annexure – 4

Based on the Electricity Bills, The average PF recorded at raw water Pump House is estimated to be < 0.85 (lagging). As per Tariff Order, During FY 2014-15, there was a penalty for power factor below 0.85; however this penalty mechanism is no longer applicable in future as new tariff/billing will be based on kVAh. As the billing is done on kW basis, improving power factor to Unity (will reduce the electricity cost paid every month)

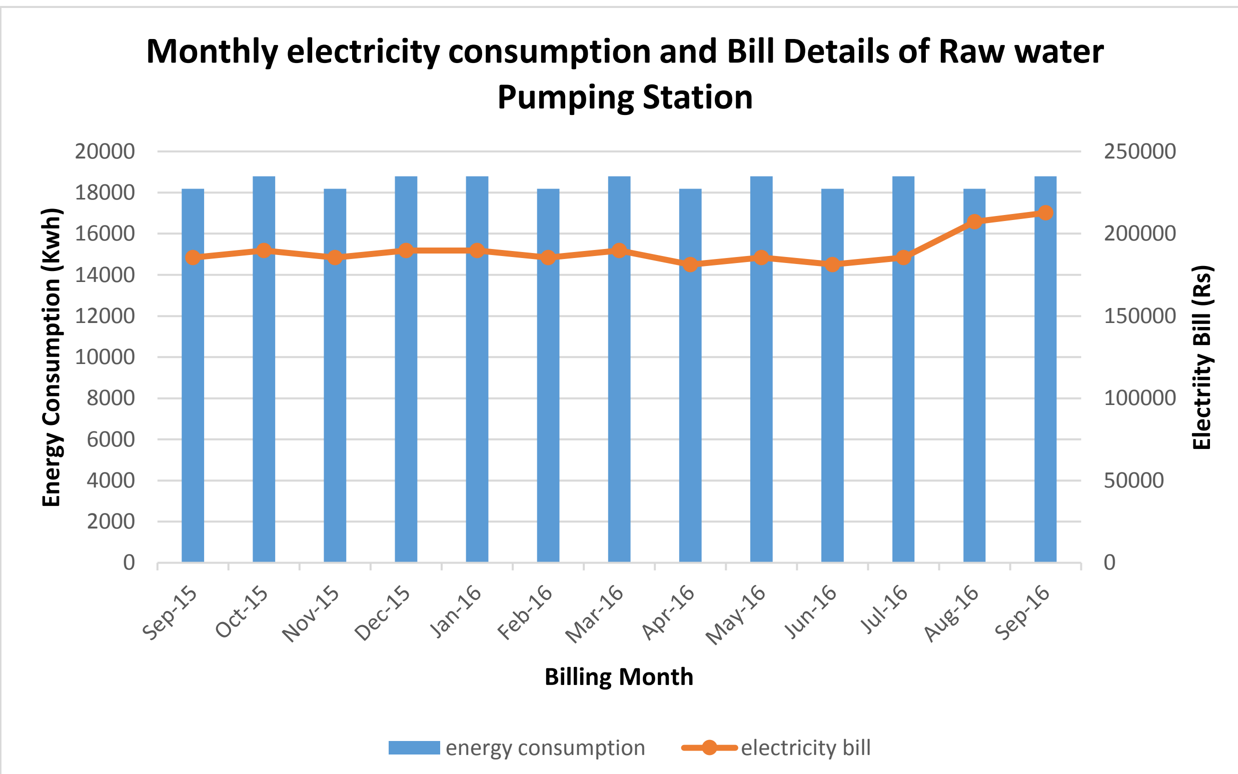


Figure 4 Monthly electricity consumption and electricity bill for Raw water Pump House

4.2.5 Energy Consumption Pattern of Raw water Pumping Station

During energy audit, Due to Low river water level pumps are not under operating condition. Thereby Measurements are not carried for Pumps 1, 2. However, Pumps 3, 4 are under maintenance for the past 6 months and are not under operating condition during site visit. Details about transformer installed at Raw water Pump House is provided in the table 12.

Table 12: Details of Transformers at Raw water Pump House

Main Incomers	Details of Transformer	Connected load
1	125 KVA Transformer	Raw water Pumping station

4.2.6 Pumping Station System Mapping

Raw water Pumping station has a water intake plant where the water flowing in Gomthi River is pumped to the water Treatment Plant. The detailed P&ID diagram of raw water Pumping station is provided in figure 5.

Raw water pumping station

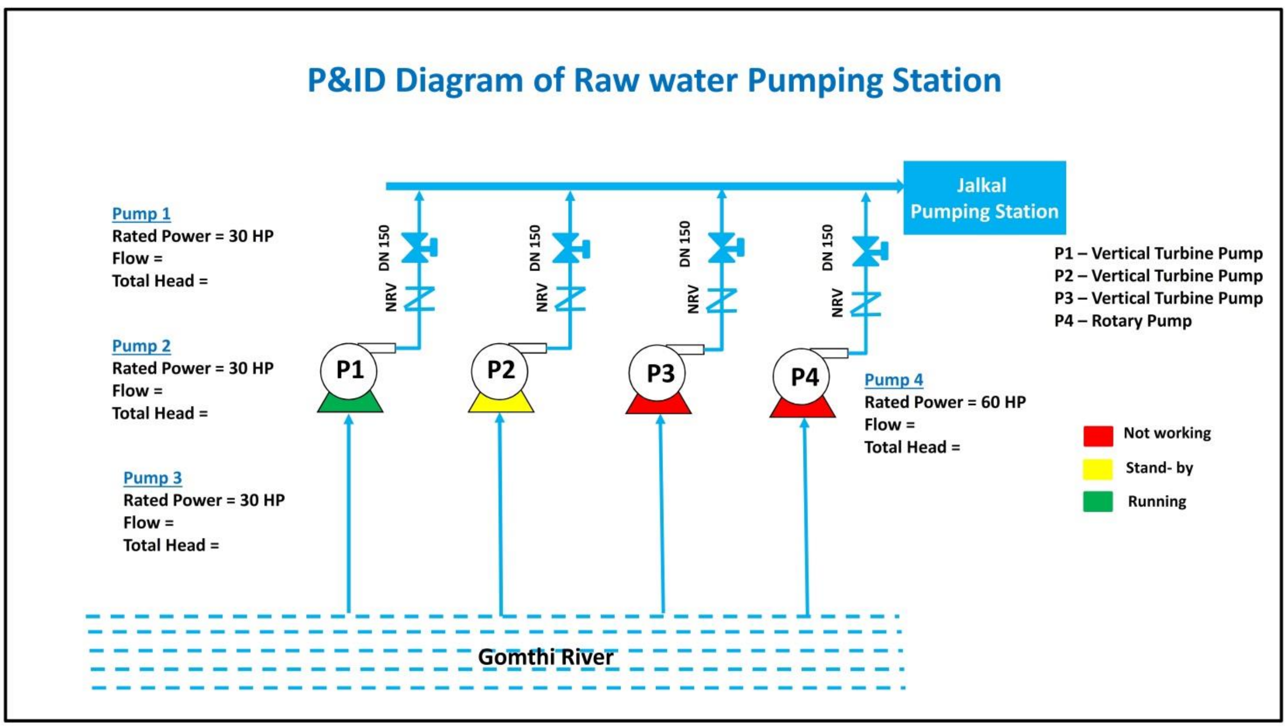


Figure 5 P&ID diagram for Raw water Pumping Station

4.2.7 Pumps Performance Evaluation

As per the methodology described in LOA, the team had collected detailed information from the pumping stations. Site data collection activities included the following:

- Data collection
- System mapping including collection of inventories, name plate details
- Measurements of flow, head and power input to motor
- Interaction with the site personnel on the operating practices
- Verification of Job card by the authorized representative of ULB

Detailed energy audit at raw water Pumping station was conducted on 4h to 13th April, 2017. The general details of the site are provided in the table 13.

Table 13: General details of Raw water Pump House

Data	Value / Details
Name of site	Raw water Pumping Station
Name of Sub-section	-
Classification (WTP,PS, SPS, STP)	Raw water Pumping station
Pumps installed	4
No. of pumps in operation	2 (during site visit, pumps are not operational due to low river level)
No. of pumps under maintenance	2
Other Details	
Basis of pump operation	Water level in Gomthi River
VFD installed (Yes/No)	Not Installed

Photographs captured at the raw water Pumping station to showcase the actual situation are provided in figure 6.

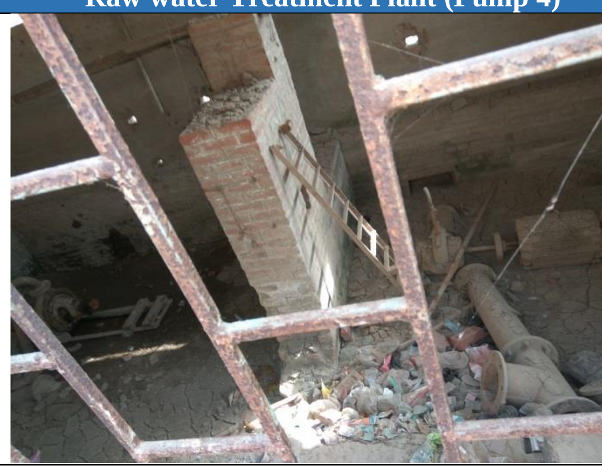
Raw water Treatment Plant (Pumps 1,2,3)	Raw water Treatment Plant (Pump 4)
	

Figure 6 Photographs of Raw water Pump House

There are four pumps installed at raw water Pump House, out of which two pumps were under maintenance during the energy audit. Pumps under maintenance were not covered in this energy audit. The details of the operational and under maintenance pumps are provided in table 14.

Table 14: Operational pumps at Raw water Pump House

Location	Name of station	Total no. of pumps	Total no. of pumps audit is done	No. of pumps under Maintenance	Remarks
Jaunpur	Raw water pump House	4	0	2	Pumps 2,3 are not running due to low water level and pumps 1,4 are under maintenance
Total		**4**	**0**	**2**	

4.2.7.1 Raw water Pump House

Three Vertical Turbine Pumps of rated capacity 90 m^3/hour each and a Rotary Pump of Rated Capacity 180 m^3/hr were installed at Raw water Pumping station, out of which two pumps were working while other two pumps were on standby mode. During energy audit, pump – 2, 3 are not running due to low water level. While pump -1, 4 was under maintenance.

Key Observations:

- The Pumps are not in operational due to low water level

4.2.8 Auxiliaries In Pumping Stations

During the energy audit, auxiliary electrical load of pumping station were also studied and details of same is provided in table 15.

Table 15: Other electrical equipment at Raw water Pumping Station

Parameters	Details
Transformers details	
Number of Transformers	one
Capacity (kVA)	125 kVA
Primary/Secondary voltages	11 kV/433 V
Instrumentation at site	
Suction pressure gauges	Available
Discharge pressure gauges	Available
Flow meter	Not available
Energy meter	For whole facility at incoming feeder (DISCOM meter only)

Table 16: Other electrical equipment at Raw water Pumping Station - Lighting

Others	Type of lamp	No. of fittings	Rating (kW)	Average Operating hours per day
Lighting	FTL (T-12)	3	0.045	12
	Sodium Vapour lamp	2	0.25	12
	CFL	1	0.075	12

4.2.9 Total Energy Consumption Estimation For Pump sets in Raw water Pump House

During energy audit, measurements were not conducted on pumps 2, 3 due to low water level and operating hours of pumps were collected from the available log books and from operators for estimating annual energy consumption.

4.3 Jalkal Pumping Station

4.3.1 Overview of Existing Systems

Jalkal Pumping Station i.e. WTP comprises of a clarifier section which receives raw water through a pipe line from Gomthi River through Raw water Pumping station. The Raw water is filtered in the water Treatment Plant and is stored in a clear water Reservoir. The Clear Water stored is then pumped to the Over Head Tank. The source of electrical energy of Jalkal Pumping station is grid electricity from Purvanchal Vidyut Vitaran Nigam Limited (PUVVNL), Uttar Pradesh. The site layout diagram for Jalkal Pumping Station is provided in figure 7.

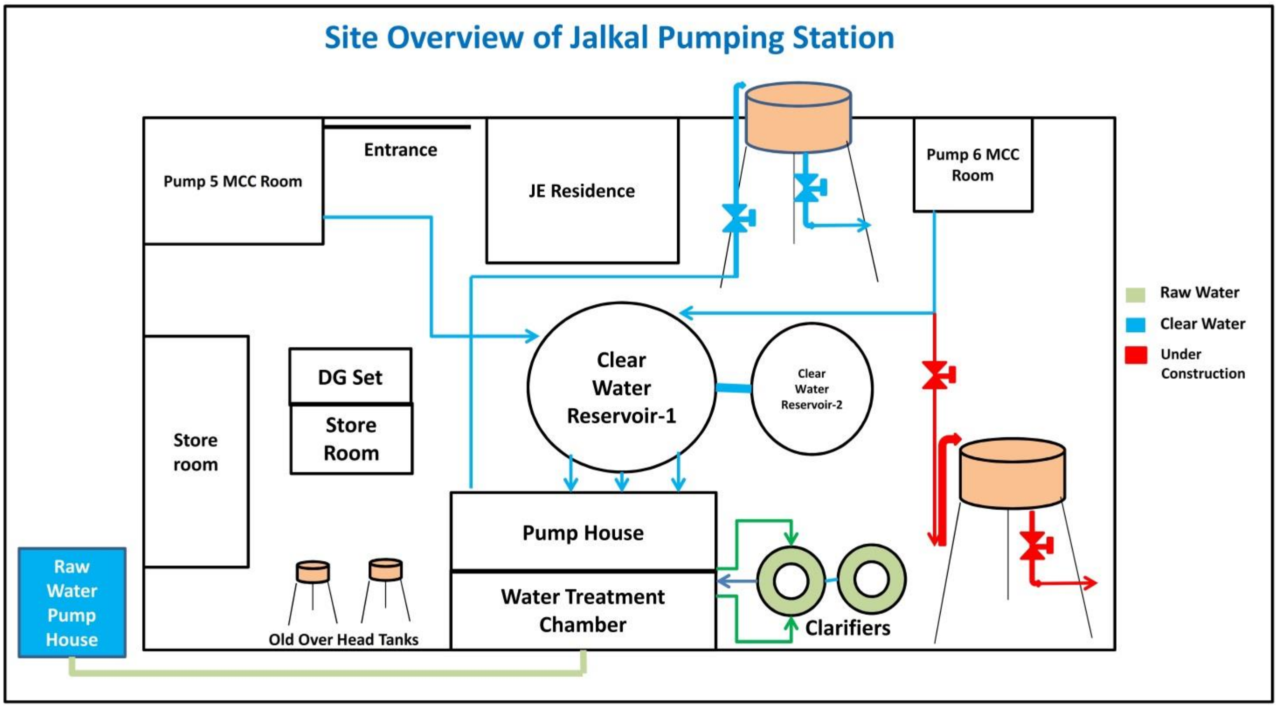


Figure 7 Layout Diagram for the Jalkal pumping station

4.3.2 Electricity supply

Jalkal Pump House is getting electricity supply from PUVVNL from one 11 kV feeder. HT supply of 11 kV feeder is transformed to LT level using 250 kVA, (11/0.433 kV) step down transformer. Energy meters are installed on LT supply line for respective billing. Jalkal Pump House has also installed diesel generator set for providing power back up in case of grid power supply interruptions. The Single Line Diagram (SLD) of raw water Pump House is provided in figure 8.

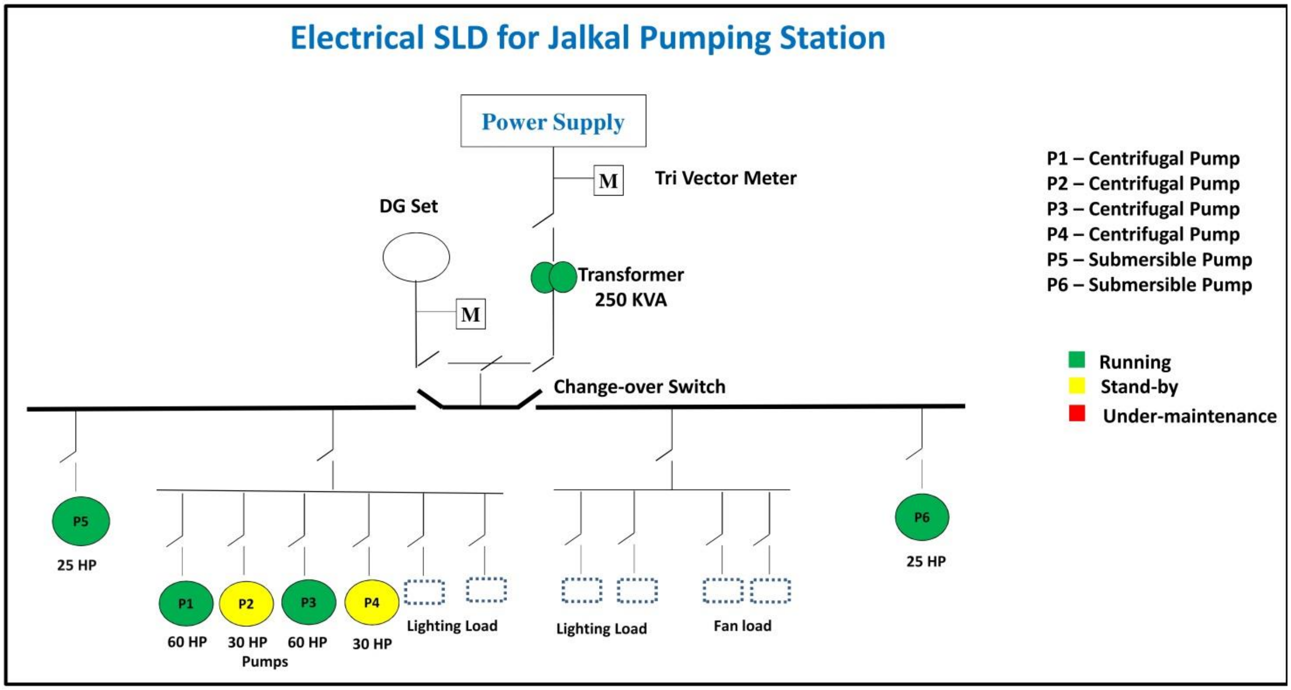


Figure 8 Single Line Diagram of Jalkal Pumping Station

4.3.3 Tariff Structure

Raw water Pump House is getting supply from one LT feeder and meters installed at plant premises. As per UP PUVVNL tariff order 2016, the tariff for Jalkal Pumping station will fall under Public Water works. The Tariff structure for Public water works and state tube wells are provided in the table 17.

Table 17: Tariff structure of Jalkal Pumping station

Description	Jalkal Pumping Station Energy Meter
Meter serial no.	-
Tariff category	Public water works
Power supply	0.440 kV line
Contract Demand	-
Energy charges	Rs. 7.95 Per KWh
Fixed/demand charge	Rs. 230 Per kW/Month
(Basis : UPPUVVNL Tariff Order for FY 2015-16)	

4.3.4 Electricity Bill Analysis

During energy audit, electricity bill of Jalkal Pumping station for last 18 Months was collected from Nagar Palika Parishad, Jaunpur. Details of annual electricity consumption, annual electricity cost along with percentage increase over previous year is provided in table 18.

Table 18: Energy cost and energy consumption detail for Jalkal Pumping Station

Period of energy bill	Energy consumption (kWh/year)	Percentage Increase from previous year	Energy cost (Rs./year)
Jan-14 to Dec-14	-	-	-
Jan-15 to Dec-15	178848	-	1421842
Jan-16 to Dec-16	-	-	-

Note: Details of month wise electricity bill is provided in Annexure – 4

Based on the Electricity Bills, The average PF recorded at Jalkal Pumping Station is estimated to be < 0.85 (lagging). As per Tariff Order, During FY 2014-15, there was a penalty for power factor below 0.85; however this penalty mechanism is no longer applicable in future as new tariff/billing will be based on kVAh. As the billing is done on kW basis, improving power factor to Unity (will reduce the electricity cost paid every month.

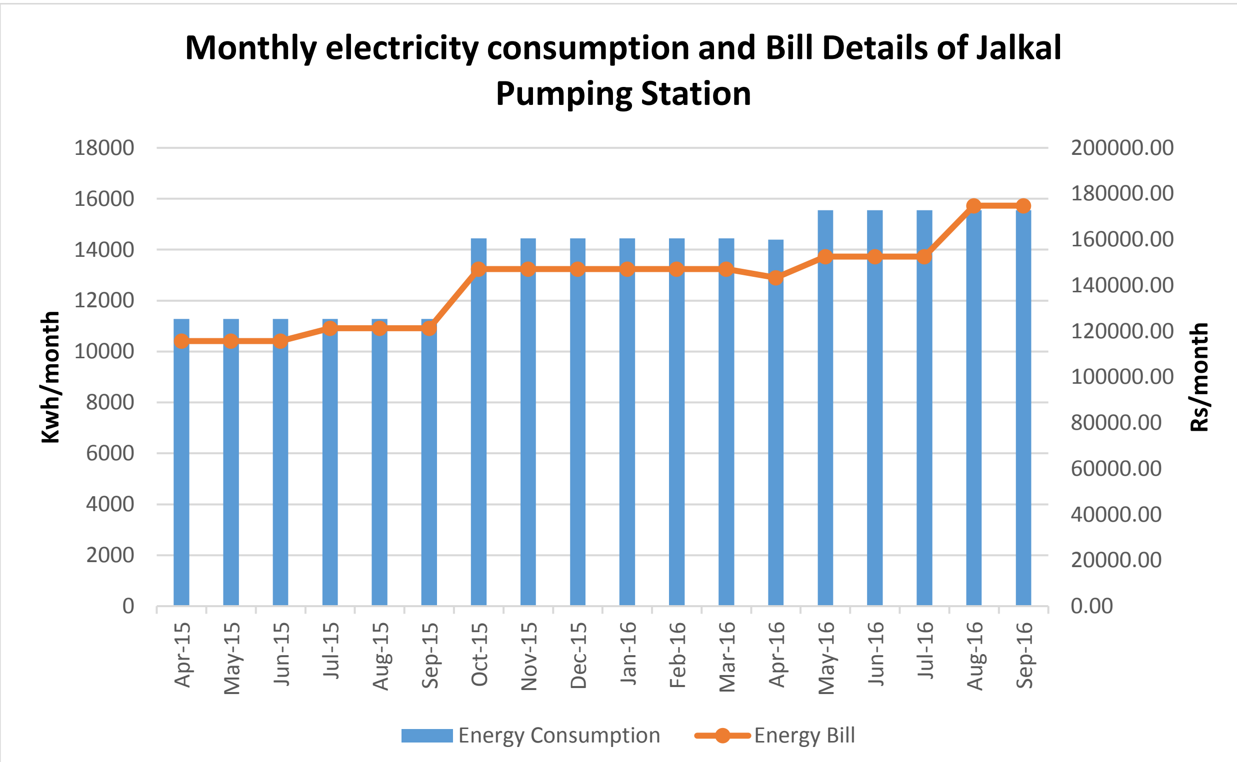


Figure 9 Energy consumption and cost analysis for Jalkal Pumping Station

4.3.5 Energy Consumption Pattern At Jalkal Pumping Station

During energy audit, three phase power analyzer was installed for about 24 hours on transformer (secondary side) at the pumping station for recording variation of electrical parameters. Details about transformers installed at Jalkal pumping station is provided in table 19.

Table 19: Details of Transformer at Jalkal Pumping Station

Main Incomers	Details of Transformer	Power Distribution
1	Transformer-1 (250 kVA, 11/0.433 kV, Working)	Jalkal pumping station

Transformer :

Transformer is a 250 kVA, 11/0.433 kV step down transformer and it is supplying the power to the Jalkal Pumping station.

Voltage Profile:

During energy audit, voltage was recorded for 24 hours at the transformer secondary side at the main LT panel of the Transformer. Voltage variation of transformer is provided in figure 10.

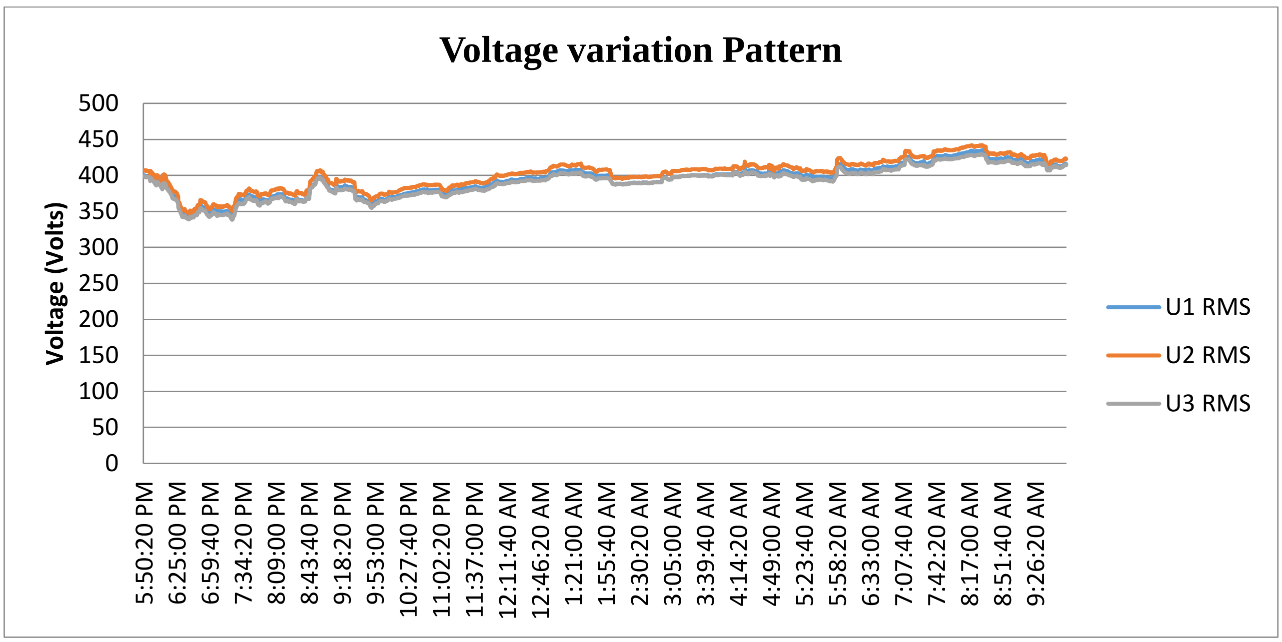


Figure 10 Voltage variation in Jalkal Pumping station

- During log period, voltage was found to be varying from 344 to 440 V, whereas average voltage was recorded as 400 V.
- Average voltage has to be in the recommended range of 415 V

Power consumption Profile:

During energy audit, power consumption was recorded for 24 hours at the transformer secondary side at the main LT panel of the Transformer. Variation in power consumption for a period is provided in figure. Stand-by Pumps, 2 No's of capacity 30 HP are in Operation during this period.

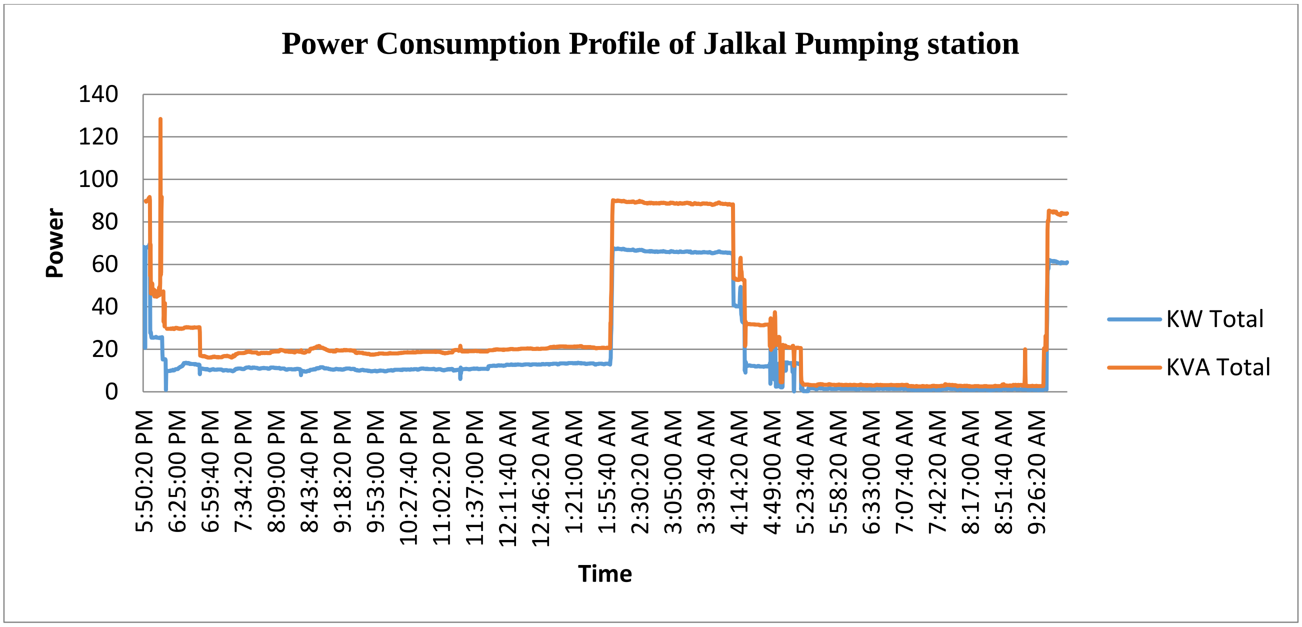


Figure 11 Power consumption variation for Transformer in Jalkal Pumping Station

- The average power consumption of Jalkal Pumping Station was found to be 65 kW (during running condition), while the maximum and minimum power consumption was 65 kW and 12 kW respectively.

- The average apparent power was found to be 88 kVA, while the maximum and minimum apparent power consumption was 88 kVA and 20 kVA respectively.

Power factor profile

Under the current tariff plan of LT feeder, energy is billed in kWh and the demand charges are based on apparent power (kVA) depend on the power factor. If the pumping station maintains low power factor, then the demand drawn from the grid will increase and consequently the pumping station will incur more demand charges. The variation in the power factor is recorded to explore opportunities for improvement. The graph provided in figure 12 presents the variations in the power factor.

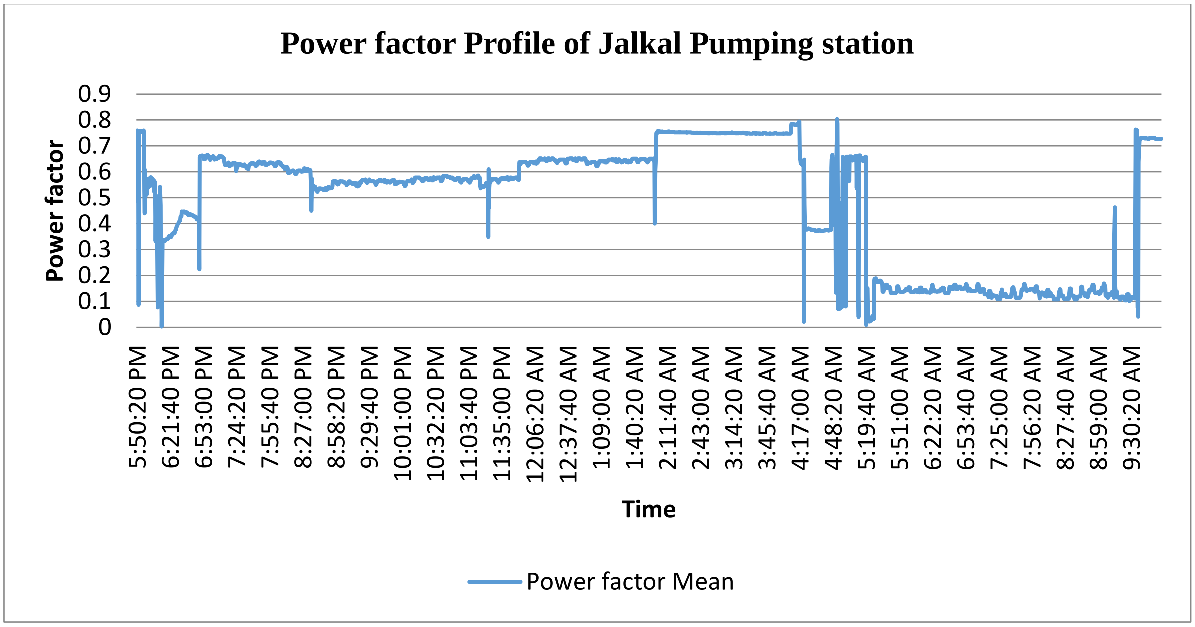


Figure 12 Power Factor variation on Transformer in Jalkal Pumping Station

- The average power factor 0.6 was measured on Main incomer of Transformer, while the maximum and minimum power factors were 0.75 and 0.55 respectively.

Frequency Profile:

During energy audit, frequency was recorded for 24 hours at the transformer secondary side at the main LT panel of the Transformer. Variation in frequency for the recorded 24 hour period is provided in figure 13.

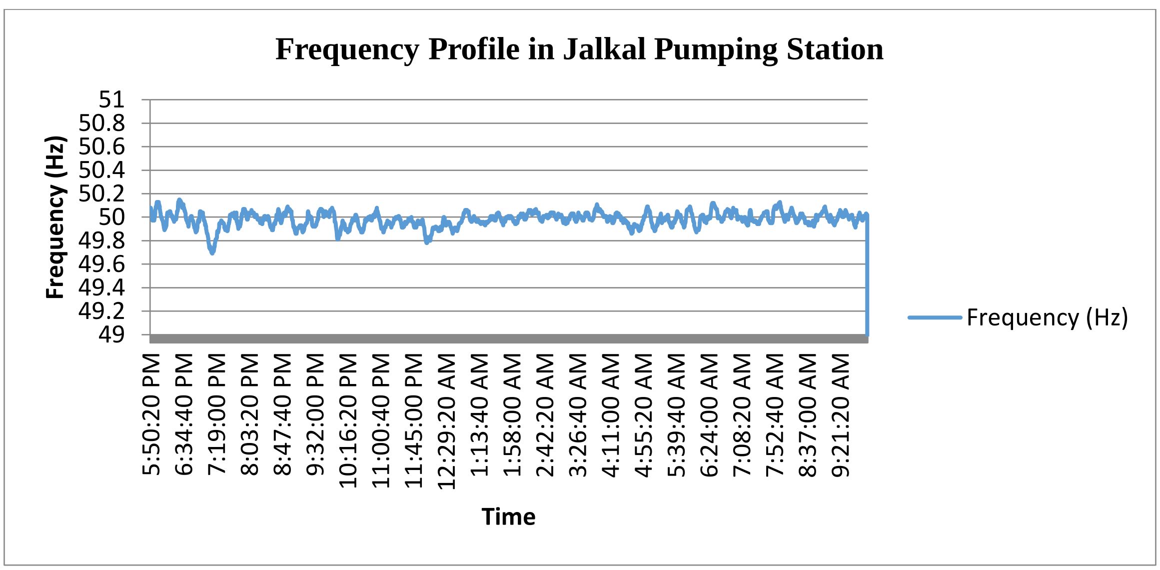


Figure 13 Variation of frequency at Jalkal pumping station

- The average frequency measured at LT incomer (Jalkal Pumping Station) was 50.0, while the maximum and minimum frequency wad 50.1 and 49.7 respectively.

Total Harmonics distortion:

During energy audit, THD was recorded for 24 hours at the transformer secondary side at the main LT panel of the Transformer. Variation in THD for the recorded 24 hour period is provided in figure 13

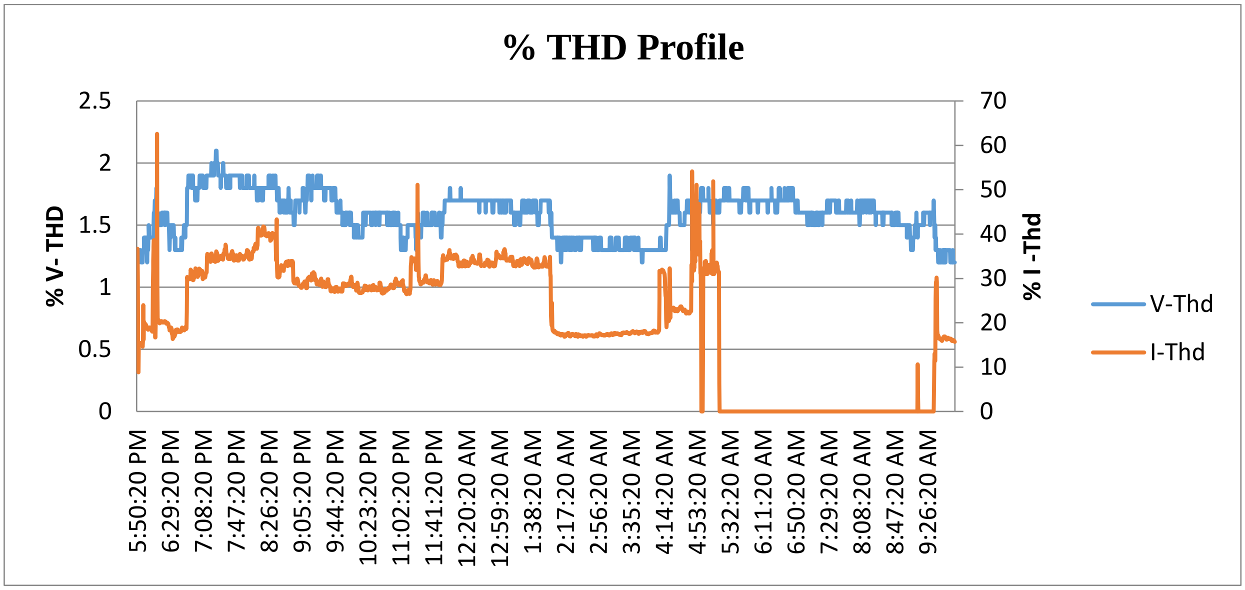


Figure 14 Variation of THD in Jalkal Pumping Station

- The average THD in voltage measured at Transformer LT side is 2.04%, while the maximum and minimum THDI were 2.5% and 1.3% respectively.
- The average THD in current measured at Transformer -1 LT side is 20 %, while the maximum and minimum THDI were 38 % and 3 % respectively.

Transformer loading:

Based on the 24 hour logging done during energy audit, average transformer loading was calculated and same is provided in table 20

Table 20 Transformer loading analysis at Jalkal Pumping Station

Parameters	Units	Jalkal Pumping Station Transformer
Rated Transformer capacity	kVA	250
Average power consumption	kW	70
Average power factor recorded	Pf	0.8 (lagging)
Average apparent power	kVA	90
Transformer loading	%	36
Tap Position		NA

- Based on the analysis of recorded parameters, maximum loading of the Transformer is found to be 36%, which is at optimum level.

4.3.6 Pumping Station System Mapping

Jalkal Pumping station has a Water Treatment Plant which filters the raw water collected from the raw water Pump House and Pumps clear water to the Over Head Tank. The detailed P&ID of the pumping system is provided in figure 15.

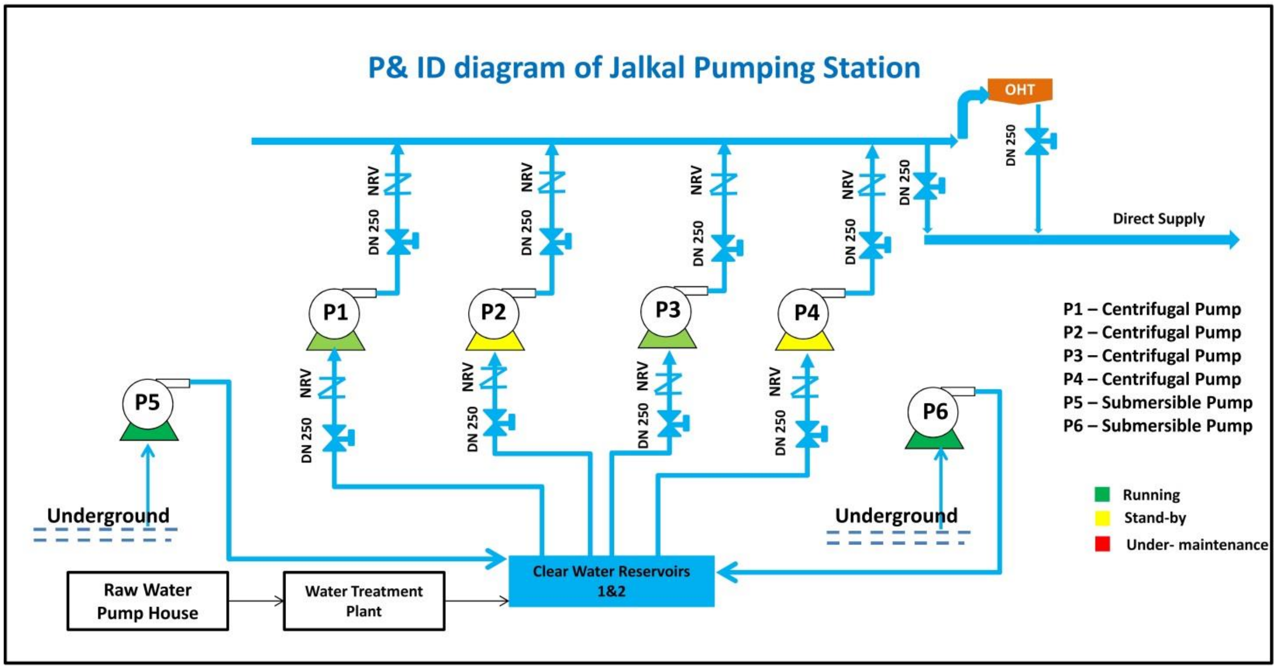


Figure 15 P&ID diagram for Jalkal Pumping Station

4.3.7 Pumps Performance Evaluation

As per the methodology described in LOA, the energy audit team has collected detailed information from the pumping stations. Site data collection activities included the following:

- Data collection
- System mapping including collection of inventories, name plate details
- Measurements of flow, head and power input to motor
- Interaction with the site personnel on the operating practices
- Verification of Job card by the authorized representative of ULB

Detailed energy audit at Jalkal Pumping Station was conducted on 4th April, 2017. The general details of the site are provided in table 21.

Table 21: General details of Jalkal Pumping Station

Data	Value / Details
Name of site	Jalkal Pumping Station
Name of Sub-section	Jalkal Pumping Station
Classification (WTP,BPS, SPS, STP)	WTP, Pumping station
Pumps installed	4
No. of pumps in operation	4
No. of pumps under maintenance	0
Other Details	
Basis of pump operation	Level of inlet reservoir tank for WTP
VFD Status	No

Out of four pumps at Jalkal Pumping Station, two pumps were under stand-by. The details of the operational and under maintenance pumps are provided in table 22.

Table 22: Operational pumps at Jalkal Pumping Station

Location	Name of station	Total no. of pumps	Total no. of pumps audit done	No. of pumps under Maintenance
Jaunpur	Jalkal Pump House	4	4	0
	Total	**4**	**4**	**0**

4.3.7.1 Pumps Efficiency Evaluation

Two Centrifugal Pumps of rated capacity 270 m3/hour each and Two Centrifugal Pumps of rated capacity 135 m3/hour each were installed at Jalkal Pumping station, Apart from this 2 No's of Submersible pumps were also installed. Out of which two centrifugal pumps were on standby mode. During energy audit, performance assessment was conducted for all the pumps.

Results of performance assessment of pumps are provided in table 23.

Table 23: Jalkal Pumping Station pumps efficiency calculations

Parameters Design Parameters	Unit	Jalkal Pump House			
		Pump -1	Pump -2	Pump-3	Pump -4
Make of the pump		Jyoti	Jyoti	Jyoti	Jyoti
Make of the motor		-	-	-	-
Pump type		End suction	End suction	End suction	End suction
Motor Serial number					
Pump Serial number					
Rated flow	m^3/hr.	270	135	270	135
Rated head	M	20	20	20	20
Motor rating	kW	45	22.5	45	22.5
Parameters Measured					
Total suction head	M	2	2	2	2
Total discharge head	M	21	21	21	21
Average flow delivered	m^3/hr.	361.6	154.1	244.8	143.2

Parameters Design Parameters	Unit	Jalkal Pump House			
		Pump -1	Pump -2	Pump-3	Pump -4
Motor input power	kW	51.48	22.04	37.85	20.07
Frequency	Hz	50	50	50	50
Speed	RPM	1440	1440	1440	1440
Performance Evaluation					
Total head developed	M	19	19	19	19
Head utilization	%	95	95	95	95
Flow utilization	%	134	114	90	106
Hydraulic power developed by pump	kW	18.72	7.98	12.67	7.42
Motor input power	kW	43.78	18.91	31.59	17.05
Calculated overall (Pump set) efficiency	%	36	36	33	37
Rated motor efficiency	%	85	85	85	85
Calculated Pump efficiency	%	40.63	40.47	37.42	41.28
Specific energy consumption	kW/m³	0.14	0.14	0.15	0.15

Key Observations:

- The actual efficiency of the pump sets for raw water pump House is found to be 40.63%, 40.47%, 37.42% & 41.28% respectively.

4.3.8 Auxiliaries In Pumping Stations

During the energy audit, auxiliary electrical load of pumping station were also studied and details of same is provided in table 24.

Table 24: Other electrical equipment at Jalkal Pumping Station

Parameters	Details
Transformers details	
Number of Transformers	One
Capacity (kVA)	250 kVA
Primary/Secondary voltages	11 kV/433 V
Instrumentation at site	
Suction pressure gauges	Available
Discharge pressure gauges	Available
Flow meter	Not available
Energy meter	For whole facility at incoming feeder (DISCOM meter only)

Table 25: Other electrical equipment at Jalkal Pumping Station

Others	Type of lamp	No. of fittings	Rating (kW)	Average Operating hours per day
Lighting	Tube light (T-12)	10	0.045	12
	Ceiling fan	8	0.06	12
	CFL	11	0.075	12
	Sodium vapor lamp	1	0.5	12

4.3.9 Total Energy Consumption Estimation For Pumps & Pumping Stations

The pumps are the major energy consumer of pumping station at Jalkal Pumping Station. During energy audit, measurements were conducted on individual pumps and operating hours of pumps were collected from the log books and from operators to estimate the annual energy consumption for the baseline estimation. Estimated energy consumption of Jalkal pumping station is provided in table

Table 26: Energy consumption for individual pump and pumping station for Jalkal Pumping Station

Name of the section	Name of the pump	Operating pattern	Annual operating hours (extrapolated)	Weighted average power consumption (kW)	Total power consumption Per year (kWh/year)
Jalkal Pumping Station (Centrifugal Pumps)	Pump-1 (60 HP)	4 pumps, 2W + 2 S S – Stand by	2190	51.48	112806.9
	Pump-2 (30 HP)		2190	22.04	48727.5
	Pump-3 (60 HP)		2190	37.85	81380.4
	Pump-4 (30 HP)		2190	20.07	43931.4
	Total			**131.44**	**287853.6**

4.4 Submersible Pumping Stations

4.4.1 Overview of Existing Systems

Submersible pumping stations comprises of a Bore wells which supplies water from underground to the nearby locations through Direct Supply or Over Head Tanks of Jaunpur. The source of electrical energy of Submersible pumping Stations is grid electricity from Purvanchal Vidyut Vitaran Nigam Limited (PUVVNL), Uttar Pradesh. The site layout diagram for Submersible pumping stations is provided in figure 16.

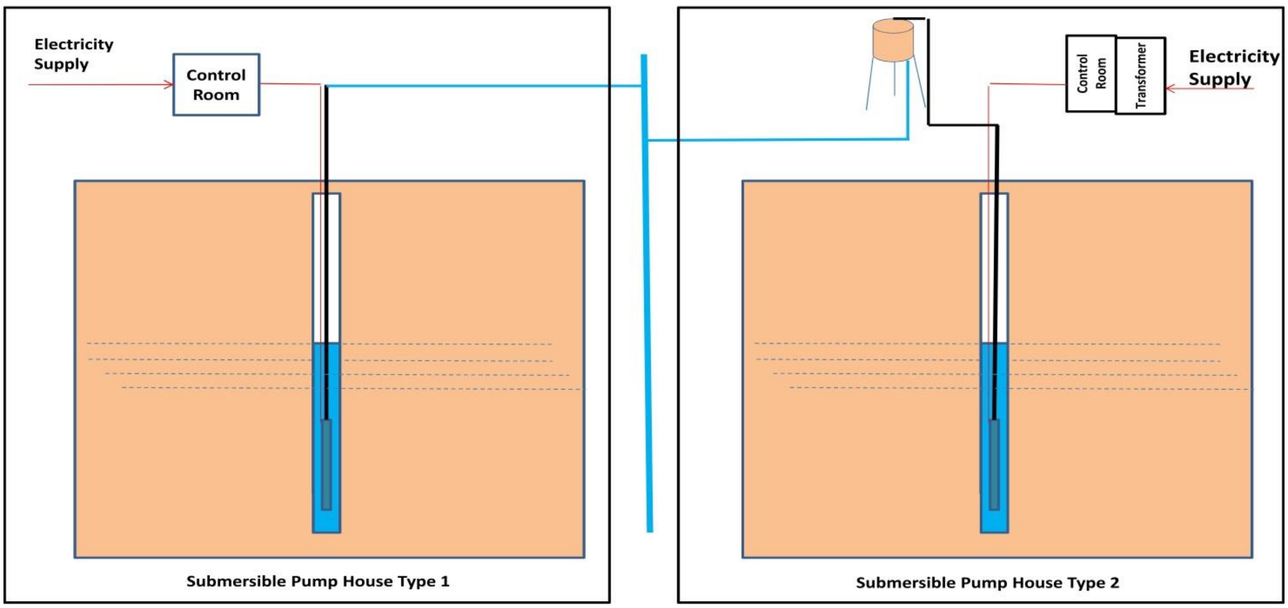


Figure 16 Site Layout Diagram of Submersible Pumping Station

4.4.2 Electricity supply

All Submersible Pumping Stations are getting electricity supply from PUVVNL from one 415 V Low Tension (LT) feeder. During Energy Audit, it is observed that Energy meters are not installed on some of the Pumping Stations. During energy audit, it was observed that transformer Name plate details are not found. The Single Line Diagram (SLD) of Submersible Pumping Stations is provided in figure 17.

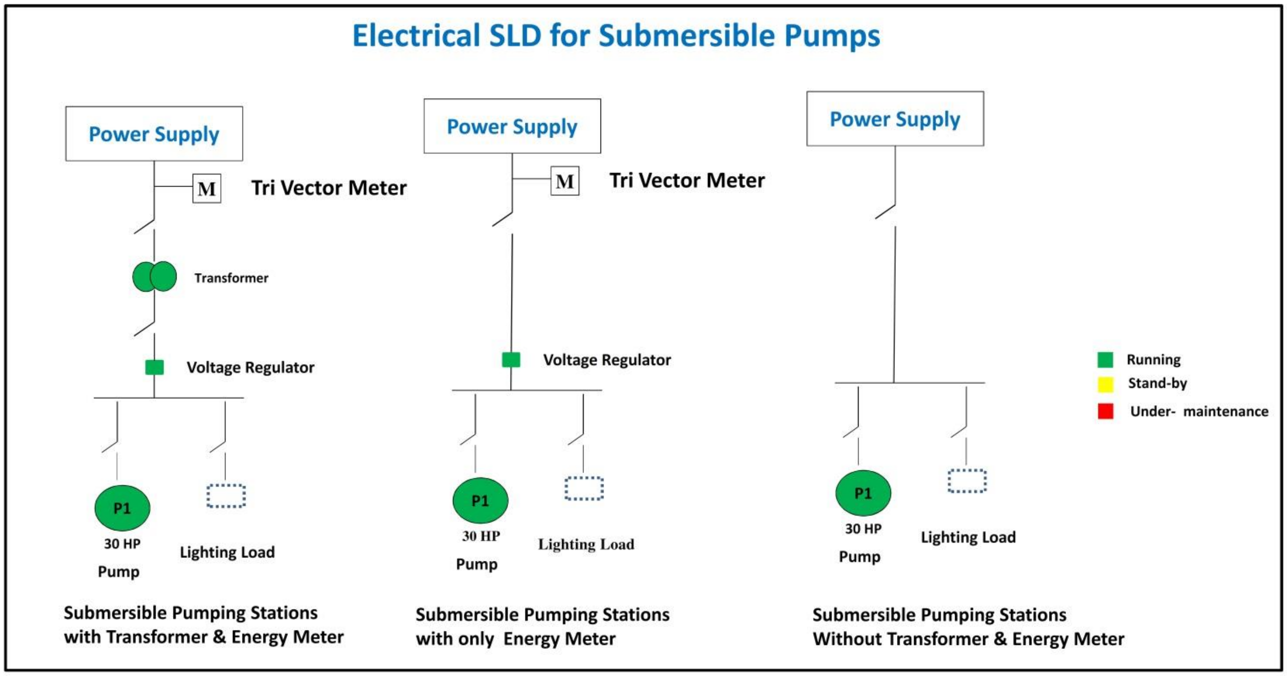


Figure 17 Electrical Single Line Diagram of Submersible Pumping Station

4.4.3 Tariff Structure

Submersible Pumping Stations are getting supply from one LT feeder and meters installed at plant premises. As per UP PUVVNL tariff order 2016, the tariff for Submersible Pumping Stations will fall under State Tube wells (load < 100 BHP) / State Tube wells (Unmetered). The details of Tariff structure for state tube wells are provided in the table 27.

Table 27: Tariff structure of Submersible Pumping Stations

Description	Submersible Pumping Stations	
	Energy Meter	Not Metered
Meter serial no.	-	-
Tariff category	State tube wells (load < 100 BHP)	State tube wells (Un metered)
Power supply	0.440 kV line	0.440 kV line
Contract Demand	-	-
Energy charges	Rs. 6.80 Per kVAh	-
Fixed/demand charge	Rs. 200 Per BHP/Month	Rs 1800 /BHP/Month
(Basis : UP PUVVNL Tariff Order for FY 2016-17)		

4.4.4 Electricity Bill Analysis

During energy audit, electricity bills of various submersible pumping stations for last 18 Months were collected from Nagar Palika Parishad, Jaunpur. Details of annual electricity consumption, annual electricity cost along with percentage increase over previous year is provided in table.

Table 28: Energy cost and energy consumption detail for Submersible Pumping Stations

Period of energy bill	Energy consumption (kWh/year)	Percentage Increase from previous year	Energy cost (Rs./year)
Jan-14 to Dec-14	-	-	-
Jan-15 to Dec-15	-	-	-
Jan-16 to Dec-16	-	-	-

Note: Details of month wise electricity bill is provided in Annexure - 4

Based on the Electricity Bills, The average PF recorded at Submersible Pumping Stations is estimated to be < 0.85 (lagging). As per Tariff Order, During FY 2014-15, there was a penalty for power factor below 0.85. As the billing is done on kWh basis, improving power factor to Unity (will reduce the electricity cost paid every month.

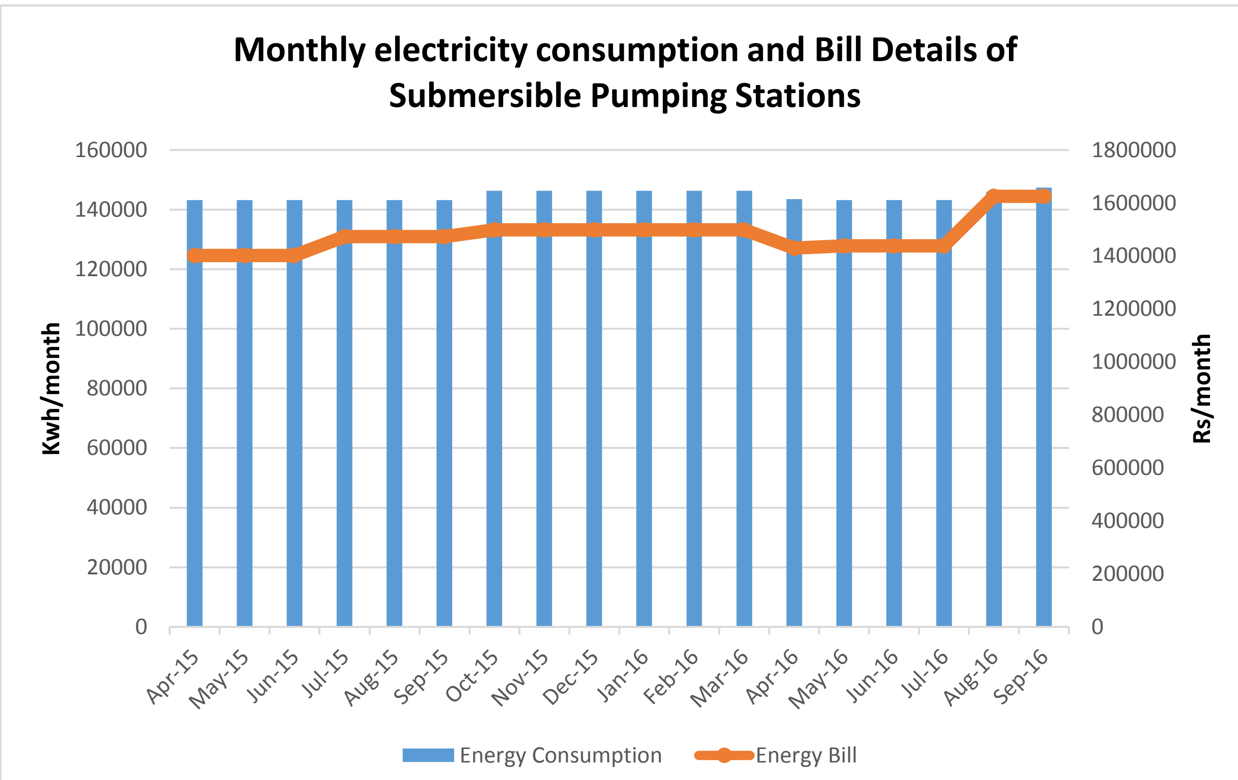


Figure 18 Monthly Energy Consumption and Bill of Submersible Pumping Station

4.4.5 Energy Consumption Pattern At Submersible Pumping Station

During energy audit, Month wise details of Electricity Bills are collected for Analyzing the Energy Consumption Pattern of the Submersible Pumping Stations. The Month wise bills are attached in the Annexure I. During Energy Audit, it is observed that Energy Meters are not installed at some of the

Submersible Pumping stations. Thereby, Energy Cost over a period is fixed as it is based on BHP Irrespective of Operating Hours. The Details of the transformers installed at submersible pumping stations are provided in table-29

Table 29: Details of Transformer at Submersible Pumping Stations

Main Incomers	Details of Transformer	Power Distribution
Misirpur	Transformer-1 (25 kVA, 11/0.433 kV, Working)	Misirpur
Bhagat singh Park	Transformer-1 (25 kVA, 11/0.433 kV, Working)	Bhagat singh Park
Hindi Bhawan	Transformer-1 (25 kVA, 11/0.433 kV, Working)	Hindi Bhawan
Sadar chungi	Transformer-1 (25 kVA, 11/0.433 kV, Working)	Sadar chungi
Jeeta patti	Transformer-1 (25 kVA, 11/0.433 kV, Working)	Jeeta patti
Polytechnic - 1	Transformer-1 (25 kVA, 11/0.433 kV, Working)	Polytechnic - 1
Muftimohalla	Transformer-1 (25 kVA, 11/0.433 kV, Working)	Muftimohalla
Tutipur	Transformer-1 (25 kVA, 11/0.433 kV, Working)	Tutipur
English Club	Transformer-1 (25 kVA, 11/0.433 kV, Working)	English Club

4.4.6 Pumping Station System Mapping

Water received from Underground through Borewell is pumped to the required OHT using dedicated pumping system. Water from OHT to end consumer was delivered by gravity. The details P&ID of the pumping system is provided in figure 19.

Submersible Pumping stations:

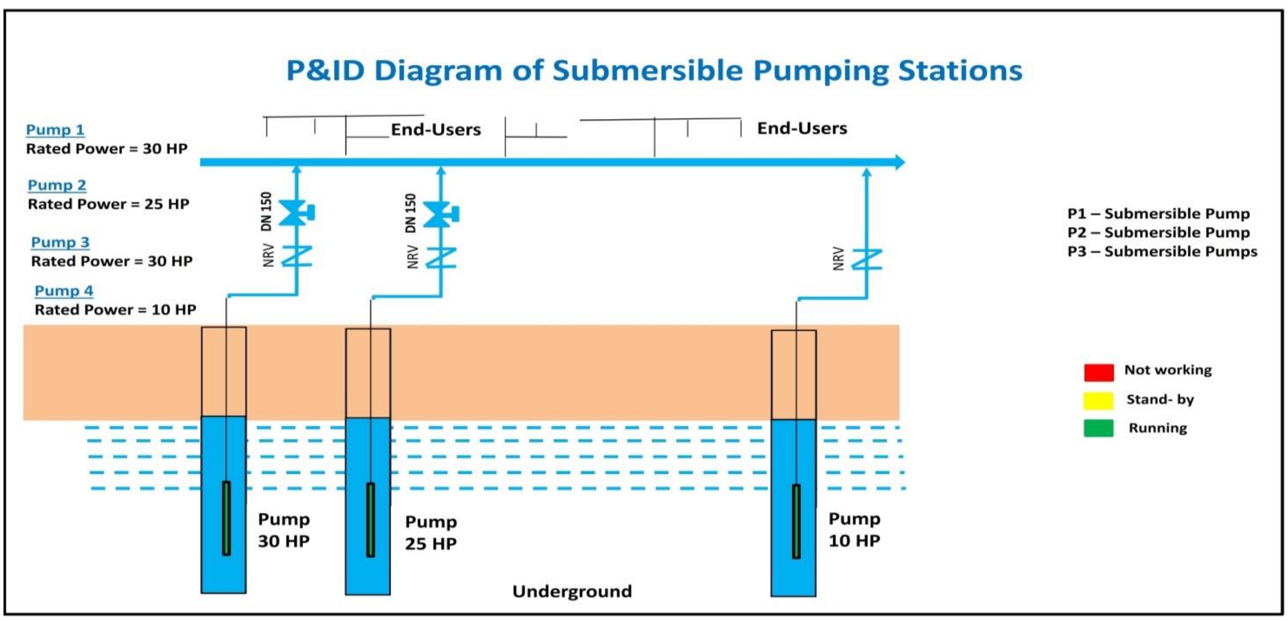


Figure 19 P&ID Diagram of Submersible Pumping Stations

4.4.7 Pumps Performance Evaluation

As per the methodology described in LOA, the team had collected detailed information from the pumping stations. Site data collection activities included the following:

- Data collection
- System mapping including collection of inventories, name plate details
- Measurements of flow, head and power input to motor
- Interaction with the site personnel on the operating practices
- Verification of Job card by the authorized representative of ULB

Detailed energy audit at Submersible Pumping stations was conducted from 4th to 13th April, 2017. The general details of the site are provided in the table 30.

Table 30: General details of Submersible Pumping Stations in Jaunpur City

Data	Value / Details
Name of site	Submersible Pumping Stations
Area covered for water distribution	Nearby locations mentioned as Name of Pump reference
Classification (WTP,BPS, SPS, STP)	Pumping Station
Delivery pipelines	
Water delivery location within the city	Nearby locations mentioned as Name of Pump reference
Pumps installed	53 (As per LOA)
No. of pumps in operation	44
No. of pumps under maintenance	9
Other Details	
Basis of pump operation	Level of Ground water level
VFD Status	Not installed

Photographs captured at the Submersible Pumping Stations to showcase the actual situation where measurements are not taken are provided in figure 20.

Naiganj Mini Tube well : Starter Problem	Naiganj Mini Tube well : Starter Problem
	

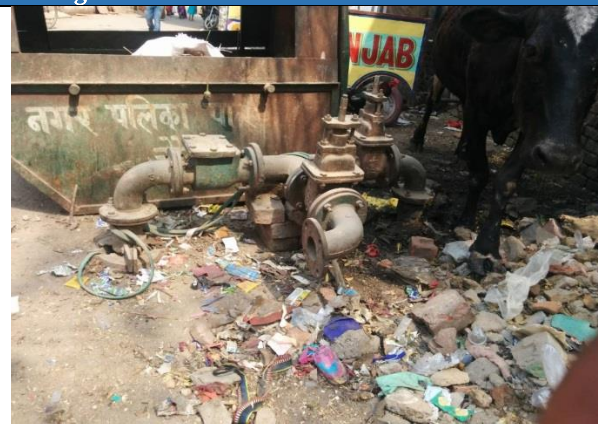
Chachakpur: No Provision for flow measurement	Abirgarh tola: No Provision for flow measurement
	
Bhandari: No Provision for flow measurement	Dhaigar Tola: No provision for flow measurement
	

Figure 20 Photographs Captured at Submersible Pumping Stations

Table 31: Operational pumps at Submersible Pumping Stations Pump House

Location	Name of station	Total no. of pumps	Total no. of pumps audit is done	No. of pumps under Maintenance	Remarks
Jaunpur	30 HP Submersible Pumps	13	11	2	Unavailability of measuring points
	25 HP Submersible Pumps	13	13	0	
	20 HP Submersible Pumps	1	1	0	
	15 Submersible Pumps	2	2	0	
	10 HP Submersible Pumps	24	17	7	Unavailability of measuring points
Total		**53**	**44**	**9**	

4.4.7.1 Submersible Pumping Stations

Submersible Pumping Stations of Capacities 30 HP, 25 HP, 15 HP, and 10 HP were installed at various Places in Jaunpur city. During energy audit, performance assessment was conducted on for all the Pumps. Results of performance assessment of pumps are provided in table 32.

Table 32: Performance Evaluation of pumps at Submersible Pumping stations- Part 1 (continued)

Parameters Design Parameters	Unit	Submersible Pumping Stations-1					
		Misirpur	Sarailatta	Bhagat Singh Park	Hindi Bhawan	Khasanpur	Pachiatia
Make of the pump		-	-	-	-	-	-
Make of the motor		-	-	-	-	-	-
Pump type		Submersible	Submersible	Submersible	Submersible	Submersible	Submersible
Rated flow	m^3/hr	72	42	78	72	78	90
Rated head	M	-	-	-	-	-	-
Motor rating	kW	11.25	22.5	18.75	22.5	22.5	18.75
Parameters Measured							
Total suction head	M	8	5	10	6	4	8
Total discharge head	M	32	35	27	25	37	32
Average flow delivered	m^3/hr.	126	26	87	119	63	118
Motor input power	kW	21.67	20.1	20.22	24.72	18.62	26.72
Frequency	Hz	50	50	50	50	50	50
Speed	RPM	-	-	-	-	-	-
Performance Evaluation							
Total head developed	M	24	30	17	19	33	24
Head utilization	%	-	-	-	-	-	-
Flow utilization	%	175%	62%	112%	165%	81%	131%
Hydraulic power developed by pump	kW	8.23	2.12	4.03	6.15	5.66	7.71
Motor input power	kW	21.67	20.1	20.22	24.72	18.62	26.72
Calculated overall (Pump set) efficiency	%	38%	11%	21%	26%	31%	29%
Rated motor efficiency	%	85%	85%	85%	85%	85%	85%
Calculated Pump efficiency	%	44.19%	12.81%	24.53%	30.31%	36.34%	34.70%
Specific energy consumption	kWh/ MLD	172.3	761.36	231.35	208.14	295.24	227.21

Table 33 Performance Evaluation of pumps at Submersible Pumping stations-Part 2 (Continued)

Parameters Design Parameters	Unit	Submersible Pumping Stations-2					
		Sipah	Sagar Chungi	Purani Bazar	Jeeta Patti	Naigang No.1	Naigang No.2
Make of the pump		-	-	-	-	-	-
Make of the motor		-	-	-	-	-	-
Pump type		Submersib le	Submersibl e	Submersi ble	Submersi ble	Submersi ble	Submersi ble
Rated flow	m^3/hr	72	72	78	78	60	60
Rated head	M	-	-	-	-	-	-
Motor rating	kW	18.75	22.5	22.5	18.75	18.75	18.75
Parameters Measured							
Total suction head	M	6	7	4	8	8	7
Total discharge head	M	27	33	23	31	33	31
Average flow delivered	m^3/hr.	120	106	106	109	126	133
Motor input power	kW	26.63	26.29	21.99	25.48	23.49	31.9
Frequency	Hz	50	50	50	50	50	50
Speed	RPM	-	-	-	-	-	-
Performance Evaluation							
Total head developed	M	21	26	19	23	25	24
Head utilization	%	-	-	-	-	-	-
Flow utilization	%	167%	147%	136%	140%	210%	222%
Hydraulic power developed by pump	kW	6.86	7.50	5.48	6.82	8.58	8.69
Motor input power	kW	26.63	26.29	21.99	25.48	23.49	31.9
Calculated overall (Pump set) efficiency	**%**	27%	29%	26%	27%	38%	28%
Rated motor efficiency	%	85%	85%	85%	85%	85%	85%
Calculated Pump efficiency	%	31.82%	34.61%	30.30%	32.11%	44.27%	33.15%
Specific energy consumption	kWh/ MLD	221.06	249.04	207.98	233.26	186.69	240.42

Table 34 Performance Evaluation of pumps at Submersible Pumping stations- Part 3 (Continued)

Parameters Design Parameters	Unit	Submersible Pumping Stations-3					
		Line Bazar	SP Bungalow	Polytechnic 1	Jalkal Main Gate	Mufti Mohalla	Chand Mari
Make of the pump		-	-	-	-	-	-
Make of the motor		-	-	-	-	-	-
Pump type		Submersible	Submersible	Submersible	Submersible	Submersible	Submersible
Rated flow	m^3/hr	72	60	72	90	90	90
Rated head	M	-	-	-	-	-	-
Motor rating	kW	18.75	18.75	18.75	18.75	18.75	18.75
Parameters Measured							
Total suction head	M	6	7	6	8	5	3
Total discharge head	M	29	26	27	34	30	15
Average flow delivered	$m^3/hr.$	117	122	119	84	105	19
Motor input power	kW	22.59	22.63	22.24	22.83	21.51	9.27
Frequency	Hz	50	50	50	50	50	50
Speed	RPM	-	-	-	-	-	-
Performance Evaluation							
Total head developed	M	23	19	21	26	25	12
Head utilization	%	-	-	-	-	-	-
Flow utilization	%	163%	203%	165%	93%	117%	21%
Hydraulic power developed by pump	kW	7.33	6.31	6.80	5.95	7.15	0.62
Motor input power	kW	22.59	22.63	22.24	22.83	21.51	9.27
Calculated overall (Pump set) efficiency	**%**	33%	28%	32%	26%	34%	7%
Rated motor efficiency	%	85%	85%	85%	85%	85%	85%
Calculated Pump efficiency	%	38.67%	33.16%	37.52%	31.04%	40.51%	7.82%
Specific energy consumption	kWh/ MLD	193.81	185.4	186.19	272.15	204.41	500.36

Table 35 Performance Evaluation of pumps at Submersible Pumping stations- Part 4 (Continued)

Parameters Design Parameters	Unit	Submersible Pumping Stations-4					
		Tutipur	Jalkal Campus near JE Residence	Bhosa Gudam	Ruhutta	DM Residen ce	English Club
Make of the pump		-	-	-	-	-	-
Make of the motor		-	-	-	-	-	-
Pump type		Submersib le	Submersibl e	Submersi ble	Submersi ble	Submersi ble	Submersi ble
Rated flow	m^3/hr	90	90	78	72	78	78
Rated head	M	-	-	-	-	-	-
Motor rating	kW	18.75	22.5	18.75	18.75	18.75	18.75
Parameters Measured							
Total suction head	M	7	8	12	7	6	7
Total discharge head	M	32	45	42	48	28	33
Average flow delivered	m^3/hr.	104	108	90	75	138	6
Motor input power	kW	25.82	24.88	19.04	21.81	19.86	4.96
Frequency	Hz	50	50	50	50	50	50
Speed	RPM	-	-	-	-	-	-
Performance Evaluation							
Total head developed	M	25	37	30	41	22	26
Head utilization	%	-	-	-	-	-	-
Flow utilization	%	116%	120%	115%	104%	177%	8%
Hydraulic power developed by pump	kW	7.08	10.88	7.35	8.37	8.26	0.42
Motor input power	kW	25.82	24.88	19.04	21.81	19.86	4.96
Calculated overall (Pump set) efficiency	**%**	28%	44%	39%	38%	43%	9%
Rated motor efficiency	%	85%	85%	85%	85%	85%	85%
Calculated Pump efficiency	%	33.35%	52.29%	46.07%	45.21%	50.42%	10.68%
Specific energy consumption	kWh/ MLD	247.25	229.56	211.02	292.28	144.22	771.38

Table 36 Performance Evaluation of pumps at Submersible Pumping stations- Part 5 (Continued)

Parameters Design Parameters	Unit	Submersible Pumping Stations-5					
		Kharka Colony	Naigang No.3	Polytechnic 2	Khasanpur	Bhaurajipur	Chitasari
Make of the pump		-	-	-	-	-	-
Make of the motor		-	-	-	-	-	-
Pump type		Submersible	Submersible	Submersible	Submersible	Submersible	Submersible
Rated flow	m^3/hr	60	78	78	30	30	30
Rated head	M	-	-	-	-	-	-
Motor rating	kW	22.5	22.5	22.5	7.5	7.5	7.5
Parameters Measured							
Total suction head	M	6	8	6	6	7	5
Total discharge head	M	30	34	43	29	26	32
Average flow delivered	m^3/hr.	90	103	103	43	51	7
Motor input power	kW	21.43	22.08	17.34	5.93	6.16	4.65
Frequency	Hz	50	50	50	50	50	50
Speed	RPM	-	-	-	-	-	-
Performance Evaluation							
Total head developed	M	24	26	37	23	19	27
Head utilization	%	-	-	-	-	-	-
Flow utilization	%	150%	132%	132%	143%	170%	23%
Hydraulic power developed by pump	kW	5.88	7.29	10.37	2.69	2.64	0.51
Motor input power	kW	21.43	22.08	17.34	5.93	6.16	4.65
Calculated overall (Pump set) efficiency	**%**	29%	34%	45%	46%	44%	11%
Rated motor efficiency	%	85%	85%	85%	85%	85%	85%
Calculated Pump efficiency	%	33.65%	39.66%	52.63%	54.42%	52.15%	13.24%
Specific energy consumption	kWh/ MLD	238.11	213.4	167.55	138.1	120.1	663.02

Table 37 Performance Evaluation of pumps at Submersible Pumping stations- Part 6 (Continued)

Parameters Design Parameters	Unit	Submersible Pumping Stations-6						
		Makhadum Shah	Achala Devi Ghat	Sipah	Matapur	Sakarmandi	Chakpyarali	Jogiyapur
Make of the pump		-	-	-	-	-	-	-
Make of the motor		-	-	-	-	-	-	-
Pump type		Submersible	Submersible	Submersible	Submersible	Submersible	Submersible	Submersible
Rated flow	m^3/hr	30	30	30	30	30	30	30
Rated head	M	-	-	-	-	-	-	-
Motor rating	kW	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Parameters Measured								
Total suction head	M	5	6	8	4	6	6	6
Total discharge head	M	24	29	28	33	35	24	31
Average flow delivered	$m^3/hr.$	25	28	33	9	11	36	27
Motor input power	kW	3.94	6.7	6.91	6.14	4.35	4.16	5.61
Frequency	Hz	50	50	50	50	50	50	50
Speed	RPM	-	-	-	-	-	-	-
Performance Evaluation								
Total head developed	M	19	23	20	29	29	18	25
Head utilization	%	-	-	-	-	-	-	-
Flow utilization	%	83%	93%	110%	30%	37%	120%	90%
Hydraulic power developed by pump	kW	1.29	1.75	1.80	0.71	0.87	1.76	1.84
Motor input power	kW	3.94	6.7	6.91	6.14	4.35	4.16	5.61
Calculated overall (Pump set) efficiency	**%**	34%	27%	26%	12%	20%	43%	33%
Rated motor efficiency	%	85%	85%	85%	85%	85%	85%	85%
Calculated Pump efficiency	%	40.06%	31.87%	30.89%	14.31%	23.16%	51.05%	39.22%
Specific energy consumption	kWh/ MLD	156.78	238.94	206.33	663.07	412.32	115.95	208.63

Table 38 Performance Evaluation of pumps at Submersible Pumping stations-Part 7

Parameters Design Parameters	Unit	Submersible Pumping Stations-7						
		Miyanpur	Rasulabad	Raj Colony	Raja Sahab Pokra	Bodkarpur	Premrejpur	Ballochtola
Make of the pump		-	-	-	-	-	-	-
Make of the motor		-	-	-	-	-	-	-
Pump type		Submersible	Submersible	Submersible	Submersible	Submersible	Submersible	Submersible
Rated flow	m^3/hr	30	30	30	30	30	30	30
Rated head	M	-	-	-	-	-	-	-
Motor rating	kW	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Parameters Measured								
Total suction head	M	7	5	8	8	8	7	6
Total discharge head	M	27	33	22	25	29	23	30
Average flow delivered	$m^3/hr.$	42	23	33	32	28	45	34
Motor input power	kW	4.74	6.47	4.49	3.84	5.2	4.22	10.19
Frequency	Hz	50	50	50	50	50	50	50
Speed	RPM	-	-	-	-	-	-	-
Performance Evaluation								
Total head developed	M	20	28	14	17	21	16	24
Head utilization	%	-	-	-	-	-	-	-
Flow utilization	%	140%	77%	110%	107%	93%	150%	113%
Hydraulic power developed by pump	kW	2.29	1.75	1.26	1.48	1.60	1.96	2.22
Motor input power	kW	4.74	6.47	4.49	3.84	5.2	4.22	10.19
Calculated overall (Pump set) efficiency	**%**	48%	27%	29%	39%	32%	50%	23%
Rated motor efficiency	%	85%	85%	85%	85%	85%	85%	85%
Calculated Pump efficiency	%	56.78%	32.13%	34.63%	45.92%	38.19%	58.71%	26.54%
Specific energy consumption	kWh/ MLD	114.15	287	136.34	121.8	183.18	92.86	296.97

4.4.8 Auxiliaries In Pumping Stations

During the energy audit, auxiliary electrical load of pumping station were also studied and details of same is provided in table.

Table 39: Other electrical equipment at Submersible Pumping Stations

Parameters	Details
Transformers details	
Number of Transformers	9
Capacity (kVA)	25 kVA (Running)
Primary/Secondary voltages	11 kV/433 V
Instrumentation at site	
Suction pressure gauges	Not Available
Discharge pressure gauges	Not Available
Flow meter	Not available
Energy meter	For whole facility at incoming feeder (DISCOM meter only)

Note: During Energy Audit, it is observed that energy meters are not installed for some of the submersible pumps and Electricity Billing is done based on BHP irrespective of the Operating Hours of the pump.

Table 40: Other electrical equipment at Submersible Pumping Station (30 HP & 25 HP) - Lighting

Type of Load	Type of lamp	No. of fittings	Rating (kW)	Average Operating hours per day
Lighting	FTL (T-12)	1	0.045	12
	Sodium Vapour lamp	1	0.25	12

Table 41 Other electrical equipment at Submersible Pumping Station (10 HP & 15 HP) - Lighting

Type of Load	Type of lamp	No. of fittings	Rating (kW)	Average Operating hours per day
Lighting	FTL (T-12)	1	0.045	12
	Sodium Vapour lamp	-	0.25	12

Note: During Energy Audit, It is Observed that the Auxiliary Lighting Load for all submersible pumping stations of capacity 30 HP & 25 HP is same at all places and similarly for 15 HP & 10 HP Submersible Pumping Stations.

4.4.9 Total Energy Consumption Estimation For Pump sets in Submersible Pumping Stations

During energy audit, measurements were conducted on individual pumps and operating hours of pumps were also collected from the available log books and from operators for estimating annual energy consumption. Estimated energy consumption for Submersible Pumping station is provided in table 42.

Table 42: Estimated energy consumption for Submersible Pumping Stations

Name of section	Name of the pump	Operating pattern	Annual operating hours (hours/Annum)	Weighted average power consumption (kW)	Total power consumption per year (kWh/Annum)
Submersible Pumping Stations	Misirpur	Working	3650	21.67	79095.5
	Sarailatta	Working	3650	20.10	73365
	Bhagat Singh Park	Working	3650	20.22	73803
	Hindi Bhawan	Working	3650	24.72	90228
	Khasanpur	Working	3650	18.62	67963
	Pachiatia	Working	3650	26.72	97528
	Sipah	Working	3650	26.63	97199.5
	Sagar Chungi	Working	5840	26.29	153533.6
	Purani Bazar	Working	3650	21.99	80263.5
	Jeeta Patti	Working	3650	25.48	93002
	Naigang No.1	Working	3650	23.49	85738.5
	Naigang No.2	Working	3650	31.90	116435
	Line Bazar	Working	3650	22.59	82453.5
	SP Bungalow	Working	3650	22.63	82599.5
	Polytechnic 1	Working	7300	22.24	162352
	Jalkal Main Gate	Working	3650	22.83	83329.5
	Mufti Mohalla	Working	3650	21.51	78511.5
	Chand Mari	Working	3650	9.27	33835.5
	Tutipur	Working	5840	25.82	150788.8
	Jalkal Campus near JE Residence	Working	7300	24.88	181624
	Bhosa Gudam	Working	7300	19.04	138992
	Ruhutta	Working	5840	21.81	127370.4
	DM Residence	Working	3650	19.86	72489
	English Club	Working	7300	4.96	36208
	Kharka Colony	Working	7300	21.43	156439
	Naigang No.3	Working	7300	22.08	161184
	Polytechnic 2	Working	3650	17.34	63291
	Khasanpur	Working	3650	5.93	21644.5
	Bhaurajipur	Working	3650	6.16	22484
	Chitarsari	Working	3650	4.65	16972.5
	Makhadum Shah	Working	3650	3.94	14381
Submersible Pumping Stations	Achala Devi Ghat	Working	3650	6.70	24455
	Sipah	Working	3650	6.91	25221.5
	Matapur	Working	3650	6.14	22411
	Sakarmandi	Working	3650	4.35	15877.5
	Chakpyarali	Working	3650	4.16	15184
	Jogiyapur	Working	3650	5.61	20476.5

	Miyanpur	Working	3650	4.74	17301
	Rasulabad	Working	3650	6.47	23615.5
	Raj Colony	Working	3650	4.49	16388.5
	Raja Sahab Pokra	Working	3650	3.84	14016
	Bodkarpur	Working	3650	5.20	18980
	Premrejpur	Working	3650	4.22	15403
	Ballochtola	Working	3650	10.19	37193.5
	Total (A)			**679.82**	**3061627.3**

5 Baseline Assessment

Estimation of baseline is the key element in design and development of any energy efficiency project. It play an important role in determining the savings associated with the implementation of energy efficiency measure (EEM) and determining the techno-financial feasibility of the EEM. In case of Municipal Energy Efficiency Programme (MEEP), the baseline is affected by many parameters including the changes in the system due to addition of command area, seasonal variations, increase in population which affect the required flow (Q) and the head (H).

Measurement and Verification (M&V) is the term given to the process for quantifying savings delivered by an Energy Efficiency Measure (EEM). It includes energy saving verification process involving measurements and reporting methodology. M & V methodology followed in this project includes following measurement schedule

a. Measurement of parameters pre EEM implementation (just before installation of EEPS) for all operating combinations using portable instruments

b. Measurement of parameters post EEM implementation for all operating combinations using portable instruments.

Energy savings are calculated as the difference in power drawn (in pre and post implementation scenario) multiplied by the operating hours mentioned in this report.

Baseline of this project will be estimated based on pre EEM implementation measurements, conducted just before installation of new EEPS at pumping station

5.1 Definition of possible and operating combinations

In ULBs, especially in case of pumping stations, where the pumps are connected in parallel, the pump operated in various combinations. For the purpose of this document, these combinations are defined as possible combinations. For example, for if 3 pumps are connected in parallel, there are 7 possible combinations considering three different pumps i.e.

Pump 1	Pump 1+ Pump 2	
Pump 2	Pump 2+ Pump 3	Pump 1+Pump 2+Pump 3
Pump 3	Pump 3 +Pump 1	

However, the ULB might be operating the pumps only in three combination, depending on the flow requirement, from the one discussed above. For the purpose of this document, these combinations are defined as operating combinations.

Operating Combination 1	Operating Combination 2	Operating Combination 3
Pump 1	Pump 1+ Pump 2	Pump 1+Pump 2+Pump 3

5.2 Key measurements for determining baseline or pre implementation level

To determine baseline, the following parameters would be measured during pre-implementation period (just before installation of new energy efficient pumps) for each operating combination.

i. Power Consumption, voltage, frequency (kW, Volt, hz)

Data Unit	kW, Volt, hz
Description	Voltage, frequency and power consumption of all operating combinations at site (pre and post implementation)
Source of Data	On site measurement using calibrated portable instrument (power analyzer)
Description of measurement methods and procedures to be applied	Instantaneous onsite measurement using portable power analyzer
QA/QC procedures to be applied	Calibrated instrument from a NABL accredited laboratory

ii. Flow rate (m3/hr)

Data Unit	m^3/hr.
Description	Flow rate delivered for all operating combinations at site (pre and post implementation)
Source of Data	On site measurement using calibrated portable instruments (flow meter)
Description of measurement methods and procedures to be applied	Instantaneous onsite measurement using portable flow meter
QA/QC procedures to be applied	Calibrated instrument from a NABL accredited laboratory

iii. Head (m)

Data Unit	meters (m)
Description	Average head delivered for all operating combinations at site (pre and post implementation)
Source of Data	On site measurement using calibrated instruments
Description of measurement methods and procedures to be applied	Instantaneous onsite measurement using pressure gauge installed at both the suction and discharge side of the pump
QA/QC procedures to be applied	Calibrated instrument from a NABL accredited laboratory

5.3 Baseline

The baselines energy consumption measurement for existing water pumping station will be established using pre implementation (just before installation of new pumps) measurements on existing pumps. Most of the electric parameters would be measured instantaneously using portable instruments, while operating hours would be provided by this report.

The baseline would be:

$$Baseline\ Energy\ Consumption\ of\ a\ pump\ (kWh) = kW1 \times hours\ of\ operation1 + kW2 \times hours\ of\ operation2 + \cdots.$$

Where, 1, 2…. represent operating combination of pump

$$Baseline\ Energy\ Consumption\ of\ a\ ULB\ (kWh) = Baseline\ of\ pump1 + Baseline\ of\ pump2 + \cdots.$$

Where 1, 2 … represent baseline energy consumption of pumps of ULB

Baseline of this project will be estimated based on pre-implementation measurements, conducted just before installation of new EEPS at pumping station. Table 43, provides estimated present energy consumption of pumps operating at Jalkal Pumping Station, submersible Pumping Stations (in different operating combination) based on data provided in this report and table 44 provides estimated present aggregate energy consumption of Jaunpur city.

Table 43: Estimated present energy consumption for Pumping Stations in Jaunpur at different operating combinations

Individual operation:

Name of pumping station	Pump Reference	Power consumption (kW)	Flow rate (m³/hr.)	Frequency (Hz)	Head (m)	Voltage (V)	Hours baseline (hours)	Baseline Energy Consumption (kWh)
Jalkal Pumping Station	Pump-1	51.48	362	50	19	408	2190	112741.2
	Pump-2	22.04	154	50	19	407	2190	48267.6
	Pump-3	37.85	245	50	19	405	2190	82891.5
	Pump-4	20.07	143	50	19	405	2190	43953.3
Submersible Pumping Station	Bhagat Singh Park	20.22	87	50	17	400	3650	73803
	Hindi Bhawan	24.72	119	50	19	429	3650	90228
	Khasanpur	18.62	63	50	33	436	3650	67963
	Pachiatia	26.72	118	50	24	402	3650	97528
	Sipah	26.63	120	50	21	418	3650	97199.5
	Sagar Chungi	26.29	106	50	26	444	5840	153533.6
	Purani Bazar	21.99	106	50	19	398	3650	80263.5
	Jeeta Patti	25.48	109	50	23	410	3650	93002
	Naigang No.2	31.90	133	50	24	439	3650	116435
	SP Bungalow	22.63	122	50	19	404	3650	82599.5
	Polytechnic 1	22.24	119	50	21	405	7300	162352
	Jalkal Main Gate	22.83	84	50	26	407	3650	83329.5
	Mufti Mohalla	21.51	105	50	25	405	3650	78511.5
	Tutipur	25.82	104	50	25	394	5840	150788.8

	Kharka Colony	21.43	90	50	24	395	7300	156439
Submersible Pumping Station	Chitarsari	4.65	7	50	27	388	3650	16972.5
	Makhadum Shah	3.94	25	50	19	390	3650	14381
	Achala Devi Ghat	6.7	28	50	23	409	3650	24455
	Sipah	6.91	33	50	20	412	3650	25221.5
	Matapur	6.14	9	50	29	410	3650	22411
	Sakarmandi	4.35	11	50	29	425	3650	15877.5
	Rasulabad	6.47	23	50	28	409	3650	23615.5
	Raj Colony	4.49	33	50	14	391	3650	16388.5
	Bodkarpur	5.2	28	50	21	377	3650	18980
	Ballochtola	10.19	34	50	24	408	3650	37193.5
Total		**549.510**					**111,690**	**2087326**

6 Energy Efficiency Measures

6.1 Summary of Energy Efficiency Measures

A summary of the proposed energy efficiency measures at Jalkal Pumping station and submersible Pumping Stations are provided in table 44.

Table 44: Summary of energy efficiency measures for pumping stations in Jaunpur City

Sl. No	Energy Efficiency Measures (EEM)	Present annual energy consumption (kWh/ year)	Annual Energy Savings (kWh/ Annum)	Investment Cost (Rs. Lakhs)	Monetary Energy Cost Saving (Rs. Lakhs)	Payback Period (Months)	Percentage of energy saving (%)
	Pumping system						
	Jalkal Pumping Station						
1	Replacement of existing Pump 1 with energy efficient Pump	112741.2	65899	2.41	5.24	6	58
2	Replacement of existing Pump 3 with energy efficient Pump	48267.6	15607	1.72	1.24	17	32
3	Replacement of existing Pump 2 with energy efficient Pump	82891.5	36039	2.41	2.87	10	43
4	Replacement of existing Pump 4 with energy efficient Pump	43953.3	11308	1.72	0.9	23	26
	Sub – Total (A)	**287853.6**	**128853**	**8.24**	**10.24**	**10**	**45**
	Submersible Pumping Stations						
5	Replacement of existing pump at Bhagat Singh Park with energy efficient pump	73803	31944	4.17	2.17	23	43
6	Replacement of existing pump at Hindi Bhawan with energy efficient pump	90228	38873	4.23	2.64	19	43
7	Replacement of existing pump at Khasanpur tube well with energy efficient pump	67963	28272	4	1.92	25	42
8	Replacement of existing pump at Pachiatia Singh Park with energy efficient pump	97528	42299	4.39	2.88	18	43
9	Replacement of existing pump at Sipah with	97199.5	45888	4.23	3.12	16	47

Sl. No	Energy Efficiency Measures (EEM)	Present annual energy consumption (kWh/ year)	Annual Energy Savings (kWh/ Annum)	Investment Cost (Rs. Lakhs)	Monetary Energy Cost Saving (Rs. Lakhs)	Payback Period (Months)	Percentage of energy saving (%)
	energy efficient pump						
10	Replacement of existing pump at Sagar Chungi with energy efficient pump	153533.6	65161	4.39	4.43	12	42
11	Replacement of existing pump at Purani Bazar with energy efficient pump	80263.5	42903	3.87	2.92	16	53
12	Replacement of existing pump at Jeeta Patti with energy efficient pump	93002	45253	4.23	3.08	16	49
13	Replacement of existing pump at Naigang No.2 with energy efficient pump	116435	61251	4.39	4.17	13	53
14	Replacement of existing pump at SP Bungalow with energy efficient pump	82599.5	40740	4.17	2.77	18	49
15	Replacement of existing pump at Polytechnic 1 with energy efficient pump	162352	82247	4.17	5.99	9	51
16	Replacement of existing pump at Jalkal Main Gate with energy efficient pump	83329.5	28094	4.39	1.91	28	34
17	Replacement of existing pump at Mufti Mohalla with energy efficient pump	78511.5	23294	4.39	1.58	33	30
18	Replacement of existing pump at Tutipur with energy efficient pump	150788.8	75244	4.24	5.12	10	50
19	Replacement of existing pump at Kharka Colony with energy efficient pump	156439	63233	4.23	4.3	12	40
20	Replacement of existing pump at Chitarsari with energy efficient pump	16972.5	9406	0.78	0.64	15	55
21	Replacement of existing pump at Makhadum Shah with energy efficient pump	14381	5993	0.9	0.04	27	41
22	Replacement of existing pump at Achala Devi Ghat with energy efficient pump	24455	9556	0.95	0.65	18	39
23	Replacement of existing pump at Sipah with energy efficient pump	25221.5	4834	1	0.33	36	19
24	Replacement of existing pump at Matapur with energy efficient pump	22411	14834	0.78	1.01	9	66
25	Replacement of existing pump at Sakarmandi with energy efficient pump	15877.5	8302	0.78	0.56	17	52

Sl. No	Energy Efficiency Measures (EEM)	Present annual energy consumption (kWh/ year)	Annual Energy Savings (kWh/ Annum)	Investment Cost (Rs. Lakhs)	Monetary Energy Cost Saving (Rs. Lakhs)	Payback Period (Months)	Percentage of energy saving (%)
26	Replacement of existing pump at Rasulabad with energy efficient pump	23615.5	8522	0.9	0.58	19	36
27	Replacement of existing pump at Raj Colony with energy efficient pump	16388.5	5286	0.78	0.46	26	32
28	Replacement of existing pump at Bodkarpur with energy efficient pump	18980	10764	0.7	0.73	18	36
29	Replacement of existing pump at Ballochtola with energy efficient pump	37193.5	14292	1.12	0.97	14	38
	Sub Total (B)	**1799472**	**802484**	**72.14**	**54.56**	**16**	**45**
	Total – Pumping system (A + B)	**2087326**	**931337**	**80.38**	**64.81**	**15**	**44.61**
	Auxiliary load						
	Jalkal Pumping Station						
30	Replacement of existing luminaries (T-8,& CFL) with LED	4429	3109	0.07	0.25	4	70
	Sub Total (C)	**4429**	**3109**	**0.07**	**0.25**	**4**	**70**
	Jalkal Pumping Station						
31	Installation of APFC to improve power factor	-	-	0.85	3	4	-
	Sub Total (C)	-	-	0.85	3	4	-
	Net Total (A + B + C)	**2091755**	**934,446**	**81.30**	**68.06**	**14**	**45**

6.1.1 Detailed Energy Efficiency Measures at Jalkal Pump House

Opportunities of energy saving identified at Jalkal Pump House are discussed below.

6.1.2 EEM 1: Replacement of existing pump-1,2,3,4 at Jalkal Pump House with energy efficient pump

Existing operating conditions: There are 4 number of pumps installed Jalkal Pump house of 2 nos of 60HP and 2 nos. of 30HP. In general practice, 2nos of 60 HP pumps operate and 30HP pumps in standby mode to meet the water requirement. During the energy audit, measurements were taken for all the pumps.

Recommendations: The present operating pump efficiency of Pump-1, 2, 3 and 4 are 40.63%, 40.47%, 37.42% and 41.28% respectively. The efficiency of the pump is low mainly due to pump operating far away from the Best Efficiency Point (BEP). Therefore, it is suggested to replace existing pump with energy efficient pump to reduce the energy consumption.

Cost benefit analysis: : Expected savings from the replacement of the pump -1,2,3 and 4 are about 128,853 kWh per year, which would result in a cost benefit of about Rs. 10.24 Lakh per year. Estimated investment for implementation of this measure is about Rs. 8.24 Lakh, which basically includes cost of pump set, installation cost, cost of NRV, gate valve and cost of Web based dashboard. Simple payback period of this intervention is estimated to be about 10 months.

The calculations leading to the cost benefit analysis is provided in table.

Table 45: Cost Benefit analysis for replacement of pumps at Jalkal Pumping Station

Description Rated Parameters	Units	Pump-1	Pump-2	Pump-3	Pump-4
Flow delivered	m^3/hr.	270	135	270	135
Head developed	M				
Motor power consumption	kW	45	22.5	45	22.5
Measured Parameters					
Flow delivered	m^3/hr.	362	154	245	143
Head developed	M	19	19	19	19
Motor power consumption	kW	51.48	22.04	37.85	20.07
Calculated efficiency of pump set	%	36	36	33	37
Proposed Parameters					
Flow of the pump	m^3/hr.	250	160	250	160
Head of the pump	M	20	20	20	20
Power of the motor on existing duty point	kW	21.39	14.91	21.39	14.91
Proposed efficiency of pump set on existing duty point	%	64	59	64	59
Operating hours of the pump	Hours	2190	2190	2190	2190

Description Rated Parameters	Units	Pump-1	Pump-2	Pump-3	Pump-4
Electricity tariff	Rs./kWh	7.95	7.95	7.95	7.95
Annual energy saving	kWh	65889	15607	36039	11308
Annual cost saving	Rs. Lakhs	5.24	1.24	2.87	0.90
Investment towards new pump set including installation and commissioning, including GST	Rs. Lakh	1.82	1.12	1.82	1.12
Investment towards NRV replacement including GST	Rs. Lakh	0.21	0.21	0.21	0.21
Investment towards gate valve replacement including GST	Rs. Lakh	0.28	0.28	0.28	0.28
Investment towards Web based dashboard including GST	Rs. Lakh	0.07	0.07	0.07	0.07
Payback period	Months	6	17	10	23

6.2 Detailed Energy Efficiency Measures at Submersible Pumping Statins

6.2.1 EEM 2: Replacement of Existing Pumps at Submersible Pumping Stations with Energy Efficient Pumps

Existing operating conditions: There are 25 numbers of submersible direct supply/overhead tank pumps installed at different locations of the city to meet the water demand, which are not operating efficiently. The measurements of all such pumps are mentioned in table.

Recommendations: All the installed pump were very old and the performance has already deteriorated. The average efficiency of the pump below the best operational duty point. The efficiency can be enhanced by changing the existing pumps and motors with new energy efficient pumps and motors.

Cost benefit analysis: Expected annual savings from replacement of 25 submersible pumps about 802,484 kWh, which would result in annual cost saving of Rs.54.56 Lakhs. Estimated investment for implementation of this measure is about Rs. 72.14 Lakhs, which basically includes cost of pump set, installation cost, cost of NRV, gate valve and cost of Web based dashboard. Simple payback period for this intervention is estimated to be about 16 months.

The calculations leading to the cost benefit analysis is provided in below tables.

Table 46: Cost Benefit analysis for replacement of pump at Submersible Pumping station- Part 1 (Continued)

Description	Units	Submersible Pumping Stations										
Rated Parameters		Bhagat Singh Park	Hindi Bhawan	Khasanpur	Pachiatia	Sipah	Sagar Chungi	Purani Bazar	Jeeta Patti	Naigang No.2	SP Bungalow	Polytechnic 1
Flow delivered	m³/hr.	78	72	78	90	72	72	78	78	60	60	72
Head developed	M											
Motor power consumption	kW	18.75	22.5	22.5	18.75	18.75	22.5	22.5	18.75	18.75	18.75	18.75
Measured Parameters												
Flow delivered	m³/hr.	87	119	63	118	120	106	106	109	133	122	119
Head developed	M	17	19	33	24	21	26	19	23	24	19	21
Motor power consumption	kW	20.22	24.72	18.62	26.72	26.63	26.29	21.99	25.48	31.9	22.63	22.24
Calculated efficiency of pump set	%	21	26	31	29	27	29	26	27	28	28	32
Proposed Parameters												
Flow of the pump	m³/hr.	130	143	70.4	124	143	124	108	118	130	130	114
Head of the pump	M	19	21	33	26	21	26	19	23	24	19	21
Power of the motor on existing duty point	kW	11.47	14.07	10.87	15.13	14.06	15.13	10.24	13.08	15.12	11.47	10.97
Proposed efficiency of pump set on existing duty point	%	58.4	58.2	58.1	57.8	58.2	57.8	54.2	56.4	56.1	58.4	59.2
Operating hours of the pump	Hours	3650	3650	3650	3650	3650	5840	3650	3650	3650	3650	7300
Electricity tariff	Rs./kWh	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Annual energy saving	kWh	31944	38873	28272	42299	45888	65161	42903	45253	61251	40740	82247
Annual cost saving	Rs. Lakhs	2.17	2.64	1.92	2.88	3.12	4.43	2.92	3.08	4.17	2.77	5.99
Investment towards new pump set including installation and commissioning, including GST	Rs. Lakh	3.58	3.64	3.41	3.80	3.64	3.80	3.28	3.64	3.80	3.58	3.58
Investment towards NRV	Rs.	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21

Description Rated Parameters	Units	Submersible Pumping Stations										
		Bhagat Singh Park	Hindi Bhawan	Khasanpur	Pachiatia	Sipah	Sagar Chungi	Purani Bazar	Jeeta Patti	Naigang No.2	SP Bungalow	Polytechnic 1
replacement including GST	Lakh											
Investment towards gate valve replacement including GST	Rs. Lakh	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Investment towards Web based dashboard including GST	Rs. Lakh	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Payback period	Months	23	19	25	18	16	12	16	16	13	18	9

Table 47 Cost Benefit analysis for replacement of pump at Submersible Pumping station- Part 2 (Continued)

Description Rated Parameters	Units	Submersible Pumping Stations										
		Jalkal Main Gate	Mufti Mohalla	Tutipur	Kharka Colony	Chitarsari	Makhadum Shah	Achala Devi Ghat	Sipah	Matapur	Sakarmandi	Rasulabad
Flow delivered	m^3/hr.	90	90	90	90	72	72	78	78	60	60	72
Head developed	M											
Motor power consumption	kW	18.75	18.75	18.75	18.75	18.75	22.5	22.5	18.75	18.75	18.75	18.75
Measured Parameters												
Flow delivered	m^3/hr.	84	105	104	90	7	25	28	33	9	11	23
Head developed	M	26	25	25	25	27	19	23	20	30	30	29
Motor power consumption	kW	22.83	21.51	25.82	21.43	4.65	3.94	6.7	6.91	6.14	4.35	6.47
Calculated efficiency of pump set	%	26	34	28	29	11	34	27	26	12	20	27
Proposed Parameters												
Flow of the pump	m^3/hr.	124	127	103	108	12	25	36	54	12	12	24
Head of the pump	M	26	25	25	24	28.5	19.5	22.5	21.5	28.5	28.5	31
Power of the motor on existing duty point	kW	15.13	15.13	12.94	12.77	2.07	2.31	4.08	5.59	2.08	2.08	4.14
Proposed efficiency of pump set on existing duty point	%	57.8	57.0	53.9	55.1	44.8	58.0	54.0	56.6	44.8	44.8	48.9
Operating hours of the	Hours	3650	3650	5840	7300	3650	3650	3650	3650	3650	3650	3650

Description Rated Parameters	Units	Submersible Pumping Stations										
		Jalkal Main Gate	**Mufti Mohalla**	**Tutipur**	**Kharka Colony**	**Chitarsari**	**Makhadum Shah**	**Achala Devi Ghat**	**Sipah**	**Matapur**	**Sakarmandi**	**Rasulabad**
pump												
Electricity tariff	Rs./kWh	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Annual energy saving	kWh	28094	23294	75244	63233	9406	5933	9556	4834	14834	8302	8522
Annual cost saving	Rs. Lakhs	1.91	1.58	5.12	4.3	0.64	0.40	0.65	0.33	1.01	0.56	0.58
Investment towards new pump set including installation and commissioning, including GST	Rs. Lakh	3.8	3.8	3.65	3.64	0.39	0.52	0.56	0.60	0.39	0.39	0.51
Investment towards NRV replacement including GST	Rs. Lakh	0.21	0.21	0.21	0.21	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Investment towards gate valve replacement including GST	Rs. Lakh	0.28	0.28	0.28	0.28	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Investment towards Web based dashboard including GST	Rs. Lakh	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Payback period	Months	28	33	10	12	15	27	18	36	9	17	19

Table 48 Cost Benefit analysis for replacement of pumps at submersible Pumping Stations – Part 3

Description Rated Parameters	Units	Submersible Pumping Station		
		Raj Colony	Bodkar pur	Balloch tola
Flow delivered	m^3/hr.	30	30	30
Head developed	M			
Motor power consumption	kW	7.5	7.5	7.5
Measured Parameters				
Flow delivered	m^3/hr.	33	28	34
Head developed	M	14.7	21.8	24.57
Motor power consumption	kW	4.49	5.2	10.19
Calculated efficiency of pump set	%	29	32	23
Proposed Parameters				
Flow of the pump	m^3/hr.	36	28	60
Head of the pump	M	15	21.8	22
Power of the motor on existing duty point	kW	3.04	3.33	6.27
Proposed efficiency of pump set on existing duty point	%	48.4	50.0	57.4
Operating hours of the pump	Hours	3650	3650	3650
Electricity tariff	Rs./kWh	6.8	6.8	6.8
Annual energy saving	kWh	5286	6822	14292
Annual cost saving	Rs. Lakhs	0.36	0.46	0.97
Investment towards new pump set including installation and commissioning, including GST	Rs. Lakh	0.39	0.33	0.72
Investment towards NRV replacement including GST	Rs. Lakh	0.13	0.13	0.13
Investment towards gate valve replacement including GST	Rs. Lakh	0.17	0.17	0.17
Investment towards Web based dashboard including GST	Rs. Lakh	0.07	0.07	0.07
Payback period	Months	26	18	14

6.2.2 EEM 4: Lighting Optimization for Jalkal Pumping Station

Existing Condition: In present scenario, type of luminaire used at Jalkal pumping station that includes 48 W FTL (T–12 lights) and 250 W Sodium Vapour lamps. In general practice, these lights are operated for about 12 hours a day

Recommendation: It is recommended to replace the existing 48 W FTL (T – 12) lights with 18 W LED tube lights and 250 W sodium vapor lamp with 60 W LED lamps.

Cost Benefit Analysis: Estimated savings in energy is about 3,109 kWh per year which is about Rs. 0.24 Lakh per year in monetary terms. Estimated investment, taking into account bulk purchase and replacement, would be about Rs. 0.077 Lakh and the simple payback period is about 4 months. Cost benefit analysis of the recommendation is provided in table.

Table 49: Cost benefit analysis for installation of energy efficient lights at Jalkal pumping station

Parameter	Unit	Existing	Proposed	Existing	Proposed
Type of Fixture		T-12	LED (18 Watt)	Sodium Vapor Lamp	LED (60 Watt)
Type of Choke if Applicable		Electronic	Electronic	Electronic	Electronic
Number of Fixtures	#	**10**	**10**	**2**	**2**
Rated Power of Fixture	Watt/Unit	48	18	250	60
Consumption of Choke	Watt/Unit	3	-	-	-
Operating Power	Watt/Unit	51	18	250	60
Operating Hour per Day	Hr/Day	12	12	12	12
Operating Days per Year	d/y	365	365	365	365
Annual Energy Consumption	kWh/year	2,234	788	2,190	526
Annual Energy Saving	kWh/year	1,445		1,664	
Electricity tariff	Rs./kWh	7.95		7.95	
Annual energy cost savings	Rs./year	1445		1664	
Investment towards LED lighting including GST	Rs.	2500		5200	
Simple payback period	Month	3		5	

6.2.3 EEM 5: Installation of APFC panel on the incomer to improve the power factor

Existing operating conditions: During energy audit, average power factor on the main incomer was estimated to be 0.75 lagging. There was no APFC panel installed at plant to compensate the reactive power requirement at the pumping station. Even, the average power factor in electricity bill was < 0.850 lagging.

Recommendations: It is recommended to install the APFC panel on the LT side of transformer to improve the power factor up to unity.

Cost benefit analysis: Expected cost savings from installation of APFC panel is about Rs. 3.0 Lakh per year. Estimated investment for implementation of this measure is about Rs. 0.85 Lakh, which basically includes the cost of civil work, logistics and the erection and commissioning cost. Simple payback period of this intervention is estimated to be about 4 months. Cost benefit analysis of the recommendation is provided in table.

Table 50: Cost Benefit analysis for installation of APFC panel at Jalkal Pumping Station

Parameters	Unit	Parameters
Present System		
Average power factor from recent EB bill	Cos ø	0.8
Average power consumption	kW	65
Proposed System		
Proposed power factor at Incomer	Cos ø	0.99
Required capacitor bank	kVAr	40
Electricity tariff	Rs./kW	7.95
Power factor penalty (<0.85) /Annum (Approx.)	Rs Lakh	3
Annual monetary saving	Rs. Lakhs	3
Investment of APFC panel including GST	Rs. Lakhs	0.85
Payback period	Months	4

7 Repair &Maintenance Measures

7.1 Present R&M and O&M expenses

Pump sets requires periodic repair and maintenance to keep them in running condition and each R & M activity has a cost associated with it. During energy audit, it was observed that need of repair and maintenance arises generally for replacement of consumables and for addressing wear and tears of components of pump set. During energy audit, data regarding repair and maintenance cost was not available with ULB. Details of Estimated R & M and other cost associated with Pumping stations in Jaunpur City are provided in table 51.

Table 51: R&M and O&M expenses for Pumping Stations in Jaunpur city

Financial Data	Units	Values		
		Raw water Pumping Station	**Jalkal Pumping Station**	**Submersible Pumping stations**
Cost of Repair & Maintenance				
Cost of Repair & Maintenance in FY2014 – 2015	Rs. Lakh	-	-	-
Cost of Repair & Maintenance in FY2015 – 2016	Rs. Lakh	-	-	-
Cost of Repair & Maintenance in FY2016-2017	Rs. Lakh	-	-	-
Cost of operation				
Cost of Operation in FY2014 -2015	Rs. Lakh	-	-	-
Cost of Operation in FY2015-2016	Rs. Lakh	22.83	13.91	400.90
Cost of Operation in FY2016-2017	Rs. Lakh	-	-	-
Cost of Purchase of new pump/motors/accessories				
Cost of Purchase of new pump/motors/accessories in FY2014-2015	Rs. Lakh	-	-	-
Cost of Purchase of new pump/motors/accessories in FY2015- 2016	Rs. Lakh	-	-	-
Cost of Purchase of new pump/motors/accessories in FY2016 -2017	Rs. Lakh	-	-	-

In above tables, cost of operations include energy cost, manpower cost, labor cost (associated with R & M) and cost of raw material used in filter plant.

In proposed scenario, repair and maintenance cost for the pumps of Jaunpur City may reduce as most of old and inefficient pumps will be replaced by new energy efficient pumps. Along with this, during project period, repair and maintenance of new pumps will be done by EESL selected manufacturer.

8 Project Financials and Business model

An IGEA Report is the process of conducting an energy audit to identify efficiency improvement opportunities, and translating the technical findings into financial terms to present it as a bankable project capable of securing a loan. Therefore it is important to conduct a detailed financial analysis for the project to ascertain the financial viability of the project.

This project would be implemented in Annuity Mode. In this mode, EESL will invest all the capital investment required for implementation of the Energy Efficiency Project. **EESL will assure a minimum energy savings of approx. 20% as compared to the existing energy consumption. Payments would not be affected if savings are higher than 20%.** Further EESL would provide Repair & Maintenance (R&M) for the replaced pump sets during the project period. The repayment to EESL (in the form of annuity) would be determined on cost plus ROE basis. Schematic of business model of this project is provided in figure 21.

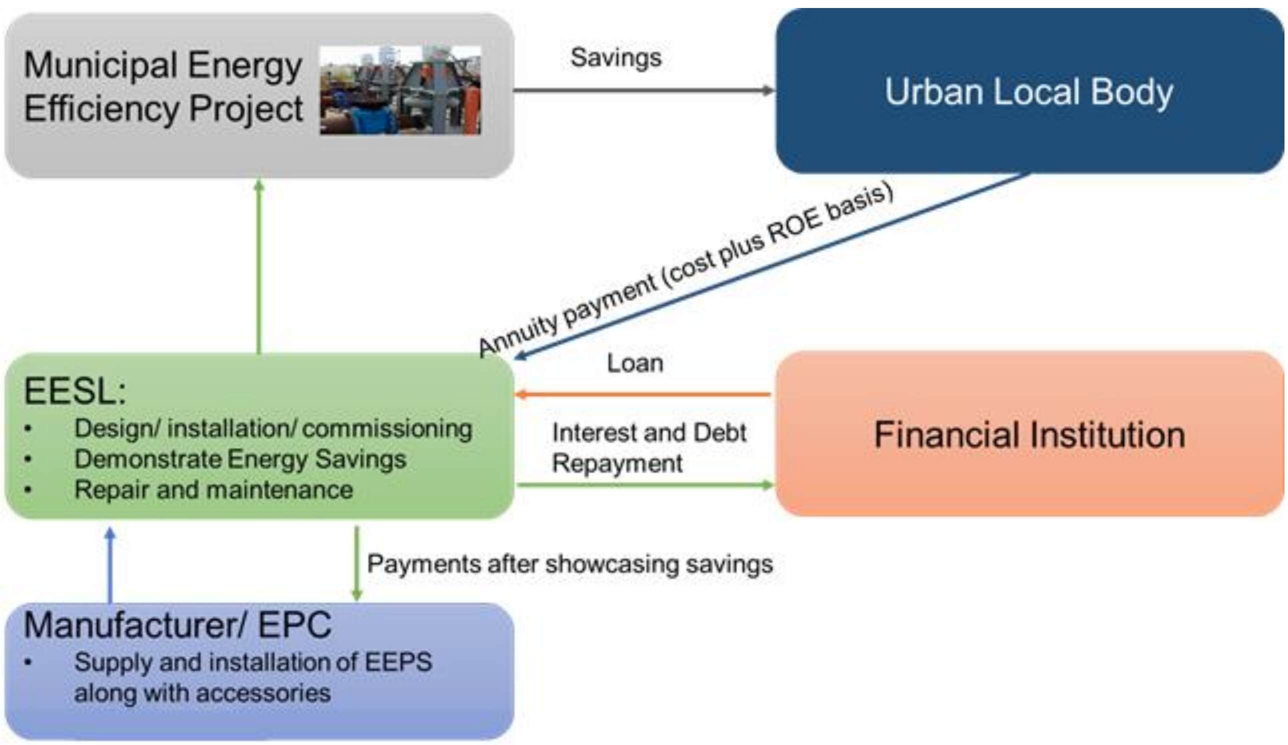


Figure 21 Schematic of business model of the project

8.1 Total Project cost (CAPEX)

The following are the key components considered while arriving at the total project cost:

i. Cost of pump, motor and other accessories (like NRV and gate valve), discovered through a transparent bidding process;

ii. Cost of dismantling, installation and commissioning including testing charges, discovered through a transparent bidding process;

iii. Project Establishment and Supervision charges of EESL at 5 % of total cost of equipment including installation;

iv. Cost of preparation of IGEA, as per actual tendered cost, plus EESL's service charge at 15%;

v. All applicable goods and services taxes on actual basis; and

vi. Capitalized interest during the Project Implementation Period.

Details of project capital cost is provided in table 52.

Table 52: Project Capital cost

Capital Cost Related assumption	Unit	Value
Number of Pumps	*No.*	29
Total Cost of Equipment including installation, commissioning and testing	*INR lakhs*	80.39
Cost of pump including motor	*INR lakhs*	60.35
Cost of NRV	*INR lakhs*	5.48
Cost of Gate valve	*INR lakhs*	7.25
Cost of Web based dashboard	*INR lakhs*	2.23
Installation and Commissioning Cost including testing charges	*INR lakhs*	5.09
EESL's administrative and establishment charge	*%*	5
Cost of preparation of IGEA report including EESL service charges and applicable GST	*INR lakhs*	6.79
Total Project Cost w/o Capitalized interest	*INR lakhs*	91.19
Commissioning Details		
Total Months for Commissioning	*months*	9
Capitalized interest	*INR lakhs*	5.11
Total Project Cost	*INR lakhs*	96.31

8.2 Operating Costs (OPEX)

The following are the key components considered while arriving at the operating cost for the project

i. Project Establishment and Supervision charges of EESL at 4% of total project cost, with annual escalation of 5%; and

ii. Actual incurred Repair & Maintenance charges, discovered through a transparent bidding process.

Details of operating cost is provided in table

Table 53: Project operating cost

Operational Details	Unit	Value
EESL's administrative and establishment charges	*%*	4%

8.3 Financing Terms and other tax related assumptions

The following are the key financial assumptions used in developing the model. Details of financing terms and tax related assumptions are provided in table 54.

Table 54: Financing terms and tax related assumptions

Parameters	Unit	Value
Term of the project	*years*	7
Financing Details		
Debt Percentage	*%*	70%
Cost of Debt	*%*	11%
Equity Percentage	*%*	30%
Cost of Equity (post- tax)	*%*	16%
Tax Details		
Corporate Tax		34.61%
Goods and Services Tax		18%

8.4 Output - Annuity Payment to EESL

Based on the cost parameters and assumptions mentioned above, the annuity payment to EESL was computed. Details of annuity payment to EESL is provided in table 55.

Table 55: Annuity payment to EESL

Year		1	2	3	4	5	6	7	Total
Calculations of annuity payment									
Total Debt to be repaid	*INR lakh*	16.65	15.59	14.53	13.47	12.41	11.35	10.29	94.29
Principal Repayment	*INR lakh*	9.63	9.63	9.63	9.63	9.63	9.63	9.63	67.41
Interest	*INR lakh*	7.02	5.96	4.90	3.84	2.78	1.72	0.66	26.88
Total Equity Repayments	*INR lakh*	10.82	9.81	8.80	7.79	6.78	5.77	4.76	54.52
Recovery of equity investment	*INR lakh*	4.13	4.13	4.13	4.13	4.13	4.13	4.13	28.89
Return on equity	*INR lakh*	6.69	5.68	4.67	3.66	2.65	1.64	0.63	25.62
R&M Charges	*INR lakh*	0.00	1.21	2.01	2.41	2.81	3.01	3.22	14.67
EESL's administrative and establishment charge	*INR lakh*	3.85	4.04	4.25	4.46	4.68	4.92	5.16	31.36
Annuity Payment to EESL	*INR lakh*	31.32	30.64	29.58	28.13	26.69	25.05	23.43	194.85
Goods and Services Tax on annuity payment	*INR lakh*	5.64	5.52	5.33	5.06	4.80	4.51	4.22	35.07
Annuity Payment to EESL incl. all applicable taxes	*INR lakh*	36.96	36.16	34.91	33.19	31.49	29.56	27.65	229.92

ULB Savings									
Total Savings	*INR lakh*	64.81	65.27	65.65	65.94	66.15	66.27	66.27	460.36
Profit to ULB	*INR lakh*	27.86	29.10	30.74	32.75	34.66	36.71	38.62	230.44
% of savings with ULBs	*%*								50.06

8.5 Sensitivity analysis

The sensitivity analysis has been conducted to determine the impact of change in capital cost and change in savings on the percentage of monetary share of accrued savings retained by the ULB. Details of project sensitivity analysis is provided in table 56.

Table 56: Project Capital cost

Change in Capital Cost	% of savings retained by the utility
-10%	54.67 %
-5%	52.37 %
0%	50.06 %
5%	47.75 %
10%	45.44 %
Change in Interest(ROE, Interest, D/E ratio)	**% of savings retained by the** utility
-10%	44.51 %
-5%	47.43 %
0%	50.06 %
5%	52.43 %
10%	54.60 %

8.6 Payment Security Mechanism

Payment default by the borrower is perceived as one of the most important risks. For projects based on ESCO model, wherein ESCO or financial institution pays the upfront capital for project implementation, the regular payment to the ESCO/financial institution is crucial to maintain a positive cash flow. There are difficulties associated with measuring energy performance accurately and equitably, and therefore the actual energy savings may be disputable, especially in circumstances where the energy baseline and stipulated factors are not well established at the pre-project stage. Apart from possible dispute on actual savings, host's bankruptcy and dismissal of a management body could also be possible reasons for non-payment. Payment security mechanism is necessary to ensure confidence of investors in an ESCO projects. The mechanism should be structured in a way which would be acceptable to ESCO/financial institution. The payment security mechanism maybe in form of irrevocable bank guarantees or letter of credit (LOC) furnished by the ESCO/financial institution.

8.6.1 Letter of credit

Letter of credit (LC) is the obligation taken by the bank to make the payment once certain criteria are met. Whereas, bank guarantee (BG) is a promise made by a bank that the liabilities of the debtor will be met in event the energy user fails to make the payment. The major difference between bank guarantee (BG) and letter of credit (LC) is that BG reduces the loss in the transaction if transaction doesn’t go as planned while letter of credit ensures that transaction proceeds as planned. As the ultimate objective of the program is to improve the energy efficiency in water supply and sewage system and ensuring the success of the project, letter of credit would be preferred payment security mechanism.

Letter of credits processes payment on receipt of required documents from the service provider. Major challenges associated with letter of credit are enlisted below:

- Letter of credits are usually irrevocable agreement and hence any changes in terms of contract will be difficult to address in letter of credit.
- Getting letter of credit is difficult considering the stringent qualification criteria. Letter of credit is usually issued to companies and organization that have cash flow, asset and good credit score.
- Usually line of credit are issued with terms for paying it back, herein energy user will be using the line of credit to pay the service provider for its services. In case of energy savings line of credit could be used as an guarantee in case of default by the government entity

In the case of the AMRUT program, the state government play a critical role in implementation of the project would sign the tri partite agreement for implementation of the project. The state government shall provide an unconditional, revolving and irrevocable Letter of Credit from a scheduled and nationalized bank (other than co-operative banks) at its own cost for the entire contract period. The amount of letter of credit shall be equivalent to 2 times the quarterly invoice. The LC may then be drawn upon by EESL for recovery of the eligible payments, in case of defaults.

9 Key Observations and Suggestions

To achieve optimum performance and reliability, a pump must be operated close to its BEP (Best efficiency point). The BEP is the most stable operating point for a centrifugal pump. At best efficiency point, the hydrodynamic unbalanced load of the centrifugal pump is at its minimum. Basically, when a pump operates at a point that is far away from the actual BEP, it results in an overall increase in hydrodynamic unbalanced load. This in turn affects the performance, reliability and efficiency of the pump.

Raw water Pump House:

1. During Energy Audit, From Electricity Bills It is observed that the Plant is maintaining Poor power Factor i.e. <0.85. As per UPPUVVNL Tariff order Billing is based on Total Energy Consumption i.e. KWh and fixed charges i.e. Billing Demand i.e. BHP. However, Power factor Penalty is imposed if Plant power factor becomes <0.85. It is recommended to maintain Power factor of 0.9 in order to avoid Power factor penalty.

Jalkal Pump House:

1. During Energy Audit, From Electricity Bills It is observed that the Plant is maintaining Poor power Factor i.e. <0.85. As per UPPUVVNL Tariff order Billing is based on Total Energy Consumption i.e. KWh and fixed charges i.e. Billing Demand i.e. BHP. However, Power factor Penality is imposed if Plant average power factor becomes <0.85. It is recommended to maintain Power factor of 0.9 in order to avoid Power factor penalty.
2. During Energy Audit, it is observed that THD is not within the limits. Installation of Harmonic Filter along with APFC panel will improve the life of the equipment.

Submersible Pumping Stations

1. During Energy Audit, it is observed that some of the pumps are running at very low Efficiency due to low water level/ dried up etc., Replacement of such pumps are not taken into consideration due to economical point of view. ULB have to take necessary action for such pump sets by proper inspection.
2. For some Submersible Pumping Stations i.e. Energy Meters are not installed. Thereby, ULB's have to monitor their electricity bills after replacement with EEPS and have to take necessary action in case of discrepancy in Electricity Billing.
3. From Electricity Bills, It is Observed that Pumping Stations are operating at a Power factor <0.85. Thereby Power factor penalty is imposed on 30 HP & 25 HP Submersible Pumping Stations. It is recommended to install capacitor banks at each Pumping station after Installation of EEPS if power factor is < 0.85.

9.1 Other Observations And Limitations

Various scope and limitations of the energy efficient projects were observed when energy audit activity was conducted and the same has also been discussed with ULB officials. It is estimated that there is immense opportunity for energy saving in Jalkal Pumping Station and submersible pumping stations.

Other observations

1. It was observed during the audit that there were water leakages in the pumping system. The leakage can be closed by maintenance and replacement of existing gate valve and NRVs. After seeing this kind of condition, it was understood that there is certain possibility of energy saving in the water system.
2. Electrical wiring is in hazardous condition and terminals are open at few locations.
3. The installed lighting system in the premises were also analyzed and it was suggested that the energy efficient lighting system would lead to significant amount of energy savings.
4. It has been observed that due to the ageing of the pumps currently present in the plant premise, its efficiency and performance is badly affected as the installed pump are around 15-20 years old. It is suggested that installation of new energy efficient pump will lead to energy savings.

Limitations

1. The installation of energy efficient systems and components should be done according to suggested EE measures.
2. Another tapping in the delivery line or change in the existing water delivery network will affect the performance of the new pump.
3. Due to variations in water level from season to season the head developed may be varied and pump may not run at BEP.

Due to the limitations observed by the CII team during the energy audit done, they were unable to cover some of the pump sets in the plants visited. Table 57 depicts the plants where energy audit was conducted with associated number of pump sets that were audited and reasons for the limitations observed.

Table 57: List of Pumping station audited with pumps operating status

<table>
<tr><th>S. No</th><th>Name of the pumping station</th><th>Number of Pumps present</th><th>Number of Pumps audited</th><th>Number of Pumps left</th><th>Reasons for not covering the pumps</th></tr>
<tr><td>1</td><td>Raw water Pump House</td><td>4</td><td>0</td><td>4</td><td rowspan="2">Under Maintenance/Low River level</td></tr>
<tr><td>2</td><td>Jalkal Pump House</td><td>4</td><td>4</td><td>0</td></tr>
<tr><td>3</td><td>Submersible Pumping Stations</td><td>53</td><td>44</td><td>9</td><td>No provision & Under Maintenance</td></tr>
<tr><td></td><td>Total</td><td>61</td><td>48</td><td>13</td><td></td></tr>
</table>

10 Measurement and Verification (M&V)

Measurement and Verification (M&V) is the term given to the process for quantifying savings delivered by an Energy Efficiency Measure (EEM). It includes energy saving verification process involving measurements and reporting methodology. M & V methodology followed in this project includes following measurement schedule

a. Measurement of parameters pre EEM implementation (just before installation of EEPS) for all operating combinations using portable instruments

b. Measurement of parameters post EEM implementation for all operating combinations using portable instruments.

Energy savings are calculated as the difference in power drawn (in pre and post implementation scenario) multiplied by the operating hours mentioned in IGEA.

These energy savings shall be verified in accordance with M&V plan presented in the final report by EESL and as agreed upon by the ULB. The energy savings will be determined and signed by EESL, Pump Supplier and the ULB. EESL shall submit a report as per the reporting template attached to this agreement verifying the savings mentioned in the agreement.

The report shall be submitted by EESL to all the ULB within 15 days of the completion of the verification

10.1 Definition of possible and operating combinations

In ULBs, especially in case of pumping stations, where the pumps are connected in parallel, the pump operated in various combinations. For the purpose of this document, these combinations are defined as possible combinations. For example, for if 3 pumps are connected in parallel, there are 7 possible combinations considering three different pumps i.e.

Pump 1	Pump 1+ Pump 2	
Pump 2	Pump 2+ Pump 3	Pump 1+Pump 2+Pump 3
Pump 3	Pump 3 +Pump 1	

However, the ULB might be operating the pumps only in three combination, depending on the flow requirement, from the one discussed above. For the purpose of this document, these combinations are defined as operating combinations.

Operating Combination 1	Operating Combination 2	Operating Combination 3
Pump 1	Pump 1+ Pump 2	Pump 1+Pump 2+Pump 3

10.2 Flow of activities under M & V process

- First, measurements of old pump would be carried out by the supplier when new pump is ready to be installed at ULB.
- Instantaneous measurement of parameters like flow, head (both at suction and discharge) and power of old pump would be carried out for all operating combinations after stabilisation using portable meters. These parameters will be called pre implementation parameters
- Pre implementation parameters will be verified by EESL, ULB and Supplier.

- Then, old pump will be replaced by new pump and instantaneous measurements of parameters mentioned above will be carried out on new pump after stabilisation for same operating combinations. These parameters will be called post implementation parameters.
- Energy savings of a pump for each combination would be determined by multiplying the difference in instantaneous power consumption in pre and post EEM implementation scenario with corresponding operating hours mentioned in IGEA. Total savings of a pump will be the summation of energy savings in each operating combination (i.e. weighted average savings of a pump would be estimated)
- The flow and head of new pump i.e. post implementation parameters should match pre implementation parameters.
- Post implementation parameters will be verified by EESL, ULB and supplier.
- Penalty would be imposed on pump supplier if energy savings, at ULB level, are less than 20% of existing energy consumption

10.3 Pre and post implementation assessment

To determine savings, the following parameters would be measured during pre and post implementation for each operating combination,

i. Power Consumption, voltage, frequency (kW, Volt, hz)

Data Unit	kW, Volt, hz
Description	Voltage, frequency and power consumption of all operating combinations (pre and post implementation)
Source of Data	On site measurement using calibrated portable instrument (power analyzer)
Description of measurement methods and procedures to be applied	Instantaneous onsite measurement using portable power analyzer
QA/QC procedures to be applied	Calibrated instrument from a NABL accredited laboratory

ii. Flow rate (m3/hr)

Data Unit	m^3/hr
Description	Flow rate delivered for all operating combinations (pre and post implementation)
Source of Data	On site measurement using calibrated portable instruments (flow meter)
Description of measurement methods and procedures to be applied	Instantaneous onsite measurement using portable flow meter
QA/QC procedures to be applied	Calibrated instrument from a NABL accredited laboratory

iii. Head (m)

Data Unit	meters (m)
Description	Average head delivered for all operating combinations (pre and post implementation)
Source of Data	On site measurement using calibrated instruments
Description of measurement methods and procedures to be applied	Instantaneous onsite measurement using pressure gauge installed at both the suction and discharge side of the pump
QA/QC procedures to be applied	Calibrated instrument from a NABL accredited laboratory

10.4 Correction Factors and adjustments

In case of deviation in frequency and voltage at the time of post implementation parameter measurements, following correction factors would be applied on parameters of new pump to determine actual. Adjustments factors to be used during M&V are provided in table 58.

Table 58: Adjustment factors to be used during M & V

Factor Affecting	Rationale for adjustment	Adjustment to be made
Variation in supply frequency	As per pump affinity law	$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$ $\frac{P_1}{P_2} = (\frac{N_1}{N_2})^3$ Where, Q is the flow of the meter N is the speed of the shaft P is the power drawn
Voltage Variation	As per BEE guidelines	If the post implementation voltage is 10% higher than pre implementation voltage, power consumption will increases by 0.75% If the post implementation voltage is 10% lower than pre implementation voltage, power consumption will increase by 2%

10.5 Determination of Savings

- Based on this data, the energy savings would be calculated as given below:

$$\% \; savings \; (s1) = \frac{\big((kWpre1 \; - kWpost1) \; X \; h1\big) + \big((kWpre2 \; - kWpost2) \; X \; h2\big) + \; \dots \dots .}{(kWpre1 \; X \; h1) + (kWpre2 \; X \; h2) + \cdots \dots}$$

  - Where, 1, 2…. represents parameter for different operating combinations of a pump
  - h1, h2 represents annual operating hours of a pump in different combinations
  - kW_{pre} – Instantaneous power consumption of old pump in a particular combination
  - kW_{post} – Instantaneous power consumption of new pump in a particular combination
  - s1 represents percentage savings of a pump

- Further, aggregate savings at a ULB level would be determined based on weighted average savings of all pumps:

  The aggregate percentage savings at ULB would be

$$aggregate \; \% \; savings \; at \; ULB = \frac{s_1 \times e_1 + \; s_2 \times e_2 + \; s_3 \times e_3 \dots \dots \dots .}{e_1 + \; e_2 + \; e_3 \dots \dots}$$

  - Where, e represents energy consumption of one pump in all combination

$$e1 = kWpre1 \; X \; hour1 + kWpre2 \; X \; hour2 + \cdots \dots \dots \dots$$

  - s1, s2, s3, s4, s5........ are percentage savings for individual pumps replaced at ULB
  - e1, e2, e3, e4, e5........ are annual energy consumption of each pump

11 Risk Responsibility Matrix & Risk Mitigation

To develop an effective business model, it is necessary to identify clear roles and responsibilities and the risks associated with the project development. This is useful to develop appropriate structure and plan for project financing and risk mitigation mechanism for ring fencing the risks of project investors. Some of the major risks and their mitigation mechanisms are discussed below.As established in the previous sections, the preferred mode for implementation of this project is annuity mode. Therefore the responsibility matrix has been prepared considering the preferred implementing mode. Details of financial risk and associated mitigation measures table 59.

Table 59: Financial Risk Analysis and Mitigation

Risk	Key Incidence of risk	Description	Mitigation Measure
Operational Risk: Usage risks are usually a direct consequence of use of equipment by the end users. These risks are usually beyond the control of the ESCO			
Inaccurate Baseline	ULB	Baseline for any ESCO based project is usually defined in terms of energy consumption and the performance level of the equipment. In case of pumping stations, when pumps are connected in parallel, few pumps might not be operational during baseline determination. Also, an increase or decrease in operating hours can show up as corresponding increase or decrease in "savings" unless adequate adjustments are applied	The design of the M&V protocol would include sufficient measures in form of engineering formula for baseline correction to sufficiently mitigate this risk
Operational change in the facility	ULB	Operational changes can be in terms of change in usage hours. Further in case of pumping system, the operational changes can be a result of use of higher size of pumps, increase in number of pumps connected in a parallel system, increase in required flow among others.	
Market Risk: Market risks arise due to uncertainty of market conditions. These risks can be attributed to various stakeholders and factors including suppliers of technology, maturity of technology and consumers among others.			
Availability of suppliers	EESL	Availability of suppliers and the technology are keys to development of any ESCO project. Competition in market leads to market forces optimizing the cost. This also leads to new technology innovations and product differentiation. Dependence on a single supplier also increase the project risk, where the project is dependent on capability of single	EESL is mitigating the risk by ensuring the involvement of manufacturers and suppliers throughout the project lifecycle including taking inputs during IGEA preparation. Further pumping is a matured industry with many suppliers

Risk	Key Incidence of risk	Description	Mitigation Measure
		vendor to supply quality products in required quantity in a pre-determined time frame. Ineffective competition may lead to installation of inferior quality product and also cause delay in implementation.	
Age of the technology	EESL	Mature technology are by nature stable and more dependable than new technology. The performance standards for mature technologies are also well defined. There are many inherent risks associated with new technology, these include price fluctuations, rapid technology improvements (which could lead to project being more effective later i.e. early adopters curse[4]), lesser awareness about technology shortcomings and effects.	Pumping is a matured technology with key technical parameters and fundamentals remaining relatively constant during the past century.
Financial Risk: The financial risk mainly deals with the cost escalations associated with the project. These risks if not mitigated properly affect the profitability and feasibility of the project			
Equipment Cost Escalation	ULB	The increase in equipment cost could be due to various factors including increase in cost of raw materials, changed policies and regulations. The escalated cost could result in reducing the project profitability and in worst scenarios making the project unviable.	In the annuity mode, the equipment cost considered is the cost discovered in competitive bidding. This will ensure the best possible cost for the ULB. Further, manufacturer's budgetary quotations are taken while developing the IGEA.
Installation and annual maintenance cost Escalation	ULB (before bidding) Technology supplier (post bidding)	Installation cost is the function of manpower cost, cost of carrying inventory and material required for installation. For a project with longer execution cycle, managing installation and annual maintenance cost can be key to success of the project. In addition to factor affecting increase in manpower cost (change in labor laws etc.), the reasons for installation and annual maintenance cost are similar to	For the ULB the mitigation measures are same above

[4] The new technology turns old very quickly. Also rapid improvements lead to reduction in cost in near future. For example early adopters of solar technology had to pay a higher feed in tariff as compared to later adopters

Risk	Key Incidence of risk	Description	Mitigation Measure
		equipment cost escalation. As the selected technology supplier is contractually responsible for installation and annual maintenance at the rate mentioned in its bids. The risk is transferred to the technology provider post bidder selection.	
M&V Costs	EESL	M&V costs tend to vary significantly depending on the extent of measurements, involvement of technical manpower, and automation required in the M&V methods and protocols adopted	M&V mechanism will be clearly defined, agreed and incorporated into project financials prior to project implementation
Time and Budget Overruns	EESL	Failure to implement a viable project in a timely manner can add costs	To be addressed by closely monitoring progress with unit
Design and construction risk: Improper design and delays in constructions are a significant risk to ESCO project.			
Delays in procurement, installation and commissioning	All stakeholders	Delay in procurement, installation and commissioning could drive up project cost. Longer project durations could also increase the probability of other regulatory and policy related risks. It is important to plan the project efficiently to minimize these risks. Projects undertaken by EESL usually require procurement of large quantity of a single product	Standardization of bidding and other contractual documents is key to minimize this risk. Additionally all the stakeholders including ULBs, state government, manufacturers and energy auditors need to be engaged since project inception
Improper selection of energy efficiency solution and integration of energy efficient solution	All stakeholders	The aim of an ESCO project is reduce energy consumption while maintaining or improving performance of the equipment. Proper selection of solution is important to achieve these objectives. Improper selection of solution could lead to non-achievement of savings as estimated. It could also lead to not meeting the performance parameters from the baseline scenario	The manufacturers and technology suppliers are engaged since the project inception including overseeing energy audit activities and selection of technology. Further the manufacturers should be encouraged to visit the facility before bidding for the project.
Performance risks: related to performance of energy efficient equipment post implementation. Poor performance could lead to reduced savings from the ESCO project. This may result in poor financial returns for the project			
Equipment performance depreciation	EESL /Technology Supplier	In many conditions the equipment performance deteriorates over the life of the project. The derating of the equipment needs to be properly	Derating of equipment has been appropriately modelled in the financial model. The values of derating have been

Risk	Key Incidence of risk	Description	Mitigation Measure
		modelled in the business model for the project. Incorrect assumptions could lead to severe financial implication of the project. There are two key reasons for the equipment performance depreciation. • **Quality of equipment:** Equipment installed as a part of the project does not conform to quality standards set. It is also possible that the vendor supplies equipment which do not meet the technical specification set out in the bidding document. • **External conditions:** These conditions include various external parameters including power quality and operating condition (flow output and pump submergence) deviating from the design parameters	finalized after consultation with manufacturers. Proper quality control action plan needs to be developed as part of the bidding documents and contract. Capacity building of pump operators in proper operations of the new pumps installed
Repair/maintenance and warranty risks	EESL /Technology Supplier	Repair/maintenance and warranty risks relate to faulty equipment risks. The risk also arises due to different agencies being responsible for operations and repair/maintenance. In case of this project, operation would be managed by urban utility, whereas EESL and in turn technology supplier would be responsible for the repair and maintenance. A dispute also might arise related to deviation from warranty conditions which are also not under EESL/technology supplier control. EESL offers extended warranty up to the life of the project under most of its projects. The payment to EESL is also linked to satisfactory replacement of faulty equipment and timely repairs.	Capacity building of pump operators will be taken up to facilitate proper operations and routine preventive maintenance of the new pumps installed EESL will define Comprehensive repair and maintenance requirements including spares and components inventory, as well as appropriate systems (e.g. for registering complaints and turn-around times) and will make the equipment suppliers contractually responsible for preventive maintenance requirements.
Environmental and Legal Risk			
Reduction of water	ULB, state	In areas where ground water is supplied	Change in operation

Risk	Key Incidence of risk	Description	Mitigation Measure
level	government and general population	through submersible pumps, another important risk is reduction of water level due to over drawl of water by the farmers because of more efficient high discharge new pumps. This could result in many short and long term environmental effects. If the water table is not recharged consistently if might result in other long term effects including desertification.	guidelines, i.e. reduction if water supply hours if the flow is increased
Utilization of old inventory in other areas	ULB and EESL	If the collected inefficient pumps are not destroyed they could be used again. This would defeat the purpose of the project and lead to over-estimation of environmental benefits associated with the project.	Proper destruction of old inventory
Health, Safety and Social risk			
Health Safety and Social risk	ULB and EESL	As principal employer EESL is responsible for these risks including: • Nonpayment of minimum wages • Child labor • Insurance for workers • Emergency preparedness, fire & electrical safety • Safety of tools and equipment used	EESL should contractually make the technology supplier and contractor adequately responsible for this risk. As principal employer of all the people working under this project, EESL should collect proper documentation.

12 Project Implementation Schedule

12.1 Execution Strategy

EESL and other stakeholders need to pay attention to project execution in order to deliver impactful projects. The efforts and money on a project that is poorly executed do not produce results on the expected lines.

Following are the project execution strategies to keep projects running efficiently and on schedule:

Define specific and measurable objectives: The well-executed project is seen as one that achieves its desired results. Those specifics should include:

- The timeline for the project- Identify milestones and deadlines that are needed to accomplish incremental progress.
- The staff and infrastructure resources necessary to complete the project. This would include full-time employees, outside contractors, part-time staff or specialized freelance support to properly execute the project.
- The cost of the project- Be sure to take into account human resources and material costs, including hardware and software or consulting fees, travel or other incremental expenses.

Plan for the unexpected: The project managers should take into account that not everything will go as planned. Being prepared for changes also means standing behind a project's goals on a broad level. As the project is being executed, project leaders should be able to explain and support what has happened in the project to date, along with: current status, what the results thus far mean to the project and its objectives, and what specific impact these results will have on the project in terms of cost reduction, broader opportunities, etc.

Measure progress through project waypoints: The process to improvement must invariably include measurement; and not just on a one-and-done basis. The different stakeholders need to measure progress along the way to see an updated view of the project so that they can respond immediately if (and when) project parameters need to be re-calibrated or changed. Measurement should be happening organically so that project leaders have visibility into the time commitment of project participants and the cost of materials and infrastructure.

12.2 Proposed schedule

The total implementation period of the EEM's as per the schedule provided by the pumping station is given in table 60.

Table 60: Project Implementation Schedule

T0: Date of signing of MoU between State Government and EESL

Sr. No	Activity	T0	T0 + 30 days	T0 + 90 days	T0 + 105 days	T0 + 135 days
1	Signing of MoU between State Government and EESL					
2	Inviting tenders for hiring of agency to prepare IGEA Report					
3	Preparation of IGEA and submission to ULB					
4	Submission of IGEA to SLTC by ULB					
5	SLTC approval on IGEA					

T1: Date of signing tripartite agreement between State Government, ULB and EESL, known as effective date

Sr. No	Activity	T1	T1 + 30 days	T1 + 90 days	T1 + 255 days	T1 + 270 days
1	Signing of tripartite agreement between State Government, ULB and EESL					
2	Inviting tenders for selection of pump supplier					
3	Selection of pump supplier					
4	Installation of energy efficient pump sets at ULB					
5	Submission of M & V report to ULB by EESL					

Since the ULB has water supplying priorities; the implementation is proposed to be carried out in such a way that the operation of pumping station is not impacted.

13 Annexures

The Annexures have been compiled as a separate document.

List of Annexures:

1. Energy Auditor/Manager Certificate
2. Verified Job Cards
3. Calibration Certificates of Instruments
4. Undertaking from ULB regarding unavailability of Electricity bills
5. Electricity Bills
6. Budgetary Quotations from Pump Manufacturers