WORLD BANK GROUP
Water

Central Asia : Energy Efficiency in Water Utilities

Energy Audit and Pre-feasibility Study

for selected utilities in Kazakhstan, Kyrgyzstan Republic, and Tajikistan

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ENERGY AGRICULTURE ENVIRONMENT HABITAT RESOURCE SECURITY CLIMATE HEALTH & NUTRITION

Introduction

Background

One third of the global population, especially those in the developing countries, will face serious water shortages by 2025. Its importance is going to be felt especially in areas of the world lacking with water resources, such as Central Asia. The issues overwhelming the water sector include disparity in water supply across regions, depletion of ground water and undercapitalized municipalities. Continuous demographic growth and expansion of urban areas are putting more pressure on water utilities to provide efficient water services.

Aim

To identify the current levels of participating water supply and sewerage utilities energy usage, and identify options to unlock energy efficiency potential, for implementation to realize energy savings;

Objectives

- To conduct a detailed energy audit of the water supply and sewerage systems of selected utilities;
- To identify, assess and recommend opportunities for energy efficiency improvement in operations with focus on short-term low-cost investment measures;
- Drawing a comprehensive energy efficiency plan along with capacity building interventions;
- Establish a reliable and accurate baseline.

Study Period : 4 months (April'23 – July'23)

Approach & Methodology

Approach

The energy audit assignment required a review of available secondary information, field investigation and direct interaction meetings with various stakeholders responsible for Vodokanal.

Methodology

A team of consultants from TERI and Local consultant was involved in the energy audit study. During the study, all the pumping stations (major energy consumers) were visited and studied in detail. The energy efficiency review involved carrying out measurements and analysis covering all major energy consuming sections, to realistically assess losses and potential for energy savings. The study focused on improving energy use efficiency and identifying energy saving opportunities in all the pumping stations. The analysis included budgetary costs where investments are required to implement recommendations and establish their economic viability.

Energy Efficiency Audit

Energy audit needs a thorough and detailed study of every aspect of the Water supply and sewerage system, various tests and measurements to be performed

- Data collection
  - Historical energy consumption (24 months)
  - Inventory of equipment at utility (including Pumps, Motors, Blowers etc.,)
  - Diagram of water distribution network
  - Pumping system wise water delivery
  - Water pressure required to reach reservoirs / storage tanks
  - No of pumps in operation
  - Design/specified water delivery quantities
  - End user water utilization

Instruments used for field measurements

(a)

(b)

(c)

(d)

a) Portable load manager to monitor and log the transformer parameters (Voltage, current, power factor, kW, kVA, kVAr, Hz, kWh);
b) Clamp on electrical power analysers to measure and logging the individual motor parameters (Voltage, current, power factor, kW, kVA, kVAr, Hz, kWh);
c) Ultrasonic water flow meter to measure the velocity and flow rate of water at the pump delivery and main transmission lines;
d) Digital pressure sensor to measure the delivery head of the pumps / Headers.

Energy Audit : Measurements

- Water flow rate of pumps at various operating conditions
  - Individual
  - Parallel
- Water flow velocity in pipelines
- Suction & discharge pressure of pumps
- Power consumption and motor electrical parameters
  - During individual operation
  - During parallel operation
- Speed of pump & motors
- Matching and application of pumps
- Flow control methods

Energy Audit : Measurements

- Pipeline status
- Pressure drop in the line
- Operating hours and pump schedule
- Variations in flow requirement
- User area operating schedule
- Measurement of water flows to the users
- Segregation of users based on operating hours
- Any modifications carried out in the pumps such as replacement of impeller, trimming of impeller, others
- Operation and maintenance practices

Dushanbe Vodokanal

Introduction : **Dushanbe City,** the Capital city of **Tajikistan.**

Particulars	Dushanbe City
Famous	The Capital city of Tajikistan
Geographical coordinates	38°32'12"N 68°46'48"E
Total urban area	185 km^2
Population (as on 1st Jan 2022)	1,201,800
Population density	6496/km^2
Elevation	823 m
Climate	Semi-arid
Weather	Mediterranean climate
Total rainfall in a year	654 mm
Total rainy days in a year	68.8

Aerial view of City Dushanbe

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	21.8 (71.2)	27.7 (81.9)	32.2 (90.0)	35.3 (95.5)	38.8 (101.8)	44.1 (111.4)	43.7 (110.7)	45.0 (113.0)	38.9 (102.0)	36.8 (98.2)	31.9 (89.4)	24.3 (75.7)	45.0 (113.0)
Average high °C (°F)	9.0 (48.2)	11.0 (51.8)	17.0 (62.6)	22.8 (73.0)	27.9 (82.2)	33.6 (92.5)	36.4 (97.5)	35.5 (95.9)	31.3 (88.3)	24.4 (75.9)	16.7 (62.1)	11.1 (52.0)	23.1 (73.6)
Daily mean °C (°F)	3.1 (37.6)	5.0 (41.0)	10.5 (50.9)	15.8 (60.4)	20.1 (68.2)	25.1 (77.2)	27.4 (81.3)	26.0 (78.8)	21.2 (70.2)	14.7 (58.5)	9.0 (48.2)	4.6 (40.3)	15.2 (59.4)

Dushanbe Vodokonal supplies water to Dushanbe city and surrounding areas.

Sources : Surface water & Ground water

DUSHAMBE CITY WATER DEMAND

DUSHANBE CITY WATER SUPPLY			
PUMPING STATION	**WATER SUPPLY, m^3/h**	**POWER CONSUMPTION OF 2nd LIFT PUMPS, kW**	**No of pumps in operation**
GROUND WATER			
KAFARNIGAN PUMPING STATION 36 N1	2580	1648	3
KAFARNIGAN PUMPING STATION 36 N2	6180	1661	2
KAFARNIGAN PUMPING STATION 37	2980	1759	3
JUNUBI PUMPING STATION	8000	2781	4
TOTAL GROUND WATER	19740	7849	
SURFACE WATER			
FISHORI PUMPING STATION	2575	1549	2
KHUGORE PUMPING STATION	2659	691	3
KHUGORE PUMPING STATION BY GRAVITY	8200	Gravity	
TOTAL SURFACE WATER	13434	2240	
GRAND TOTAL	33174	10089	17
GROUND WATER PERCENTAGE		59.5	
SURFACE WATER PERCENTAGE		40.5	
Per Capita water consumption (Includes Non Revenue Water)		Measured Values	As per Utility
TOTAL WATER, m^3/day		796176	705000
TOTAL CITY POPULATION		1201800	120180

Summaries of Results

Ground water intake facility has a total of 124 bore well pumps and 23 second lift pumps for primary distribution. Surface water intake facility has around 11 pumps for primary distribution. The sewerage/waste water flow by the gravity to the regional sewerage treatment plant. The present operating electrical load of the water utility is 14.3 MW. The actual energy consumption depends on duration of usage of the booster pumps, whereas an intake water supply pump operates 24 X 7.

The identified energy saving potential is about 22.5 million kWh which equals to 19.5% of total annual energy consumption (115.8 million kWh).

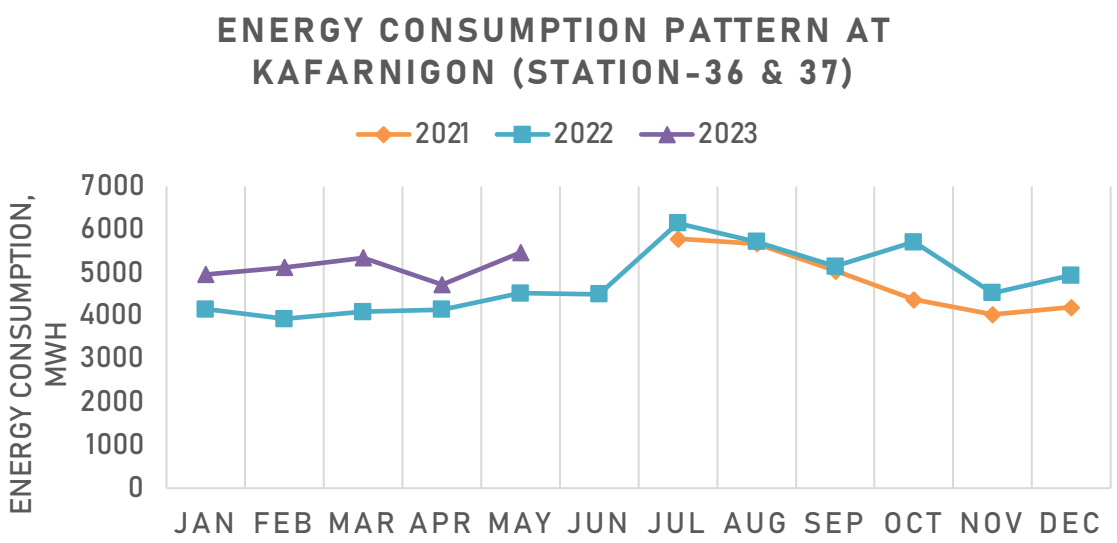
Summary of Energy Conservation measures

S. No	Energy conservation measures	Annual Energy Savings, Million kWh	Annual Cost Savings, USD Based on Cost recovery tariff	Investment, USD	Simple Payback period, years Based on Cost recovery tariff
Kofarnihon ground water intake plant					
1	Provide Variable Speed Drive (VSD) for the Pumps in Kofarnihon pumping station 36 (N1)	3.33	70,241	183,486	2.61
2	Replace existing old pumps with new optimum size energy efficient pumps and operate with VSD in Kofarnihon pumping station-36 (N2)	5.06	106,721	229,358	2.15
Janubi groundwater intake plant					
3	Provide separate pumps based on the pressure required in individual distribution headers	5.59	117,980	366,972	3.11
Fishori surface water intake plant					
4	Replace existing pump sets and pipelines to up to main header with new energy efficient pump set and optimum size pipe line	5.87	123,825	275,229	2.22
Khudjore surface water intake plant					
5	Optimise pumps' operation by providing variable speed/frequency drives	2.64	55,809	137,615	2.47
Grand Total		**22.49**	**474,576**	**1,192,661**	**2.51**

KAFARNIGAN PUMPING STATION 36 & 37

KAFARNIGAN PUMPING STATION 36 & 37

Historical Energy consumption:



Average power consumption, kW			
	2021	2022	2023
Jan		5574	6664
Feb		5845	7625
Mar		5502	7185
Apr		5752	6555
May		6076	7344
Jun		6247	
Jul	7776	8256	
Aug	7624	7683	
Sep	7002	7142	
Oct	5872	7674	
Nov	5595	6289	
Dec	5641	6635	

Total Measured load:

Description	1st lift pumps load, kW	2nd lift pumps load, kW	Total load, kW
Kafarnigan station # 36 (N1)	475.4	1628.0	2103.4
Kafarnigan station # 36 (N2)	854.0	1661.0	2515.0
Kafarnigan station # 37	250.0	1760.0	2010.0
Total measured load, kW	**1579.4**	**5049.0**	**6628.4**

KAFARNIGAN PUMPING STATION 36, N1

Second Lift Pumps (Centrifugal Pumps)

PUMP PERFORMANCE SHEET		Pump Station 36 (N1)		
Design Parameters	Unit	Pump 2	Pump 3	Pump 5
Make				
Model		1250/125	1250/125	1250/125
Flow rate,	m^3/h	1250	1250	1250
Head,	meters	125	125	125
Motor efficiency	%	94.8	94.8	94.8
Motor Rating	kW	630	630	630
Operating Parameters				
Flow rate	m^3/h	870	860	850
Total Head	meters	127	129	130
Header pressure (day time/night time)			114/108	
Measured Power	kW	563	520	565
Performance Parameters				
Head utilization	%	91.2	91.2	91.2
Flow utilization	%	70	69	68
Pump Efficiency	%	56	61	56
Overall Efficiency	%	53	58	53

Energy Saving Potential : 200kWh

KAFARNIGAN PUMPING STATION 36, N2

Second Lift Pumps (Centrifugal Pumps)

PUMP PERFORMANCE SHEET		Pump Station 36 N2	
Design Parameters	Unit	Pump 2	Pump 5
Model		2000/100	2000/100
Flow rate,	m^3/h	2000	2000
Head, meters	meters	100	100
Motor efficiency	%	95.1	95.1
Motor Rating	kW	800	800
Operating Parameters			
Flow rate	m^3/h	2930	3250
Total Head	meters	49	45
Header pressure (day time/night time)		42 / 40	38 / 35
Measured Power	kW	815	846
Performance Parameters			
Head utilization	%	42	38
Flow utilization	%	147	163
Pump Efficiency	%	50	50
Overall Efficiency	%	48	47

Replace Pumps with New Pump sets (Q -2000m^3/h, H- 55meters)

Energy Saving Potential : 360kWh

KAFARNIGAN PUMPING STATION 37

Second Lift Pumps (Centrifugal Pumps)

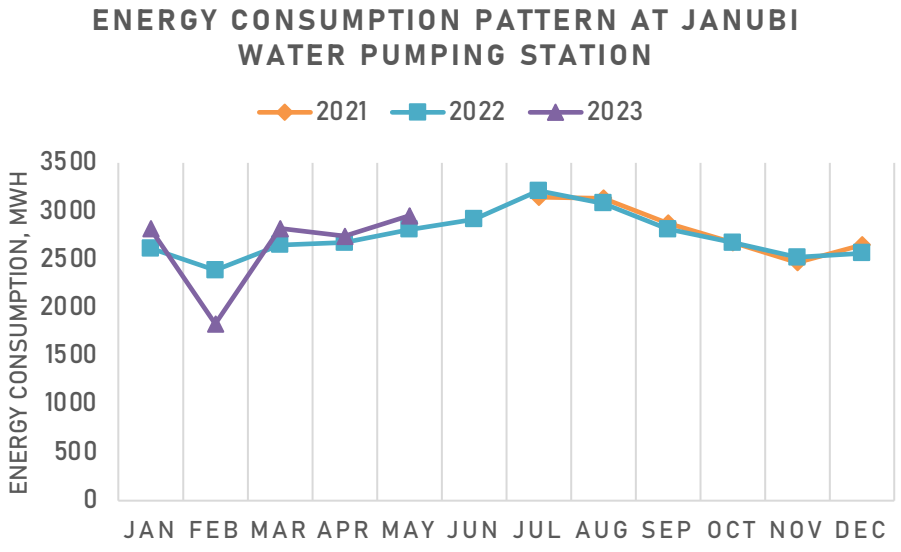
PUMP PERFORMANCE SHEET		Pump Station 37		
Design Parameters	Unit	Pump 1	Pump 2	Pump 5
Model		1250/125	1250/125	1250/125
Flow rate,	m^3/h	1250	1250	1250
Head, meters	meters	125	125	125
Motor efficiency	%	94.8	94.8	94.8
Motor Rating	kW	630	630	630
Operating Parameters				
Flow rate	m^3/h	943	1050	980
Total Head	meters	115.5	117.5	117.5
Header pressure, day /night			115 /110	
Measured Power	kW	552	614	593
Performance Parameters				
Head utilization	%	92.4	94	94
Flow utilization	%	76	84	78
Pump Efficiency	%	57	58	56
Overall Efficiency	%	54	55	53

Energy loss due to pressure drop across the Valve is 110kW

JANUBI PUMPING STATION

JANUBI PUMPING STATION

Historical Energy consumption:



Average power consumption, kW			
	2021	2022	2023
Jan		3514	3783
Feb		3554	2726
Mar		3562	3789
Apr		3712	3806
May		3777	3969
Jun		4047	
Jul	4226	4316	
Aug	4214	4140	
Sep	3994	3905	
Oct	3593	3593	
Nov	3427	3499	
Dec	3561	3448	

Total Measured load:

Description	1st lift pumps load, kW	2nd lift pumps load, kW	Total load, kW
Januni pumping station	1486.3	2781.3	4520.0

JUNUBI PUMPING STATION

Second Lift Pumps (Centrifugal Pumps)

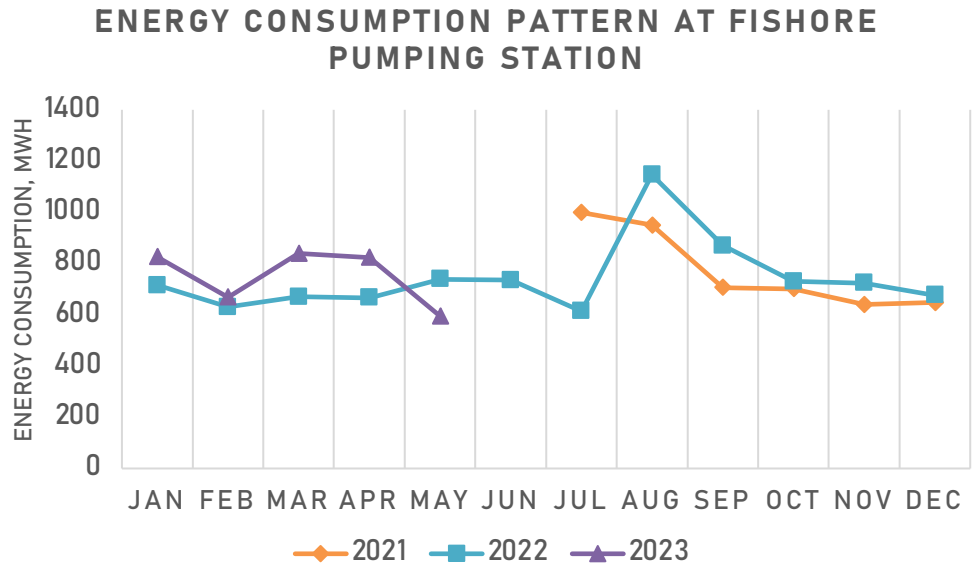
PUMP PERFORMANCE SHEET		JUNUBI PUMPING STATION			
Design Parameters	Unit	Pump 1	Pump 2	Pump 3	Pump 8
Model			2000/100		
Flow rate,	m^3/h	2000	2000	2000	2000
Head, meters	meters	100	100	100	100
Motor efficiency	%	95.1	95.1	95.1	95.1
Motor Rating	kW	800	800	800	800
Operating Parameters					
Flow rate	m^3/h	2077	1795	1883	2213
Total Head	meters	82	89	87	77
Header Pressure (Day /Night)	kg/cm2	8 /7.7	7.8/6.8	2.8/2.6	3.5/3.2
Measured Power	kW	705	650	694	732
Performance Parameters					
Flow utilization	%	104	90	94	111
Pump Efficiency	%	69	70	68	67
Overall Efficiency	%	66	67	64	63

- Provide Low Head (50 meter pump to meet water demand of Boiler and 33 District
- Provide Variable frequency drive for other pumps
- Energy Savings : 500 kW

FISHORE PUMPING STATION

FISHORE PUMPING STATION

Historical Energy consumption:



Average power consumption, kW			
	2021	2022	2023
Jan		961	1110
Feb		938	995
Mar		901	1128
Apr		926	1144
May		993	799
Jun		1022	
Jul	1343	825	
Aug	1277	1541	
Sep	982	1208	
Oct	942	981	
Nov	889	1005	
Dec	870	910	

Total Measured load:

Description	Filter pump load, kW	2nd lift pumps load, kW	Total load, kW
Fishore pumping station	149.1	1401.7	1401.7

FISHORE PUMPING STATION

Surface Water Lift Pumps (Centrifugal Pumps)

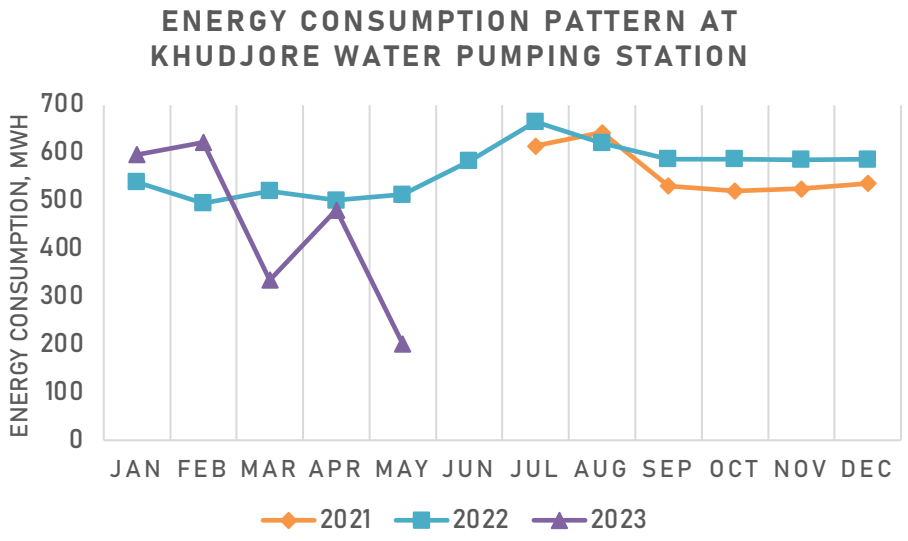
PUMP PERFORMANCE SHEET		FISHORI PUMPS	
Design Parameters	Unit	Pump 1	Pump 4
Model		2000/100	1250/125
Flow rate,	m^3/h	2000	1250
Head, meters	meters	100	125
Motor efficiency	%	95.1	94.8
Motor Rating	kW	800	630
Operating Parameters			
Flow rate	m^3/h	1850	725
Total Head	meters	102	127
Measured Power	kW	784	616
Performance Parameters			
Flow utilization	%	93	58
Pump Efficiency	%	69	43
Overall Efficiency	%	66	41

- There are 5 different headers. Header pressure varies from 4.5 – 6.2 kg/cm^2(maximum). Replace the existing Pumps with New Pumps with new Pipe line up to main Header line.
- Energy Savings : 600kW

KHUDJORE PUMPING STATION

KHUDJORE PUMPING STATION

Historical Energy consumption:



Average power consumption, kW			
	2021	2022	2023
Jan		725	802
Feb		737	926
Mar		700	450
Apr		696	669
May		690	270
Jun		811	
Jul	827	894	
Aug	865	834	
Sep	738	816	
Oct	700	790	
Nov	730	814	
Dec	721	789	

Total Measured load:

Description	Filter pump load, kW	2nd lift pumps load, kW	Total load, kW
Khudjore pumping station	312.0	701.0	701.0

KHUDJORE PUMPING STATION

Surface Water Lift Pumps (Centrifugal Pumps)

PUMP PERFORMANCE SHEET		KHUGORE PUMPING STSTION		
Design Parameters	Unit	Pump 1	Pump 4	Pump 6
Model		1250/63	1250/63	1250/63
Flow rate,	m^3/h	1250	1250	1250
Head, meters	meters	63	63	63
Motor efficiency	%	94.8	94.8	94.8
Motor Rating	kW	315	315	315
Operating Parameters				
Flow rate	m^3/h	1209	662	788
Total Head	meters	58	53	54
Header Pressure (Day /Night)	kg/cm2	3/2.8	4.2/3.8	4.2/3.8
Measured Power	kW	246	221	224
Performance Parameters				
Pump Efficiency	%	82	46	55
Overall Efficiency	%	78	43	52

- Separate Pumps for Low pressure and High pressure water demand / Provide Variable frequency drive for the pumps and operate Drive with pump discharge water pressure as feedback.
- Energy Savings : 200kW

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Thank You