Nagar Palika Parishad,
Fatehpur

INVESTMENT GRADE ENERGY AUDIT REPORT

NAGAR PALIKA PARISHAD, FATEHPUR UP

Submitted by

Energy Efficiency Services Limited

Submitted To

NAGAR PALIKA PARISHAD, FATEHPUR, UP

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- Mr. Pawan Kumar – Team Member, TUV SUD South Asia Private Limited
- Mr. Pankaj Kumar – Team Member, TUV SUD South Asia Private Limited

On Behalf of Energy Efficiency Services Limited

Mr. Tarun Tayal – Zonal Manager (Central Zone), EESL

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 Housing and Urban Affairs (MoHUA), 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, Government of UP has jointly entered into an agreement on 09th Feb 2017 in order to provide an overarching framework to facilitate engagement between State Government and various ULBs (covered under AMRUT) of UP. Under this agreement, EESL is undertaking the project to replace old inefficient pump sets by energy efficient pump sets in Fatehpur, City of UP.

Description of Facilities

Fatehpur District is one of the 71 districts of Uttar Pradesh state in northern India. The district covers an area of 4,152 km square. Fatehpur city is administrative headquarters of district. Located on the banks of the sacred rivers Ganges and Yamuna, Fatehpur was mentioned in the puranic literature. The ghats of Bhitaura and Asani were described as sacred in the puranas. Bhitaura, the site of the sage Bhrigu, was an important source of learning. Fatehpur district is a part of Allahabad Division.

Source of water in the city is ground water. This is serving the water demand of the Fatehpur city as on 2017. The water supply system at Fatehpur includes 47 no's Submersible pumps. Out of 47 pumps, 3 pumps' bore are blocked and 4 pumps are under maintenance. 38 pumps directly supply water to end users and 9 pumps supply water to Over Head Tanks/ direct users. During the audit, auditors observed that OHT were not operational, water is direct supplied to end users and NPP officials also confirmed that OHT are not operational and water is supplied directly to users. NPP officials informed that OHT is not filled by pumps, due to the low pressure for all pumps. As advised by EESL and NPP we have considered total head of 55 m with the 25 m head addition owing to future requirement of filling OHT. The operating period for the distribution pumps depends on the level of water in the ground, while the operating period for the transmission line depends on the requirement at the receiving site. Pumps for water supply services in the city are tabulated in the following table:

Description of facility and water storage capacity

S. No.	Pump House Name	Type Of Pump	Type of the facility	Source of water	MLD Capacity	Type of Storage	No. of UGR/ OHT
1	Lodhi Ganj TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
2	Fire Station Shanti Nagar TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
3	Behind MG College Shantinagar TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
4	Pakka Talab O/HT TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
5	Pakka Talab TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
6	Pakka Talab Tiraha TW-3A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
7	Sarai TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
8	Peranpur O/HT TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
9	Chhotibazar TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
10	Gadhiva TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
11	Kotwali TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
12	Gadhiva (Krishna Nagar) TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
13	Verma Chauraha(Sai Mandir) TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
14	Verma Chauraha(Chungi Chauk)TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
15	Sllater House TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
16	Anandpuram TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
17	Muraintola TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
18	Muraintola O/HT TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
19	Muraintola TW-3A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
20	Muraintola TW-4A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
21	Moosepur (Gadariyan Purwa) TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
22	Turab Ali Ka Purwa TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
23	Turab Ali Ka Purwa TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
24	Nagar Palika Campus TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
25	Tambeshwar Chauraha TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-

S. No.	Pump House Name	Type Of Pump	Type of the facility	Source of water	MLD Capacity	Type of Storage	No. of UGR/ OHT
26	New Tahsil TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
27	Asti O/HT TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
28	Asti TW-2B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
29	Patelnagar TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
30	50 No. Railway Gate TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
31	Aboonagar Redaiya TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
32	CO Office TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
33	Maharishi Vidya Mandir TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
34	Awas Vikas O/HT TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
35	Awas Vikas TW-2B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
36	Jairam Nagar, Joniha Chauraha TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
37	Shadipur O/HT TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
38	Deviganj TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
39	Deviganj TW-2C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
40	Deviganj TW-3C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
41	Jhaoopur TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
42	Khambhapur TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
43	Dhakauli Bahua Road TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
44	Radhanagar O/HT TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
45	Radhanagar TW-2C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
46	Andauli TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
47	Shadipur SP Office TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-

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:

Sr. No	Pump Type	Pump Capacity Range (kW)	Weighted average pump efficiency (%)	Weighted average pump set efficiency (%)
1	Submersible	22.37 kW to 30.57 kW	33.62	36.54

Performance Indicators (SEC, kWh/kL)

In order to evaluate the actual performance and efficiency of the installed pump sets in all the pumping stations, following table takes into account set of different performance indicators such as specific energy consumption and efficiency:

Performance Indicators of pump sets in reference to Pump Location

Sr. No.	Pump Reference	Type Of Pump	Total Measured head (m)	Measured power cons. (kW)	Pumping quantity (kL)	Estimated annual operating hours	Estimated quantity pumped per annum (kL)	Estimated annual power consumption (kWh/annum)	Estimated SEC (kW/kL)	Pump Efficiency (%)	Pump set Efficiency (%)
1	Lodhi Ganj TW-1A	Submersible	29.43	41.32	138.37	4,380	606,061	180,982	0.299	29.19	26.86
2	Fire Station Shanti Nagar TW-2A	Submersible	29.43	42.92	103.08	4,380	451,490	187,990	0.416	20.94	19.26
3	Behind MG College Shantinagar TW-1A	Submersible	29.43	33.36	155.31	4,380	680,258	146,117	0.215	40.58	37.34
4	Pakka Talab O/HT TW-1A	Submersible	29.43	21.01	23.56	4,380	103,193	92,024	0.892	9.78	8.99
5	Pakka Talab TW-2A	Submersible	29.43	26.87	92.6	4,380	405,588	117,691	0.290	30.04	27.64
6	Sarai TW-1A	Submersible	29.43	25.44	124.63	4,380	545,879	111,427	0.204	42.70	39.29
7	Peeranpur O/HT TW-1A	Submersible	29.43	25.94	186.53	4,380	817,001	113,617	0.139	62.68	57.67
8	Gadhiva TW-1A	Submersible	29.43	22.58	130.85	4,380	573,123	98,900	0.173	50.51	46.47
9	Kotwali TW-1A	Submersible	29.43	9.73	53.36	4,380	233,717	42,617	0.182	47.80	43.98
10	Gadhiva (Krishna Nagar) TW-1A	Submersible	29.43	21.23	95.87	4,380	419,911	92,987	0.221	39.36	36.22
11	Verma Chauraha(Sai Mandir) TW-1A	Submersible	29.43	20.46	101.27	4,380	443,563	89,615	0.202	43.15	39.69
12	Sllater House TW-1A	Submersible	29.43	26.39	92.52	4,380	405,238	115,588	0.285	30.56	28.12
13	Anandpuram TW-1A	Submersible	29.43	25.41	102.1	4,380	447,198	111,296	0.249	35.03	32.22
14	Muraintola TW-1A	Submersible	29.43	15.2	70.73	4,380	309,797	66,576	0.215	40.56	37.32
15	Muraintola O/HT TW-2A	Submersible	29.43	23.93	93.33	4,380	408,785	104,813	0.256	34.00	31.28
16	Muraintola TW-3A	Submersible	29.43	21.78	100.7	4,380	441,066	95,396	0.216	40.30	37.08
17	Muraintola TW-4A	Submersible	29.43	25.41	83.34	4,380	365,029	111,296	0.305	28.59	26.30
18	Turab Ali Ka Purwa TW-1A	Submersible	29.43	28.1	122.69	4,380	537,382	123,078	0.229	38.06	35.02
19	Nagar Palika Campus TW-1A	Submersible	29.43	23.03	110.73	4,380	484,997	100,871	0.208	41.91	38.56

Sr. No.	Pump Reference	Type Of Pump	Total Measured head (m)	Measured power cons. (kW)	Pumping quantity (kL)	Estimated annual operating hours	Estimated quantity pumped per annum (kL)	Estimated annual power consumption (kWh/annum)	Estimated SEC (kW/kL)	Pump Efficiency (%)	Pump set Efficiency (%)
20	Tambeshwar Chauraha TW-1B	Submersible	29.43	24.15	95.83	4,380	419,735	105,777	0.252	34.59	31.82
21	New Tahsil TW-1B	Submersible	29.43	19.34	92.24	4,380	404,011	84,709	0.210	41.57	38.25
22	Asti O/HT TW-1B	Submersible	29.43	27	88.33	4,380	386,885	118,260	0.306	28.52	26.24
23	Asti TW-2B	Submersible	29.43	18.53	55.33	4,380	242,345	81,161	0.335	26.03	23.95
24	Patelnagar TW-1B	Submersible	29.43	21.56	97.46	4,380	426,875	94,433	0.221	39.40	36.25
25	50 No. Railway Gate TW-1B	Submersible	29.43	28.83	121.42	4,380	531,820	126,275	0.237	36.71	33.78
26	Aboonagar Redaiya TW-1B	Submersible	29.43	24.15	136.83	4,380	599,315	105,777	0.176	49.39	45.44
27	CO Office TW-1B	Submersible	29.43	24.99	103.62	4,380	453,856	109,456	0.241	36.14	33.25
28	Maharishi Vidya Mandir TW-1B	Submersible	29.43	23.02	112.42	4,380	492,400	100,828	0.205	42.57	39.16
29	Awas Vikas O/HT TW-1B	Submersible	29.43	19.27	96.61	4,380	423,152	84,403	0.199	43.70	40.21
30	Awas Vikas TW-2B	Submersible	29.43	19.5	107.69	4,380	471,682	85,410	0.181	48.14	44.29
31	Jairam Nagar, Joniha Chauraha TW-1C	Submersible	29.43	17.26	37.83	4,380	165,695	75,599	0.456	19.11	17.58
32	Shadipur O/HT TW-1C	Submersible	29.43	30.02	145.6	4,380	637,728	131,488	0.206	42.28	38.90
33	Deviganj TW-1C	Submersible	29.43	29.88	133.65	4,380	585,387	130,874	0.224	38.99	35.87
34	Deviganj TW-2C	Submersible	29.43	21.75	87.76	4,380	384,389	95,265	0.248	35.17	32.36
35	Deviganj TW-3C	Submersible	29.43	25.69	101.6	4,380	445,008	112,522	0.253	34.47	31.72
36	Khambhapur TW-1C	Submersible	29.43	23.87	101.03	4,380	442,511	104,551	0.236	36.89	33.94
37	Dhakauli Bahua Road TW-1C	Submersible	29.43	21.01	75.5	4,380	330,690	92,024	0.278	31.32	28.82
38	Radhanagar O/HT TW-1C	Submersible	29.43	22.86	78.62	4,380	344,356	100,127	0.291	29.98	27.58
39	Andauli TW-1C	Submersible	29.43	23.89	86.83	4,380	380,315	104,638	0.275	31.68	29.15
40	Shadipur SP Office TW-1C	Submersible	29.43	27.4	92.09	4,380	403,354	120,012	0.298	29.30	26.95
	Total						**17,650,787**	**4,266,470**	**0.242**		

Summary of Project Cost Benefit Analysis

The energy saving has been calculated on the basis of energy audit activity conducted at all the sites. 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) (Replacement with Energy Efficient Pump)	Annual Energy Savings (kWh/Annum)	Investment Cost (Rs. Lakhs)	Monetary Cost Saving per annum (Rs. Lakhs)	Payback Period (Months)
1	Lodhi Ganj TW-1A	46,655	1.91	3.71	6
2	Fire Station Shanti Nagar TW-2A	84,263	1.70	6.70	3
3	Pakka Talab TW-2A	24,690	1.54	1.96	9
4	Sllater House TW-1A	22,596	1.54	1.80	10
5	Muraintola O/HT TW-2A	11,721	1.54	0.93	20
6	Muraintola TW-4A	33,004	1.49	2.62	7
7	Tambeshwar Chauraha TW-1B	12,465	1.54	0.99	19
8	Asti O/HT TW-1B	13216	1.57	1.05	18
9	Asti TW-2B	25815	1.54	2.05	9
10	Jairam Nagar, Joniha Chauraha TW-1C	35,982	1.22	2.86	5
11	Dhakauli Bahua Road TW-1C	20,287	1.44	1.61	11
12	Radhanagar O/HT TW-1C	28,081	1.44	2.23	8
13	Andauli TW-1C	12,339	1.54	0.98	19
14	Shadipur SP Office TW-1C	27,060	1.54	2.15	9
	Total	**398,174**	**21.55**	**31.64**	**8**

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. We have also not considered those pumps having difference of more than 10% between the pump set efficiency of existing pumps and proposed pumps.

Implementation of the energy efficiency measures on pumping system may result in annual energy savings of 398,174 kWh per year which is 24.64% of the existing electricity consumption. This energy saving is equivalent to 34.24 toe and results in reduction 326.50 tCO_2 per year.

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, 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 are provided in the table below:

Project Capital Cost

Capital Cost Related assumption	Unit	Value
Number of Pumps	*No.*	14
Total Cost of Equipment including installation, commissioning and testing	*INR lakhs*	21.58
Cost of pump including motor	*INR lakhs*	11.59
Cost of NRV	*INR lakhs*	3.07
Cost of Gate valve	*INR lakhs*	4.06
Cost of Web based dashboard	*INR lakhs*	1.08
Installation and Commissioning Cost including testing charges	*INR lakhs*	1.79
EESL's administrative and establishment charge	*%*	5
Cost of preparation of IGEA report including EESL service charges and applicable GST	*INR lakhs*	9.98
Total Project Cost w/o Capitalized interest	*INR lakhs*	32.64
Commissioning Details		
Total Months for Commissioning	*months*	9
Capitalized interest	*INR lakhs*	1.83
Total Project Cost	*INR lakhs*	34.47

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 are provided in the table below.

Project Operating Cost

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

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
Term of the project	***year***								
Calculations of annuity payment									
Total Debt to be repaid	*INR lakh*	5.96	5.58	5.20	4.82	4.44	4.06	3.68	33.75
Principal Repayment	*INR lakh*	3.45	3.45	3.45	3.45	3.45	3.45	3.45	24.13
Interest	*INR lakh*	2.51	2.13	1.75	1.37	1.00	0.62	0.24	9.62
Total Equity Repayments	*INR lakh*	3.87	3.51	3.15	2.79	2.43	2.06	1.70	19.51
Recovery of equity investment	*INR lakh*	1.48	1.48	1.48	1.48	1.48	1.48	1.48	10.34
Return on equity	*INR lakh*	2.39	2.03	1.67	1.31	0.95	0.59	0.23	9.17
R&M Charges	*INR lakh*	0.00	0.54	1.62	2.05	2.48	3.24	3.88	13.81
EESL's administrative and establishment charge	*INR lakh*	1.38	1.45	1.52	1.60	1.68	1.76	1.85	11.23
Annuity Payment to EESL	*INR lakh*	11.21	11.08	11.49	11.25	11.03	11.12	11.12	78.29
Service Tax on annuity payment	*INR lakh*	2.02	1.99	2.07	2.03	1.98	2.00	2.00	14.09
Annuity Payment to EESL incl. Goods and Services Tax	*INR lakh*	13.23	13.07	13.56	13.28	13.01	13.13	13.12	92.39
Total Savings	*INR lakh*	31.65	30.57	29.35	27.98	26.46	24.77	22.90	193.68
Profit to ULB	*INR lakh*	18.43	17.50	15.79	14.70	13.45	11.64	9.78	101.29
% of savings with ULBs	*%*								52.30%

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%	56.23%
-5%	54.26%
0%	52.30%
5%	50.33%
10%	48.37%
Change in Interest(ROE, Interest, D/E ratio)	**% of savings retained by the utility**
-10%	47.00%
-5%	49.79%
0	52.30%
5%	54.57%
10%	56.63%

Key facts of IGEA

Key facts of the project are as follows:

Particular	Unit	Value
Total number of pump sets as per LOA	Nos.	47
Total number of pump sets present at the site	Nos.	47
Total number of pump sets under maintenance	Nos.	7
Total number of pump sets where measurement was not possible	Nos.	0
Total number of pump sets not Identified	Nos.	0
Total number of pump sets audited	Nos.	40
Total numbers of pumps sets considered for replacement	Nos.	14
Estimated present annual energy consumption (for 14 pump sets)	kWh	1,615,957
Estimated annual energy consumption with proposed EEPS (for 14 pump sets)	kWh	1,217,783
Estimated Annual Energy Saving Present (for 14 pump sets)	kWh	398,174
Percentage energy saving potential	%	24.64%
Total project cost (including IGEA cost and capitalized interest)	Rs. Lakhs	34.47

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 house	Rated Flow (m^3/hr.)	Rated Head (m)	Motor rating (kW)	Flow (m^3/hr)	Total head (m)	Actual power cons. (kW)	Pump efficiency (%)	NRV to be installed (Yes/No)	Gate valve to be installed (Yes/No)	Apparatus for Web based dashboard (Yes/No)
Lodhi Ganj TW-1A	-	25	22.5	138.37	29.43	41.32	29.19	Yes	Yes	Yes
Fire Station Shanti Nagar TW-2A	-	25	22.5	103.08	29.43	42.92	20.94	Yes	Yes	Yes
Pakka Talab TW-2A	-	25	22.5	92.6	29.43	26.87	30.04	Yes	Yes	Yes
Sllater House TW-1A	-	25	22.5	92.52	29.43	26.39	30.56	Yes	Yes	Yes
Muraintola O/HT TW-2A	-	25	22.5	93.33	29.43	23.93	34.00	Yes	Yes	Yes
Muraintola TW-4A	-	25	22.5	83.34	29.43	25.41	28.59	Yes	Yes	Yes
Tambeshwar Chauraha TW-1B	-	25	22.5	95.83	29.43	24.15	34.59	Yes	Yes	Yes
Asti O/HT TW-1B	-	32	30.75	88.33	29.43	27	28.52	Yes	Yes	Yes
Asti TW-2B	--	25	22.5	55.33	29.43	18.53	26.03	Yes	Yes	Yes
Jairam Nagar, Joniha Chauraha TW-1C	-	25	22.5	37.83	29.43	17.26	19.11	Yes	Yes	Yes
Dhakauli Bahua Road TW-1C	-	32	32.75	75.5	29.43	21.01	31.32	Yes	Yes	Yes
Radhanagar O/HT TW-1C	-	25	22.5	78.62	29.43	22.86	29.98	Yes	Yes	Yes
Andauli TW-1C	-	25	31.75	86.83	29.43	23.89	31.68	Yes	Yes	Yes
Shadipur SP Office TW-1C	-	25	30.75	92.09	29.43	27.4	29.30	Yes	Yes	Yes

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ABBREVIATIONS

AMRUT	Atal Mission Rejuvenation and Urban Transformation
APFC	Automatic Power Factor Control
BEP	Best Efficiency Points
BPS	Booster Pumping Stations
CEA	Certified Energy Auditor
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
MoHUA	Ministry of Housing and Urban Affairs
MoU	Memorandum of Understanding
NPP	Nagar Palika Parishad
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
TOE	Tonne of oil equivalent
ULB	Urban Local Body
VFD	Variable Frequency Drive
WTP	Water Treatment Plant

1. Introduction

1.1 Background of the Project

The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) was launched by the Prime Minister of India in June 2015 with the objective of providing basic services (e.g. water supply, sewerage, urban transport) to households and building amenities in cities to 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 Housing and Urban Affairs (MoHUA), Government of India signed a Memorandum of Understanding (MoU) with Energy Efficiency Services Limited (EESL), a public sector entity 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 from of fixed annuity.

Energy audit and optimizing energy consumption are mandatory reforms under AMRUT. EESL and Department of Urban Department, Government of U.P. have jointly entered into an agreement on 09th Feb, 2017 in order to provide an overarching framework to facilitate engagement between the state government and various ULBs (covered under AMRUT) of UP. Under this agreement, EESL is undertaking the project to replace old inefficient pump sets by energy efficient pump sets in Fatehpur City of UP.

According to MoHUA, energy audit 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 programmes across the country and will ensure supply of latest technologies under these municipal programmes".

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 to4, 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 the cost of the proposed Municipal Energy Efficiency Programmes would be borne out of the savings. MoU states that performance contracting offers a mechanism for ULBs 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 Sewerage 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 DUD and EESL was signed successfully on 09th Feb 2017, EESL initiated an open tendering process for hiring Energy Auditing Agency through competitive bidding. Based on the bidding evaluation, M/s TUV SUD South Asia Private Limited was selected for doing the energy audit for Fatehpur city. EESL has engaged M/s. TUV SUD South Asia Private Limited for preparation of (IGEA) reports for Nagar Palika Parishad (NPP), Fatehpur with an objective to replace inefficient pump sets with efficient ones vide its work order Ref: EESL/06/2017-18/Energy Audit/Fatehpur/22-61/LOA-1718167 dated 25/08/2017.

1.2 Stakeholders Involved

There are many stakeholders involved in AMRUT. Their roles and responsibilities are already defined by the MoHUA and other technical committee. Generally, the MoHUA, EESL, ULB and NPP, Fatehpur have major role to execute under AMRUT.

MoHUA: The MoHUA 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 MoHUA 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.

DUD: Department of Urban Development was setup to ensure the proper implementation and monitoring of the centrally assisted programme. 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 – TUV SUD South Asia Private Limited: EESL has engaged M/s. TUV SUD South Asia Private Limited for preparation of IGEA reports for public water works in Fatehpur, UP with an objective to replace inefficient pump sets with energy efficient ones. M/s. TUV SUD South Asia Private Limited had conducted energy audit activity at Fatehpur and had made IGEA with financial projections for Fatehpur 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 MoHUA 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 discussions 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, Sewerage 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 Nagar Palika Parishad, Fatehpur from 13/09/2017 to 21/09/2017 & 3/10/2017. The energy audit team of TUV SUD South Asia Private Limited comprised of BEE certified energy auditors/managers and pump experts. During the field visit, adequate numbers 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 under the in-charge Executive Engineer, Water Supply, NPP, Fatehpur on 13th Sep, 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. TUV SUD South Asia Private Limited 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 a few pumping stations in city on 13th Sep, 2017 following points were discussed:

- Support from the ULB will be given to the TUV SUD South Asia Private Limited team for conducting energy audit
- Energy audit will be conducted by TUV SUD South Asia Private Limited team in presence of EESL personnel &nodal official of ULB
- Observations will be discussed with the appointed officials of ULB and EESL
- TUV SUD South Asia Private Limited 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.
- TUV SUD South Asia Private Limited will regularly report the ULB official by informing the status of work and work schedule
- TUV SUD South Asia Private Limited will report the status of work on a daily basis to project-coordinator of EESL
- TUV SUD South Asia Private Limited to submit the job card to EESL after completion of site work
- Signature of authorized personnel should be obtained on 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 has 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 TUV SUD South Asia Private Limited 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

Fatehpur District is one of the 71 districts of Uttar Pradesh state in northern India. The district covers an area of 4,152 km square. Fatehpur city is administrative headquarters of district. Located on the banks of the sacred rivers Ganges and Yamuna, Fatehpur was mentioned in the puranic literature. The ghats of Bhitaura and Asani were described as sacred in the puranas. Bhitaura, the site of the sage Bhrigu, was an important source of learning. Fatehpur district is a part of Allahabad Division.

This district is situated between two important cities: Allahabad, which is also known as "Prayag", and Kanpur of the state Uttar Pradesh. Fatehpur is well connected with those cities by train routes and roads. The distance from Allahabad is 117 km and from Kanpur is 76 km by railway. The north boundary of the district is limited by the river Ganges and its southern boundary is the river Yamuna.

Details about city population are provided in table 1.

Table 1: Population data for city[1]

Description	Nos.
Population (2001)	2,308,384
Population (2011)	2,632,733

3.2 Accessibility to city from Metro cities & State capital

Rail

This city is connected with important cities by train. Fatehpur Station is on the main route of New Delhi-Kolkata. Trains are available frequently. It has longest platform of any station on the route from Howrah to Delhi.

Road

Fatehpur is fairly well connected to other parts of Uttar Pradesh and India with national and state highways. The national highway (NH2) (Grand Trunk Road known as G.T. Road) passes through Fatehpur. Fatehpur is 78 km from Kanpur, 121 km from Allahabad and state capital Lucknow is 120 km away. There are frequent buses to Kanpur, Allahabad, Banda, Uttar Pradesh, and Lucknow.

Air

The closest major airport to Fatehpur is Kanpur Airport (KNU / VICX). This airport is in Kanpur, and is 74 km from the center of Fatehpur.

[1]http://www.censusindia.gov.in/towns/up_towns.pdf

3.3 Pumping Stations in Fatehpur city

Source of water in the city is ground water. This is serving the water demand of the Fatehpur city as on 2017. The water supply system at Fatehpur includes 47 no's Submersible pumps. Out of 47 pumps, 3 pumps' bore are blocked and 4 pumps are under maintenance. 38 pumps directly supply water to end users and 9 pumps supply water to Over Head Tanks/ direct users. During the audit, auditors observed that OHT were not operational, water is direct supplied to end users and NPP officials also confirmed that OHT are not operational and water is supplied directly to users. NPP officials informed that OHT is not filled by pumps, due to the low pressure for all pumps. As advised by EESL and NPP we have considered total head of 55 m for new pumps with the 25 m head addition owing to future requirement of filling OHT. The operating period for the distribution pumps depends on the level of water in the ground, while the operating period for the transmission line depends on the requirement at the receiving site. The further supplied to the city shown in Figure 1.

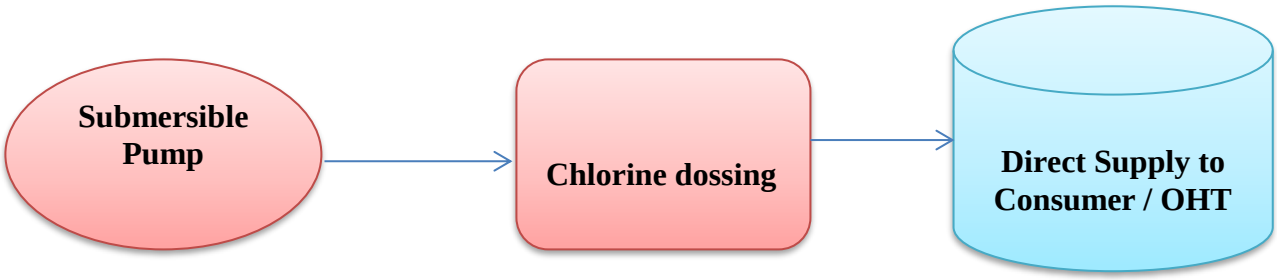

Figure 1 Pumping Station Overview

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

Table 2: Details of Water Supply Pumps:

S. No.	Pump House Name	Type Of Pump	Type of the facility	Source of water	MLD Capacity	Type of Storage	No. of UGR/ OHT
1	Lodhi Ganj TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
2	Fire Station Shanti Nagar TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
3	Behind MG College Shantinagar TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
4	Pakka Talab O/HT TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
5	Pakka Talab TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
6	Pakka Talab Tiraha TW-3A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
7	Sarai TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
8	peeranpur O/HT TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
9	Chhotibazar TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
10	Gadhiva TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
11	Kotwali TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-

S. No.	Pump House Name	Type Of Pump	Type of the facility	Source of water	MLD Capacity	Type of Storage	No. of UGR/ OHT
12	Gadhiva (Krishna Nagar) TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
13	Verma Chauraha(Sai Mandir) TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
14	Verma Chauraha(Chungi Chauk)TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
15	Sllater House TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
16	Anandpuram TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
17	Muraintola TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
18	Muraintola O/HT TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
19	Muraintola TW-3A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
20	Muraintola TW-4A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
21	Moosepur (Gadariyan Purwa) TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
22	Turab Ali Ka Purwa TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
23	Turab Ali Ka Purwa TW-2A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
24	Nagar Palika Campus TW-1A	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
25	Tambeshwar Chauraha TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
26	New Tahsil TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
27	Asti O/HT TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
28	Asti TW-2B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
29	Patelnagar TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
30	50 No. Railway Gate TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
31	Aboonagar Redaiya TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
32	CO Office TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
33	Maharishi Vidya Mandir TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
34	Awas Vikas O/HT TW-1B	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
35	Awas Vikas TW-2B	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
36	Jairam Nagar, Joniha Chauraha TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
37	Shadipur O/HT TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
38	Deviganj TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1

S. No.	Pump House Name	Type Of Pump	Type of the facility	Source of water	MLD Capacity	Type of Storage	No. of UGR/ OHT
39	Deviganj TW-2C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
40	Deviganj TW-3C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
41	Jhaoopur TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
42	Khambhapur TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
43	Dhakauli Bahua Road TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
44	Radhanagar O/HT TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply/OHT	1
45	Radhanagar TW-2C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
46	Andauli TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-
47	Shadipur SP Office TW-1C	Submersible	Water Supply	Ground Water	Nil	Direct Supply	-

3.4 Historical Water Pumped and Energy Consumption Analysis

Historical data about water pumped and energy consumption of NPP, Fatehpur is provided in table below.

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)
Apr-14 to Mar-15	NA	NA	NA
Apr-15 to Mar-16	NA	NA	NA
Apr-16 to Mar-17	17,650,787	4,266,470	0.242

3.5 Power Failure Data

Power failure data is not available with NPP, Fatehpur.

3.6 Rainfall and Climate data

Rainfall and climate data of Nagar Palika Parishad, Fatehpur is provided in Table 4.

Table 4 Rainfall and climate data of Fatehpur[2]

	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Avg. Temperature (°C)	15.7	18.4	24	29.6	33.1	32.7	29.7	29.2	28.8	26.1	20.8	16.7
Min. Temperature (°C)	8.7	11	15.7	21.3	25.9	27.2	26.2	26	24.9	20.2	13	9.2
Max. Temperature (°C)	22.8	25.9	32.4	37.9	40.3	38.2	33.2	32.4	32.7	32.1	28.6	24.3
Precipitation / Rainfall (mm)	31	9	12	2	16	115	310	302	171	76	1	7

3.7 Ground Water Profile[3]

The average annual rainfall is 932 mm. The climate is typical sub humid punctuated by long and intense summer and mild winter. About 90% of annual rain fall is received from south west monsoon. May is the hottest month with temperature shooting up to 46.5 degree C. January is generally the eldest month and temperature drops generally 80 degree C but occasionally even up to 40 degree C.

Annual seasonal fluctuations of water level have been determined from the pre monsoon (May) and post monsoon (Nov.) water level data of ground water monitoring wells. The fluctuation varies from min. 0.65 mbgl to max 19.25 mbgl.

[2] https://en.climate-data.org/location/767335/

[3] CENTRAL GROUND WATER BOARD Ministry of Water Resources

3.8 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 are provided in the table5:

Table 5: Water cost estimation

Particular	Units	Values
Energy cost (Electricity) (2016-17)	Rs. Lakhs	NA
Repair & Maintenance	Rs. Lakhs	8.34
Operation (Man Power & Raw Material)	Rs. Lakhs	NA
Miscellaneous cost (Cost of Major Replacement)	Rs. Lakhs	NA
Total cost	Rs. Lakhs	8.34
Annual water pumped to City (estimated)	kL	17,650,787
Water cost	Rs./kL	NA

4. Pumping Stations Performance Evaluation

Source of water in the city is ground water. This is serving the water demand of the Fatehpur city as on 2017. The water supply system at Fatehpur includes 47 no's Submersible pumps. Out of 47 no's pumps, 3 no pumps bore are blocked and 4 no pumps are under maintenance. The 38 no's Pumps direct supply water to end users and 9 no's pumps Supply water to Over Head Tanks/ direct users. During the audit, auditors observed that OHT were not operational, water is direct supply to end users and NPP officials also confirmed that OHT are not operational and water is supply to direct users. NPP officials informed that OHT is not filled by pumps, due to the low pressure for all pumps. As advised by EESL and NPP we have considered total head of 55 m for new pumps with the 25 m head addition owing to future requirement of filling OHT. The operating period for the distribution pumps depends on the level of water in the ground, while the operating period for the transmission line depends on the requirement at the receiving site.

4.1 Connected load at Pumping Stations

Based on the data collected of pumping station from NPP, Fatehpur office, details of connected load of pumps in pumping station is not provided by NPP Officials, detail provided in the table 6.

Table 6: Connected load details for the pumping stations

S. No.	Pump Reference No.	Type Of Pump	Connection no.	Sanctioned Load (kW)
1	Lodhi Gang TW-1A	Submersible	NA	NA
2	Fire Station Shanti Nagar TW-2A	Submersible	NA	NA
3	Behind MG College Shantinagar TW-1A	Submersible	NA	NA
4	Pakka Talab O/Ht TW-1A	Submersible	NA	NA
5	Pakka Talab TW-2A	Submersible	NA	NA
6	Pakka Talab Tiraha TW-3A	Submersible	NA	NA
7	Sarai TW-1A	Submersible	NA	NA
8	Preernapur TW-1A	Submersible	NA	NA
9	Chhotibazar TW-1A	Submersible	NA	NA
10	Ghadhiva TW-1A	Submersible	NA	NA
11	Kotwali TW-1A	Submersible	NA	NA
12	Ghadhiva TW-1A (Krishnanagar)	Submersible	NA	NA
13	Verma Chauraha, Sai Mandir TW-1A	Submersible	NA	NA
14	Verma Chauraha, Chungi Chauki TW-1A	Submersible	NA	NA
15	Sllater House TW-1A	Submersible	NA	NA
16	Anandpuram TW-1A	Submersible	NA	NA
17	Muraintola TW-1A	Submersible	NA	NA
18	Muraintola TW-2A	Submersible	NA	NA
19	Muraintola TW-3A	Submersible	NA	NA
20	Muraintola TW-4A	Submersible	NA	NA
21	Moosepur TW-1A	Submersible	NA	NA

S. No.	Pump Reference No.	Type Of Pump	Connection no.	Sanctioned Load (kW)
22	Turab Ali Ka Purwa TW-1A	Submersible	NA	NA
23	Turab Ali Ka Purwa TW-2A	Submersible	NA	NA
24	Nagar Palika Campus TW-1A	Submersible	NA	NA
25	Tambeshwer Chauraha TW-1B	Submersible	NA	NA
26	New Teshil TW- 1B	Submersible	NA	NA
27	Gram Asti TW-1B	Submersible	NA	NA
28	Asti TW-2B	Submersible	NA	NA
29	Patelnagar TW-1B	Submersible	NA	NA
30	50 No. Railway Gate TW-1B	Submersible	NA	NA
31	Aboonagar Redaiya TW-1B	Submersible	NA	NA
32	C O Office TW-1B	Submersible	NA	NA
33	Maharishi Vidya Mandir TW-1A	Submersible	NA	NA
34	Awas Vikas TW-1B	Submersible	NA	NA
35	Awas Vikas TW-2B	Submersible	NA	NA
36	Jairam Nagar TW-1C	Submersible	NA	NA
37	Shadipur S.P. Office TW-1C	Submersible	NA	NA
38	Deviganj TW-1C	Submersible	NA	NA
39	Deviganj TW-2C	Submersible	NA	NA
40	Deviganj` TW-3C	Submersible	NA	NA
41	Jhaoopur TW-1C	Submersible	NA	NA
42	Khambapur` TW-1C	Submersible	NA	NA
43	Dhakauli Bahua Road TW - 1C	Submersible	NA	NA
44	Radhanagar TW-1C	Submersible	NA	NA
45	Radhanagar TW-2C	Submersible	NA	NA
46	Andauli TW- 1C	Submersible	NA	NA
47	Shadipur TW-1C	Submersible	NA	NA

4.2 Fatehpur Pumping station

4.2.1 Overview of existing systems

Source of water in the city is ground water. This is serving the water demand of the Fatehpur city as on 2017. The water supply system at Fatehpur includes 47 no's Submersible pumps. Out of 47 no's pumps, 3 no pumps bore are blocked and 4 no pumps are under maintenance. The 38 no's Pumps direct supply water to end users and 9 no's pumps Supply water to Over Head Tanks/ direct users. During the audit, auditors observed that OHT were not operational, water is direct supply to end users and NPP officials also confirmed that OHT are not operational and water is supply to direct users.

Repair and maintenance cost were given by NPP Officials, No history cards of pumps showing cumulative operating hours, Operational, purchase of new pump/motor/accessories cost was not given by NPP, Officials. The generic layout diagram of pumping station is shown in Figure 2.

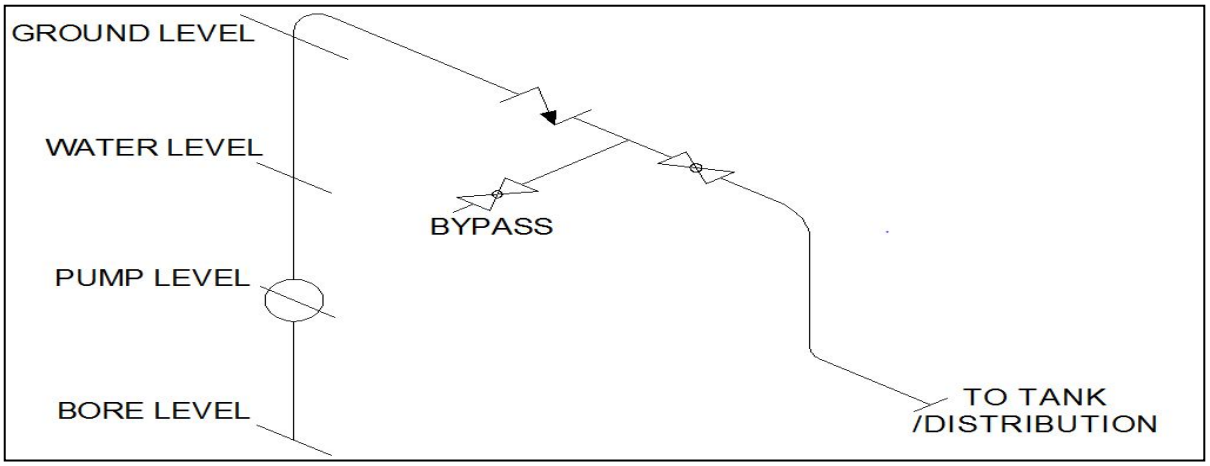

Figure 2 Generic Layout diagram of pumping station

4.2.2 Electricity Supply

All installations have low tension (LT) supply at 400V, 50Hz from electricity board. The NPP was provided us the total amount of Pump House, paid to electricity board. They have not provided us the electricity bills. The total amount paid by NPP FY-2014-15, FY-2015-16 & FY-2016-17 is indicated in Table-8. The SLD of the pumping system is shown in figure 3:

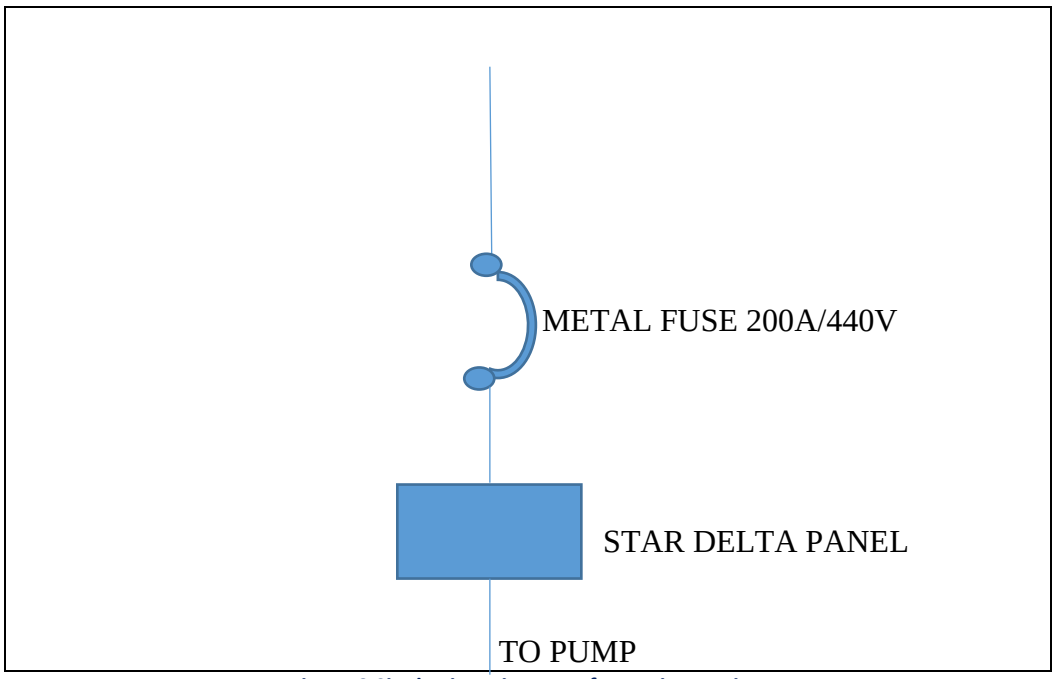

Figure 3 Single Line Diagram of Pumping station

4.2.3 Tariff structure

Fatehpur Pumping Station is getting supply from LT feeder at plant premises at different locations. The NPP was provided us the total amount of Pump House, paid to electricity board. They have not provided us the electricity bills. Details of tariff of LT connections have not been provided.

Table 7: Tariff structure

Description	Tariff Details
Tariff Code	LMV 7 – Public Water Works
Power supply	400 V
Energy charges (Unit rate)	Rs 7.95 Per kWh
Fixed/demand charge	Rs 290 / KW / month

All tube-well installations have low tension (LT) supply at 400V, 50Hz from PUVVNL under tariff category of consumers (Public water works), category- LMV-7.

4.2.4 Electrical Bill Analysis

The NPP was provided us the total amount paid to SEB of Pump House. They have not provided us the electricity bills. Summary of same has been tabulated in the table 8:

Table 8: Energy cost and energy consumption

Period of energy bill	Energy consumption (kWh/Annum)	Percentage Increase from previous year	Energy cost (Rs./Annum)
Apr-14 to Mar-15	NA	NA	13,521,030
Apr-15 to Mar-16	NA	NA	67,837,487
Apr-16 to Mar-17	NA	NA	54,084,120

4.2.5 Energy Consumption Pattern of Pumping Station

During energy audit, three phase power analyzer was installed for about 5-6 hours on LT side of Panel at each pumping station for recording variations of electrical parameters, key findings of analysis or recorded data is as follows:

Table 9: Energy Consumption Pattern

Voltage			Power Factor			VTHD			ITHD		
Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
338.2	441.8	394.5	0.68	0.96	0.86	1.3	3.4	2.24	4	5.4	4.7

4.2.6 Pumping Station System Mapping

Generic P&ID station of pumping stations of Fatehpur is provided in figure 4.

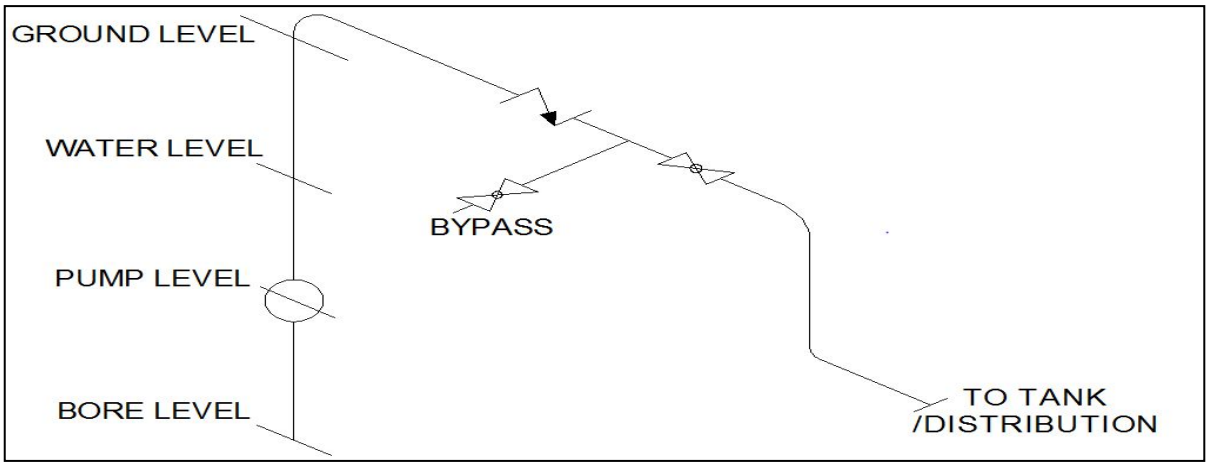

Figure 4 P&ID diagram of all pumping stations

4.2.7 Pumps Performance Evaluation

As per the methodology described in chapter-1, the study team collected detailed information from the pumping stations as per the guidelines provided in EESL job card.

Site data collection activities included the following:

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

Detailed energy audit at Nagar Palika Parishad, Fatehpur UP was conducted from 13/09/2017 to 21/09/2017 & 03/10/2017. The general details of the sites audited are given table 10:

Table 10 General details of Fatehpur Pumping stations

Date	Value/Details
Name of Site	Nagar Palika Parishad, Fatehpur
Classification (WTP, PS, SPS, STP)	Pumping Station
Pump installed	47
No. of pumps in operation	40
No. of pumps under maintenance	4
No. of pumps Blocked	3

Photographs captured at the Nagar Palika Parishad, Fatehpur to showcase the actual situation are provided in figure 5.

Figure 5 Photographs of Pumping Station

Out of 47 pumps, 3 pumps were blocked and 4 pumps were under maintenance. Pumps under maintenance/blocked were not covered in this energy audit. The details of the operational and under maintenance pumps are provided in table 10.

Table 11: Operational pumps

Location	Name of station	Total no. of pumps	Total no. of pumps audit is done	No. of pumps under Maintenance/ Blocked	Remarks
Nagar Palika Parishad, Fatehpur	Nagar Palika Parishad, Fatehpur	47	40	9	
	Pakka Talab Tiraha TW-3A	1	-	1	Blocked
	Chhotibazar TW-1A	1	-	1	Under Maintenance
	Verma Chauraha, Chungi Chauki TW-1A	1	-	1	Blocked
	Moosepur TW-1A	1	-	1	Under Maintenance
	Turab Ali Ka Purwa TW-2A	1	-	1	Under Maintenance
	Jhaoopur TW-1C	1	-	1	Under Maintenance
	Radhanagar TW-2C	1	-	1	Blocked
Total		**47**	**40**	**7**	

Note: - EESL RO team and NPP, Fatehpur has advised to consider additional 25 m head over and above present head for the proposed pump sets (This is in lieu of filling OHTs in the near future to serve the distribution network). Hence, additional 25 m head is considered in chapter 6 for proposed pumps.

The performance evaluation of the pumps was done based on the measurement done during energy audit. Results of performance evaluation of pumps are provided in table 12:

Table 12 Pumping Station pumps efficiency calculations

Pump Ref. Sr. No Pump Identification Rated Parameters	UOM	TW-1A Lodhi Ganj TW-1A	TW-2A Fire Station Shanti Nagar TW-2A	TW-1A Behind MG College Shantinagar TW-1A	TW-1A Pakka Talab O/HT TW-1A	TW-2A Pakka Talab TW-2A
Pump Type		Submersible	Submersible	Submersible	Submersible	Submersible
Rated Flow	m^3/hr.	NA	NA	NA	NA	NA
Rated Power	kW	22.5	22.5	30.75	22.5	22.5
Rated Head	meter	25	25	32	25	25
Parameters Measured						
Measured Flow	m^3/hr.	138.37	103.08	155.31	23.56	92.6
Measured Discharge Pressure (A)	Kgf/cm^2	0.1	0.1	0.1	0.1	0.1
Total Bore Length	meter	182.88	182.88	182.88	182.88	182.88
Water Level Below Ground (B)	meter	27.43	27.43	27.43	27.43	27.43
Height above Suction to measured gauge pressure if any (C)	meter	1	1	1	1	1
Static Discharge Head (D=B+C)	meter	28.43	28.43	28.43	28.43	28.43
Performance Evaluation						
Total Head (=(AX10)+(D)	meter	29.43	29.43	29.43	29.43	29.43
Head Utilization	%	117.72	117.72	91.97	117.72	117.72
Flow Utilization	%	-	-	-	-	-
Average kW	kW	41.32	42.92	33.36	21.01	26.87
Hydraulic Power	kW	11.10	8.27	12.46	1.89	7.43
Motor Efficiency	%	92	92	92	92	92
Pump Shaft Power	kW	38.01	39.49	30.69	19.33	24.72

Pump Ref. Sr. No Pump Identification Rated Parameters	UOM	TW-1A Lodhi Ganj TW-1A	TW-2A Fire Station Shanti Nagar TW-2A	TW-1A Behind MG College Shantinagar TW-1A	TW-1A Pakka Talab O/HT TW-1A	TW-2A Pakka Talab TW-2A
Pump Efficiency	%	29.19%	20.94%	40.58%	9.78%	30.04%
Overall (Pump Set) Efficiency	%	26.86%	19.26%	37.34%	8.99%[3]	27.64%
Specific Energy Consumption	kW/m^3	0.299	0.416	0.215	0.892	0.290

Pump Ref. Sr. No Pump Identification Rated Parameters	UOM	TW-1A Sarai TW-1A	TW-1A Peeranpur O/HT TW-1A	TW-1A Gadhiva TW-1A	TW-1A Kotwali TW-1A	TW-1A Gadhiva (Krishna Nagar) TW-1A
Pump Type		Submersible	Submersible	Submersible	Submersible	Submersible
Rated Flow	m^3/hr.	NA	NA	NA	NA	NA
Rated Power	kW	22.5	22.5	22.5	22.5	22.5
Rated Head	meter	25	25	25	25	25
Parameters Measured						
Measured Flow	m^3/hr	124.63	186.53	130.85	53.36	95.87
Measured Discharge Pressure (A)	kgf/cm^2	0.1	0.1	0.1	0.1	0.1
Total Bore Length	meter	182.88	182.88	182.88	182.88	182.88
Water Level Below Ground (B)	meter	27.43	27.43	27.43	27.43	27.43
Height above Suction to measured gauge pressure if any (C)	meter	1	1	1	1	1
Static Discharge Head (D=B+C)	meter	28.43	28.43	28.43	28.43	28.43
Performance Evaluation						
Total Head (=(AX10)+(D)	meter	29.43	29.43	29.43	29.43	29.43
Head Utilization	%	117.72	117.72	117.72	117.72	117.72

[3] Lower efficiency can case of the bore failure or lower water level, hence the pump is not considered for the replacement, as per discussion with ULB at time of audit (In absence of the rated parameters)

Pump Ref. Sr. No Pump Identification	UOM	TW-1A Sarai TW-1A	TW-1A Peeranpur O/HT TW-1A	TW-1A Gadhiva TW-1A	TW-1A Kotwali TW-1A	TW-1A Gadhiva (Krishna Nagar) TW-1A
Flow Utilization	%	-	-	-	-	-
Average kW	kW	25.44	25.94	22.58	9.73	21.23
Hydraulic Power	kW	9.99	14.96	10.49	4.28	7.69
Motor Efficiency	%	92	92	92	92	92
Pump Shaft Power	kW	23.40	23.86	20.77	8.95	19.53
Pump Efficiency	%	42.70%	62.68%	50.51%	47.80%	39.36%
Overall (Pump Set) Efficiency	%	39.29%	57.67%	46.47%	43.98%	36.22%
Specific Energy Consumption	kW/m^3	0.204	0.139	0.173	0.182	0.221

Pump Ref. Sr. No Pump Identification	UOM	TW-1A Verma Chauraha(Sai Mandir) TW-1A	TW-1A SIlater House TW-1A	TW-1A Anandpuram TW-1A	TW-1A Muraintola TW-1A	TW-2A Muraintola O/HT TW-2A
Rated Parameters						
Pump Type		Submersible	Submersible	Submersible	Submersible	Submersible
Rated Flow	$m^3/hr.$	NA	NA	NA	NA	NA
Rated Power	kW	30.75	22.5	30.75	22.5	22.5
Rated Head	meter	32	25	32	25	25
Parameters Measured						
Measured Flow	$m^3/hr.$	101.27	92.52	102.1	70.73	93.33
Measured Discharge Pressure (A)	kgf/cm^2	0.1	0.1	0.1	0.1	0.1
Total Bore Length	meter	182.88	182.88	182.88	182.88	182.88
Water Level Below Ground (B)	meter	27.43	27.43	27.43	27.43	27.43
Height above Suction to measured gauge pressure if any (C)	meter	1	1	1	1	1
Static Discharge Head (D=B+C)	meter	28.43	28.43	28.43	28.43	28.43

Pump Ref. Sr. No		TW-1A	TW-1A	TW-1A	TW-1A	TW-2A
Pump Identification	UOM	Verma Chauraha(Sai Mandir) TW-1A	Sllater House TW-1A	Anandpuram TW-1A	Muraintola TW-1A	Muraintola O/HT TW-2A
Performance Evaluation						
Total Head (=(AX10)+(D)	meter	29.43	29.43	29.43	29.43	29.43
Head Utilization	%	91.97	117.72	91.97	117.72	117.72
Flow Utilization	%	-	-	-	-	-
Average kW	kW	20.46	26.39	25.41	15.2	23.93
Hydraulic Power	kW	8.12	7.42	8.19	5.67	7.48
Motor Efficiency	%	92	92	92	92	92
Pump Shaft Power	kW	18.82	24.28	23.38	13.98	22.02
Pump Efficiency	%	43.15%	30.56%	35.03%	40.56%	34.00%
Overall (Pump Set) Efficiency	%	39.69%	28.12%	32.22%	37.32%	31.28%
Specific Energy Consumption	kW/m^3	0.202	0.285	0.249	0.215	0.256

Pump Ref. Sr. No Pump Identification Rated Parameters	UOM	TW-3A Muraintola TW-3A	TW-4A Muraintola TW-4A	TW-1A Turab Ali Ka Purwa TW-1A	TW-1A Nagar Palika Campus TW-1A	TW-1B Tambeshwar Chauraha TW-1B
Pump Type		Submersible	Submersible	Submersible	Submersible	Submersible
Rated Flow	$m^3/hr.$	NA	NA	NA	NA	NA
Rated Power	kW	22.5	22.5	22.5	22.5	22.5
Rated Head	meter	25	25	25	25	25
Parameters Measured						
Measured Flow	$m^3/hr.$	100.7	83.34	122.69	110.73	95.83
Measured Discharge Pressure (A)	kgf/cm^2	0.1	0.1	0.1	0.1	0.1
Total Bore Length	meter	182.88	182.88	182.88	182.88	182.88
Water Level Below Ground (B)	meter	27.43	27.43	27.43	27.43	27.43
Height above Suction to measured gauge pressure if any (C)	meter	1	1	1	1	1
Static Discharge Head (D=B+C)	meter	28.43	28.43	28.43	28.43	28.43
Performance Evaluation						
Total Head (=(AX10)+(D)	meter	29.43	29.43	29.43	29.43	29.43
Head Utilization	%	117.72	117.72	117.72	117.72	117.72
Flow Utilization	%	-	-	-	-	-
Average kW	kW	21.78	25.41	28.1	23.03	24.15
Hydraulic Power	kW	8.08	6.68	9.84	8.88	7.69
Motor Efficiency	%	92	92	92	92	92
Pump Shaft Power	kW	20.04	23.38	25.85	21.19	22.22
Pump Efficiency	%	40.30%	28.59%	38.06%	41.91%	34.59%
Overall (Pump Set) Efficiency	%	37.08%	26.30%	35.02%	38.56%	31.82%
Specific Energy Consumption	kW/m^3	0.216	0.305	0.229	0.208	0.252

Pump Ref. Sr. No Pump Identification Rated Parameters	UOM	TW-1B New Tahsil TW-1B	TW-1B Asti O/HT TW-1B	TW-2B Asti TW-2B	TW-1B Patelnagar TW-1B	TW-1B 50 No. Railway Gate TW-1B
Pump Type		Submersible	Submersible	Submersible	Submersible	Submersible
Rated Flow	m^3/hr.	NA	NA	NA	NA	NA
Rated Power	KW	23.5	30.75	22.5	22.5	22.5
Rated Head	meter	25	32	25	25	25
Parameters Measured						
Measured Flow	m^3/hr.	92.24	88.33	55.33	97.46	121.42
Measured Discharge Pressure (A)	kgf/cm^2	0.1	0.1	0.1	0.1	0.1
Total Bore Length	meter	182.88	182.88	182.88	182.88	182.88
Water Level Below Ground (B)	meter	27.43	27.43	27.43	27.43	27.43
Height above Suction to measured gauge pressure if any (C)	meter	1	1	1	1	1
Static Discharge Head (D=B+C)	meter	28.43	28.43	28.43	28.43	28.43
Performance Evaluation						
Total Head (=(AX10)+(D)	meter	29.43	29.43	29.43	29.43	29.43
Head Utilization	%	117.72	91.97	117.72	117.72	117.72
Flow Utilization	%	-	-	-	-	-
Average kW	kW	19.34	27	18.53	21.56	28.83
Hydraulic Power	kW	7.40	7.08	4.44	7.82	9.74
Motor Efficiency	%	92	92	92	92	92
Pump Shaft Power	kW	17.79	24.84	17.05	19.84	26.52
Pump Efficiency	%	41.57%	28.52%	26.03%	39.40%	36.71%
Overall (Pump Set) Efficiency	%	38.25%	26.24%	23.95%	36.25%	33.78%
Specific Energy Consumption	kW/m^3	0.210	0.306	0.335	0.221	0.237

Pump Ref. Sr. No		TW-1B	TW-1B	TW-1B	TW-1B	TW-2B
Pump Identification	UOM	Aboonagar Redaiya TW-1B	CO Office TW-1B	Maharishi Vidya Mandir TW-1B	Awas Vikas O/HT TW-1B	Awas Vikas TW-2B
Rated Parameters						
Pump Type		Submersible	Submersible	Submersible	Submersible	Submersible
Rated Flow	$m^3/hr.$	NA	NA	NA	NA	NA
Rated Power	kW	22.5	22.5	22.5	22.5	30.75
Rated Head	meter	25	25	32	25	32
Parameters Measured						
Measured Flow	$m^3/hr.$	136.83	103.62	112.42	96.61	107.69
Measured Discharge Pressure (A)	kgf/cm^2	0.1	0.1	0.1	0.1	0.1
Total Bore Length	meter	182.88	182.88	182.88	182.88	182.88
Water Level Below Ground (B)	meter	27.43	27.43	27.43	27.43	27.43
Height above Suction to measured gauge pressure if any (C)	meter	1	1	1	1	1
Static Discharge Head (D=B+C)	meter	28.43	28.43	28.43	28.43	28.43
Performance Evaluation						
Total Head (=(AX10)+(D)	meter	29.43	29.43	29.43	29.43	29.43
Head Utilization	%	117.72	117.72	91.97	117.72	91.97
Flow Utilization	%	-	-	-	-	-
Average kW	kW	24.15	24.99	23.02	19.27	19.5
Hydraulic Power	kW	10.97	8.31	9.02	7.75	8.63
Motor Efficiency	%	92	92	92	92	92
Pump Shaft Power	kW	22.22	22.99	21.18	17.73	17.94
Pump Efficiency	%	49.39%	36.14%	42.57%	43.70%	48.14%
Overall (Pump Set) Efficiency	%	45.44%	33.25%	39.16%	40.21%	44.25%
Specific Energy Consumption	kW/m^3	0.176	0.241	0.205	0.199	0.181

Pump Ref. Sr. No Pump Identification Rated Parameters	UOM	TW-1C Jairam Nagar, Joniha Chauraha TW-1C	TW-1C Shadipur O/HT TW-1C	TW-1C Deviganj TW-1C	TW-2C Deviganj TW-2C	TW-3C Deviganj TW-3C
Pump Type		Submersible	Submersible	Submersible	Submersible	Submersible
Rated Flow	$m^3/hr.$	NA	NA	NA	NA	NA
Rated Power	kW	22.5	22.5	30.75	22.5	22.5
Rated Head	meter	25	25	32	25	25
Parameters Measured						
Measured Flow	$m^3/hr.$	37.83	145.6	133.65	87.76	101.6
Measured Discharge Pressure (A)	kgf/cm^2	0.1	0.1	0.1	0.1	0.1
Total Bore Length	meter	182.88	182.88	182.88	182.88	182.88
Water Level Below Ground (B)	meter	27.43	27.43	27.43	27.43	27.43
Height above Suction to measured gauge pressure if any (C)	meter	1	1	1	1	1
Static Discharge Head (D=B+C)	meter	28.43	28.43	28.43	28.43	28.43
Performance Evaluation						
Total Head (=(AX10)+(D)	meter	29.43	29.43	29.43	29.43	29.43
Head Utilization	%	117.72	117.72	91.97	117.72	117.72
Flow Utilization	%	-	-	-	-	-
Average kW	kW	17.26	30.02	29.88	21.75	25.69
Hydraulic Power	kW	3.03	11.68	10.72	7.04	8.15
Motor Efficiency	%	92	92	92	92	92
Pump Shaft Power	kW	15.88	27.62	27.49	20.01	23.63
Pump Efficiency	%	19.11%	42.28%	38.99%	35.17%	34.47%
Overall (Pump Set) Efficiency	%	17.58%	38.90%	35.87%	32.36%	31.72%
Specific Energy Consumption	kW/m^3	0.456	0.206	0.224	0.248	0.253

Pump Ref. Sr. No Pump Identification Rated Parameters	UOM	TW-1C Khambhapur TW-1C	TW-1C Dhakauli Bahua Road TW-1C	TW-1C Radhanagar O/HT TW-1C	TW-1C Andauli TW-1C	TW-1C Shadipur SP Office TW-1C
Pump Type		Submersible	Submersible	Submersible	Submersible	Submersible
Rated Flow	m^3/hr.	NA	NA	NA	NA	NA
Rated Power	KW	22.5	32.75	22.5	31.75	30.75
Rated Head	meter	25	32	25	25	25
Parameters Measured						
Measured Flow	m^3/hr.	101.03	75.5	78.62	86.83	92.09
Measured Discharge Pressure (A)	kgf/cm^2	0.1	0.1	0.1	0.1	0.1
Total Bore Length	meter	182.88	182.88	182.88	182.88	182.88
Water Level Below Ground (B)	meter	27.43	27.43	27.43	27.43	27.43
Height above Suction to measured gauge pressure if any (C)	meter	1	1	1	1	1
Static Discharge Head (D=B+C)	meter	28.43	28.43	28.43	28.43	28.43
Performance Evaluation						
Total Head (=(AX10)+(D)	meter	29.43	29.43	29.43	29.43	29.43
Head Utilization	%	117.72	91.97	117.72	117.72	117.72
Flow Utilization	%	-	-	-	-	-
Average kW	kW	23.87	21.01	22.86	23.89	27.4
Hydraulic Power	kW	8.10	6.05	6.31	6.96	7.39
Motor Efficiency	%	92	92	92	92	92
Pump Shaft Power	kW	21.96	19.33	21.03	21.98	25.21
Pump Efficiency	%	36.89%	31.32%	29.98%	31.68%	29.30%
Overall (Pump Set) Efficiency	%	33.94%	28.82%	27.58%	29.15%	26.95%
Specific Energy Consumption	kW/m^3	0.236	0.278	0.291	0.275	0.298

4.2.8 Total Energy Consumption Estimation for Pumps

The pumps are the major energy consuming equipment at the pumping stations. During energy audit activity, the measurements on individual pumps were taken. The operating hours of the individual pumps were also collected at pumping stations to estimate annual energy consumption. The details are given in table12.

Table 13: Energy consumption of pumping station

S .No	Name of Pump	Operating Pattern	Annual Operating Hrs. (Hours/Annum)	Measured Power Consumption (kW)	Annual Power Consumption (kWh/year)
1	Lodhi Ganj TW-1A	Running	4,380	41.32	180,982
2	Fire Station Shanti Nagar TW-2A	Running	4,380	42.92	187,990
3	Pakka Talab TW-2A	Running	4,380	26.87	117,691
4	Sllater House TW-1A	Running	4,380	26.39	115,588
5	Muraintola O/HT TW-2A	Running	4,380	23.93	104,813
6	Muraintola TW-4A	Running	4,380	25.41	111,296
7	Tambeshwar Chauraha TW-1B	Running	4,380	24.15	105,777
8	Asti O/HT TW-1B	Running	4,380	27	118,260
9	Asti TW-2B	Running	4,380	18.53	81,161
10	Jairam Nagar, Joniha Chauraha TW-1C	Running	4,380	17.26	75,599
11	Dhakauli Bahua Road TW-1C	Running	4,380	21.01	92,024
12	Radhanagar O/HT TW-1C	Running	4,380	22.86	100,127
13	Andauli TW-1C	Running	4,380	23.89	104,638
14	Shadipur SP Office TW-1C	Running	4,380	27.4	120,012
	Total				**1,615,957**

4.2.9 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 13

Table 14 Auxiliary Connected load details for the pumping stations

S. No	Pump House Name	CFL (15W)	LED (15W)	Tube Light (40W)	Bulb (100W)
1	Pakka Talab O/HT TW-1A	-	-	-	1
2	Pakka Talab TW-2A	-	-	-	1
3	Pakka Talab Tiraha TW-3A	-	-	-	1
4	Sarai TW-1A	-	-	-	1
5	Chhotibazar TW-1A	-	-	-	1
6	Gadhiva TW-1A	-	-	-	1

S. No	Pump House Name	CFL (15W)	LED (15W)	Tube Light (40W)	Bulb (100W)
7	Kotwali TW-1A	-	-	-	1
8	Gadhiva (Krishna Nagar) TW-1A	1	-	1	1
9	Verma Chauraha(Sai Mandir) TW-1A	-	-	1	1
10	Verma Chauraha(Chungi Chauk)TW-2A	-	-	-	1
11	Sllater House TW-1A	-	-	-	1
12	Anandpuram TW-1A	-	-	-	1
13	Muraintola TW-1A	-	-	-	2
14	Muraintola O/HT TW-2A	-	1	-	-
15	Muraintola TW-3A	-		-	1
16	Muraintola TW-4A	-	1	-	-
17	Moosepur (Gadariyan Purwa) TW-1A	-	-	-	1
18	Turab Ali Ka Purwa TW-1A	-	-	1	1
19	Turab Ali Ka Purwa TW-2A	-	-		1
20	Nagar Palika Campus TW-1A	-	-	1	-
21	New Tahsil TW-1B	-	-	-	1
22	Asti O/HT TW-1B	1	-	-	-
23	Asti TW-2B	-	-	1	-
24	Patelnagar TW-1B	-	-	1	-
25	Aboonagar Redaiya TW-1B	-	-	-	1
26	CO Office TW-1B	-	-	-	1
27	Maharishi Vidya Mandir TW-1B	-	-	-	1
28	Awas Vikas O/HT TW-1B	1	-	1	1
29	Awas Vikas TW-2B	-	-	1	1
30	Jairam Nagar, Joniha Chauraha TW-1C	1	-	-	-
31	Deviganj TW-1C	-	-	-	1
32	Deviganj TW-2C	-	-	-	-
33	Deviganj TW-3C	-	-	1	-
34	Jhaoopur TW-1C	-	-	-	1
35	Khambhapur TW-1C	-	1	-	-
36	Dhakauli Bahua Road TW-1C	-	1	-	-
37	Radhanagar O/HT TW-1C	-	-	1	1
38	Radhanagar O/HT TW-2C	-	-	-	-
39	Andauli TW-1C	-	-	-	-
40	Shadipur SP Office TW-1C	-	-	-	1
	Total No's	**4**	**4**	**10**	**28**
	Total Wattage	**60**	**60**	**550**	**2800**

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 of Water Pumping Stations

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

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 (m^3/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:

$$Baseline\ Energy\ Consumption\ of\ a\ pump\ (kWh) = kW \times hours\ of\ operation$$

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

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. Estimated energy consumption of pumps of Fatehpur is provided in table 15.

Table 15: Baseline Energy Consumption for Water Pumping Station[4]

S. No	Pump House Name	Measured Power Consumption (kW)	Flow Rate (m^3/hr.)	Frequency (Hz)	Head (m)	Voltage (V)	Estimated annual operating hours	Baseline Energy Consumption (kWh)
1	Lodhi Ganj TW-1A	41.32	138.37	50	29.43	363.79	4,380	180,982
2	Fire Station Shanti Nagar TW-2A	42.92	103.08	50	29.43	362.44	4,380	187,990
3	Pakka Talab TW-2A	26.87	92.6	50	29.43	392.58	4,380	117,691
4	Sllater House TW-1A	26.39	92.52	50	29.43	425.29	4,380	115,588
5	Muraintola O/HT TW-2A	23.93	93.33	50	29.43	400.68	4,380	104,813
6	Muraintola TW-4A	25.41	83.34	50	29.43	413.37	4,380	111,296
7	Tambeshwar Chauraha TW-1B	24.15	95.83	50	29.43	369.43	4,380	105,777
8	Asti O/HT TW-1B	27.00	88.33	50	29.43	403.78	4,380	118,260
9	Asti TW-2B	18.53	55.33	50	29.43	389.35	4,380	81,161
10	Jairam Nagar, Joniha Chauraha TW-1C	17.26	37.83	50	29.43	388.86	4,380	75,599
11	Dhakauli Bahua Road TW-1C	21.01	75.5	50	29.43	402.24	4,380	92,024
12	Radhanagar O/HT TW-1C	22.86	78.62	50	29.43	426.19	4,380	100,127
13	Andauli TW-1C	23.89	86.83	50	29.43	389.91	4,380	104,638
14	Shadipur SP Office TW-1C	27.4	92.09	50	29.43	372.18	4,380	120,012
	Total							**1,615,957**

[4] EESL RO team and NPP, Fatehpur has advised to consider additional 25 m head over and above present head for the proposed pump sets (This is in lieu of filling OHTs in the near future to serve the distribution network). Thus only 14 pumps are able to serve the payback during project period. Thus considered for replacement.

6. Energy Efficiency Measures

6.1 Summary of Energy Efficiency Measures

A summary of the proposed energy efficiency measures for water pumping station is provided in Table 16:

Table 16: Summary of energy efficiency measures for water pumping stations

Sl. No	Energy Efficiency Measures (EEM) (Replacement with Energy Efficient Pump)	Present Energy Consumption (kWh/year)	Annual Energy Savings (kWh/Annum)	Investment Cost (Rs. Lakhs)	Energy Cost Saving per annum (Rs. Lakhs)	Payback Period (Months)	Percentage of energy saving (%)
1	Lodhi Ganj TW-1A	180,982	46,655	1.91	3.71	6	25.78
2	Fire Station Shanti Nagar TW-2A	187,990	84,263	1.70	6.70	3	44.82
3	Pakka Talab TW-2A	117,691	24,690	1.54	1.96	9	20.98
4	Sllater House TW-1A	115,588	22,596	1.54	1.80	10	19.55
5	Muraintola O/HT TW-2A	104,813	11,721	1.54	0.93	20	11.18
6	Muraintola TW-4A	111,296	33,004	1.49	2.62	7	29.65
7	Tambeshwar Chauraha TW-1B	105,777	12,465	1.54	0.99	19	11.78
8	Asti O/HT TW-1B	118,260	13216	1.57	1.05	18	11.17
9	Asti TW-2B	81,161	25815	1.54	2.05	9	31.80
10	Jairam Nagar, Joniha Chauraha TW-1C	75,599	35,982	1.22	2.86	5	47.60
11	Dhakauli Bahua Road TW-1C	92,024	20,287	1.44	1.61	11	22.05
12	Radhanagar O/HT TW-1C	100,127	28,081	1.44	2.23	8	28.05
13	Andauli TW-1C	104,638	12,339	1.54	0.98	19	11.79
14	Shadipur SP Office TW-1C	120,012	27,060	1.54	2.15	9	22.55
	Total	**1,615,957**	**398,174**	**21.55**	**31.64**	**8**	**24.64**

6.2 Detailed Energy Efficiency Measures at Nagar Palika Parishad, Fatehpur

EESL RO team and NPP, Fatehpur has advised to consider additional 25 m head over and above present head for the proposed pump sets (This is in lieu of filling OHTs in the near future to serve the distribution network). Thus proposed pumpset are considered on the basis which meets the payback during the project period. The opportunity of energy saving was identified in the following individual pumping stations:

6.2.1 EEM 1: Replacement of existing pump inefficient pump with energy efficient pump

Existing Operating Conditions: Out of 47 no's pumps, 3 pumps' bore are blocked and 4 pumps are under maintenance and 40 pumps were operational at the time of energy audit. Out of 47 Nos. we have recommended 14 Nos. pumps to be replaced with energy efficient pumps.

Recommendations: The present operating pumps' efficiencies are in range of 9.78% to 62.68%. The lower efficiencies of the pumps can be attributed to the fact that they are operated far away from their respective Best Efficiency Point (BEP). Therefore, it is suggested to replace the existing pumps.

Cost benefit analysis: Expected savings from the replacement of the pumps have been calculated and tabulated below:

Expected savings from replacement of 14 Nos. of pump is about 398,174 kWh per year, which would result in a cost benefit of about Rs. 31.64 Lakh per year. Estimated investment for implementation of this measure is about Rs. 21.55 Lakh, which basically includes cost of pump set, installation cost and cost of Web based dashboard. Simple payback period is estimated to be about 8 months. Cost benefit analysis of recommendation is provided in table-17.

Table 17: Cost Benefit analysis for replacement of pumps

Pump Ref. S. No. Pump House Name Rated Parameters		TW-1A Lodhi Ganj TW-1A	TW-2A Fire Station Shanti Nagar TW-2A	TW-2A Pakka Talab TW-2A	TW-1A Sllater House TW-1A	TW-2A Muraintola O/HT TW-2A
Type of Pump		Submersible	Submersible	Submersible	Submersible	Submersible
Flow delivered	m^3/hr.	NA	NA	NA	NA	NA
Head developed	m	25	25	25	25	25
Motor power consumption	kW	22.5	22.5	22.5	22.5	22.5
Measured Parameters						
Flow delivered	m^3/hr.	138.37	103.08	92.6	92.52	93.33
Head developed	m	29.43	29.43	29.43	29.43	29.43
Motor power consumption	kW	41.32	42.92	26.87	26.39	23.93
Calculated efficiency of pump set	%	29.19	20.94	30.04	30.56	34.00
Proposed Parameters						
Flow of the pump	m^3/hr.	142.70	106.40	95.52	95.47	96.00
Head of the pump	m	58.46	58.62	58.53	58.57	58.19
Power of the motor on existing duty point	kW	30.67	23.68	21.23	21.23	21.25
Proposed efficiency of pump set on existing duty point	%	74%	72%	72%	72%	72%
Operating hours of the pump	Hours	12	12	12	12	12
Electricity tariff	Rs./kWh	7.95	7.95	7.95	7.95	7.95
Annual energy saving	kWh	46,655	84,263	24,690	22,596	11,721
Annual cost saving	Rs. Lakhs	370,907	669,891	196,284	179,641	93,183
Investment towards new pump set including installation and commissioning, including GST	Rs. Lakh	132,159	111,558	95,822	95,822	95,822
Investment towards NRV replacement including GST	Rs. Lakh	21,927	21,927	21,927	21,927	21,927

Pump Ref. S. No. / Pump House Name		TW-1A Lodhi Ganj TW-1A	TW-2A Fire Station Shanti Nagar TW-2A	TW-2A Pakka Talab TW-2A	TW-1A Sllater House TW-1A	TW-2A Muraintola O/HT TW-2A
Investment towards gate valve replacement including GST	Rs. Lakh	28,997	28,997	28,997	28,997	28,997
Investment towards Web based dashboard including GST	Rs. Lakh	7,680	7,680	7,680	7,680	7,680
Payback period	Months	6	3	9	10	20

Pump Ref. S. No. / Pump House Name / Rated Parameters		TW-4A Muraintola TW-4A	TW-1B Tambeshwar Chauraha TW-1B	TW-1B Asti O/HT TW-1B	TW-2B Asti TW-2B	TW-1C Jairam Nagar, Joniha Chauraha TW-1C
Type of Pump		Submersible	Submersible	Submersible	Submersible	Submersible
Flow delivered	$m^3/hr.$	NA	NA	NA	NA	NA
Head developed	m	25	25	32	25	25
Motor power consumption	kW	22.5	22.5	30.75	22.5	22.5
Measured Parameters						
Flow delivered	$m^3/hr.$	83.34	95.83	88.33	55.33	37.83
Head developed	m	29.43	29.43	29.43	29.43	29.43
Motor power consumption	kW	25.41	24.15	27	18.53	17.26
Calculated efficiency of pump set	%	28.59	34.59	28.52	26.03	19.11
Proposed Parameters						
Flow of the pump	$m^3/hr.$	84.46	97.30	88.33	57.6	38.92
Head of the pump	m	56.49	57.23	55.0	59.6	58.21
Power of the motor on existing duty point	kW	17.87	21.30	23.98	12.64	9.04
Proposed efficiency of pump set on existing duty point	%	73%	71%	55%	74%	68%

Pump Ref. S. No.		TW-4A	TW-1B	TW-1B	TW-2B	TW-1C
Pump House Name		Muraintola TW-4A	Tambeshwar Chauraha TW-1B	Asti O/HT TW-1B	Asti TW-2B	Jairam Nagar, Joniha Chauraha TW-1C
Operating hours of the pump	Hours	12	12	12	12	12
Electricity tariff	Rs./kWh	7.95	7.95	7.95	7.95	7.95
Annual energy saving	kWh	33,004	12,465	13.216	25,815	35,982
Annual cost saving	Rs. Lakhs	262,378	99,099	105,067	205,229	286,058
Investment towards new pump set including installation and commissioning, including GST	Rs. Lakh	90,479	95,822	98,188	94,968	63,487
Investment towards NRV replacement including GST	Rs. Lakh	21,927	21,927	21,927	21,927	21,927
Investment towards gate valve replacement including GST	Rs. Lakh	28,997	28,997	28,997	28,997	28,997
Investment towards Web based dashboard including GST	Rs. Lakh	7,680	7,680	7,680	7,680	7,680
Payback period	Months	7	19	18	9	5

Pump Ref. S. No.	UOM	TW-1C	TW-1C	TW-1C	TW-1C
Pump House Name		Dhakauli Bahua Road TW-1C	Radhanagar O/HT TW-1C	Andauli TW-1C	Shadipur SP Office TW-1C
Rated Parameters					
Type of Pump		Submersible	Submersible	Submersible	Submersible
Flow delivered	$m^3/hr.$	NA	NA	NA	NA
Head developed	m	32	25	25	25
Motor power consumption	kW	32.75	22.5	31.75	30.75
Measured Parameters					
Flow delivered	$m^3/hr.$	75.5	78.62	86.83	92.09
Head developed	m	29.43	29.43	29.43	29.43
Motor power consumption	kW	21.01	22.86	23.89	27.4
Calculated efficiency of pump set	%	30.91	32.85	31.68	46.32

Pump Ref. S. No. Pump House Name Proposed Parameters	UOM	TW-1C Dhakauli Bahua Road TW-1C	TW-1C Radhanagar O/HT TW-1C	TW-1C Andauli TW-1C	TW-1C Shadipur SP Office TW-1C
Flow of the pump	m^3/hr.	76.34	78.74	91.61	95.19
Head of the pump	m	56.23	55.16	61.22	58.77
Power of the motor on existing duty point	kW	16.38	16.45	21.07	21.22
Proposed efficiency of pump set on existing duty point	%	71%	72%	73%	72%
Operating hours of the pump	Hours	12	12	12	12
Electricity tariff	Rs./kWh	7.95	7.95	7.95	7.95
Annual energy saving	kWh	20,287	28,081	12,339	27,060
Annual cost saving	Rs. Lakhs	161,280	223,242	98,096	215,125
Investment towards new pump set including installation and commissioning, including GST	Rs. Lakh	85,873	85,873	95,822	95,822
Investment towards NRV replacement including GST	Rs. Lakh	21,927	21,927	21,927	21,927
Investment towards gate valve replacement including GST	Rs. Lakh	28,997	28,997	28,997	28,997
Investment towards Web based dashboard including GST	Rs. Lakh	7,680	7,680	7,680	7,680
Payback period	Months	11	8	19	9

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. Details of R & M and other cost associated with pumping stations are provided in table 18.

Table 18: R&M and O&M expenses for Fatehpur, Nagar Palika Parishad

Financial Data	Units	Values
Cost of Repair & Maintenance in FY2014 – 2015	Rs. Lakh	2.6
Cost of Repair & Maintenance in FY2015 – 2016	Rs. Lakh	3.91
Cost of Repair & Maintenance in FY2016- 2017	Rs. Lakh	8.34
Cost of Operation in FY2014 -2015	Rs. Lakh	NA
Cost of Operation in FY2015-2016	Rs. Lakh	NA
Cost of Operation in FY2016-2017	Rs. Lakh	NA
Cost of Purchase of new pump/motors/accessories in FY2014-2015	Rs. Lakh	NA
Cost of Purchase of new pump/motors/accessories in FY2015- 2016	Rs. Lakh	NA
Cost of Purchase of new pump/motors/accessories in FY2016 -2017	Rs. Lakh	NA

As per the above table, ULB has provided only cost of repair and maintenance, cost of operation and cost of purchase of new pump/motors/accessories is not available

In proposed scenario, repair and maintenance cost for the pump sets 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 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.

The 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 approximately 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 6.

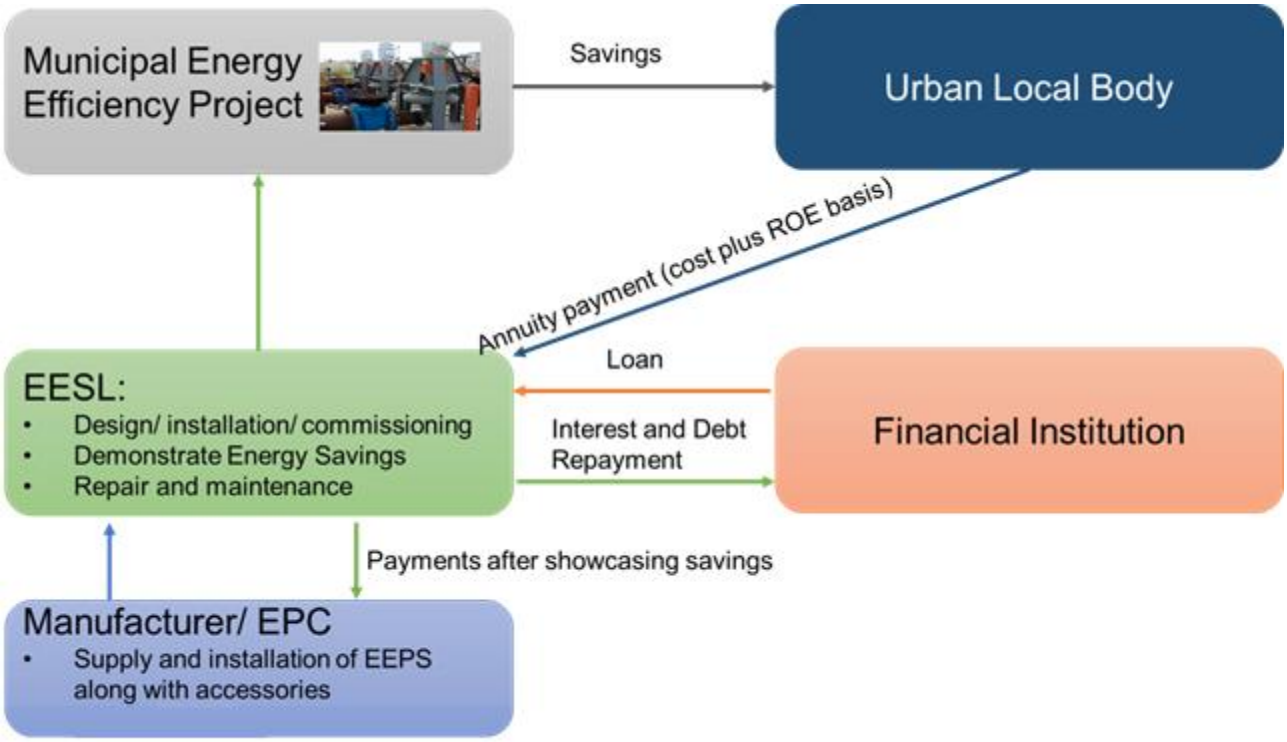

Figure 6 Schematic of business model of the project

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 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 capitalized interest during the Project Implementation Period.

Details of project capital cost are provided in table 19

Table 19: Project Capital cost

Capital Cost Related assumption	Unit	Value
Number of Pumps	*No.*	14
Total Cost of Equipment including installation, commissioning and testing	*INR lakhs*	21.58
Cost of pump including motor	*INR lakhs*	11.59
Cost of NRV	*INR lakhs*	3.07
Cost of Gate valve	*INR lakhs*	4.06
Cost of Web based dashboard	*INR lakhs*	1.08
Installation and Commissioning Cost including testing charges	*INR lakhs*	1.79
EESL's administrative and establishment charge	*%*	5
Cost of preparation of IGEA report including EESL service charges and applicable GST	*INR lakhs*	9.98
Total Project Cost w/o Capitalized interest	*INR lakhs*	32.64
Commissioning Details		
Total Months for Commissioning	*months*	9
Capitalized interest	*INR lakhs*	1.83
Total Project Cost	*INR lakhs*	34.47

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 are provided in table 20.

Table 20: 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 21.

Table 21: 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 are provided in Table 22.

Table 22: Annuity payment to EESL

Year		1	2	3	4	5	6	7	Total
Term of the project	***year***								
Calculations of annuity payment									
Total Debt to be repaid	*INR lakh*	5.96	5.58	5.20	4.82	4.44	4.06	3.68	33.75
Principal Repayment	*INR lakh*	3.45	3.45	3.45	3.45	3.45	3.45	3.45	24.13
Interest	*INR lakh*	2.51	2.13	1.75	1.37	1.00	0.62	0.24	9.62
Total Equity Repayments	*INR lakh*	3.87	3.51	3.15	2.79	2.43	2.06	1.70	19.51
Recovery of equity investment	*INR lakh*	1.48	1.48	1.48	1.48	1.48	1.48	1.48	10.34
Return on equity	*INR lakh*	2.39	2.03	1.67	1.31	0.95	0.59	0.23	9.17
R&M Charges	*INR lakh*	0.00	0.54	1.62	2.05	2.48	3.24	3.88	13.81
EESL's administrative and establishment charge	*INR lakh*	1.38	1.45	1.52	1.60	1.68	1.76	1.85	11.23
Annuity Payment to EESL	*INR lakh*	11.21	11.08	11.49	11.25	11.03	11.12	11.12	78.29
Service Tax on annuity payment	*INR lakh*	2.02	1.99	2.07	2.03	1.98	2.00	2.00	14.09
Annuity Payment to EESL incl. Goods and Services Tax	*INR lakh*	13.23	13.07	13.56	13.28	13.01	13.13	13.12	92.39
Total Savings	*INR lakh*	31.65	30.57	29.35	27.98	26.46	24.77	22.90	193.68
Profit to ULB	*INR lakh*	18.43	17.50	15.79	14.70	13.45	11.64	9.78	101.29
% of savings with ULBs	*%*								52.30%

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 are provided in table 23.

Table 23: Project Capital cost

Change in Capital Cost	% of savings retained by the utility
-10%	56.23%
-5%	54.26%
0%	52.30%
5%	50.33%
10%	48.37%
Change in Interest(ROE, Interest, D/E ratio)	**% of savings retained by the utility**
-10%	47.00%
-5%	49.79%
0	52.30%
5%	54.57%
10%	56.63%

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 Sewerage 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 best efficiency point (BEP). The BEP is the most stable operating point for a centrifugal pump. At the BEP, 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.

9.1 Good practice

- Co-ordination among the staff was observed to be great
- Treated water transferred to users.

9.2 General observations

- Pumps having least efficiency are the oldest ones.
- There is no monitoring of water level and discharge pressure throughout the system.
- Leakage in the pumping stations.
- Due to the lower pressure of pumps, OHT is not filled by pumps.
- NPP officials informed that OHT is not filled by pumps, due to the low pressure for all pumps. As advised by EESL and NPP we have considered 55 meter head for the calculation.
- Water is leaking from pump valves.
- Lack of staff at the pumping stations.

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 combinations, 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 (m^3/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 24.

Table 24: 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:

$$\%\ savings\ (s1) = \frac{\left((kWpre1\ -kWpost1)\ X\ h1\right) + \left((kWpre2\ -kWpost2)\ X\ h2\right) + \ \ldots\ldots.}{(kWpre1\ X\ h1) + (kWpre2\ X\ h2) + \cdots \ldots}$$

  - 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

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

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

$$e1 = kWpre1\ X\ hour1 + kWpre2\ X\ hour2 + \cdots \ldots\ldots\ldots$$

  - 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 25.

Table 25: 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	EESL is mitigating the risk by ensuring the involvement of manufacturers and suppliers throughout the project lifecycle including taking inputs during IGEA preparation.

Risk	Key Incidence of risk	Description	Mitigation Measure
		dependent on capability of single 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.	Further pumping is a matured industry with many suppliers
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[5]), 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.	For the ULB the mitigation measures are same above

[5] 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
		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 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			

Risk	Key Incidence of risk	Description	Mitigation Measure
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 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	Derating of equipment has been appropriately modelled in the financial model. The values of derating have been 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	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

Risk	Key Incidence of risk	Description	Mitigation Measure
		linked to satisfactory replacement of faulty equipment and timely repairs.	responsible for preventive maintenance requirements.
Environmental and Legal Risk			
Reduction of water level	ULB, state government and general population	In areas where ground water is supplied 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.	Change in operation 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 26.

Table 26: 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 Annexure 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. Electricity Bills (Not Provided)
5. Performance Curves of new proposed pump sets
6. Budgetary Quotations from Pump Manufacturers