2011

Energy Audit of Water and Wastewater Utilities in 6 towns of Moldova

Final Report

UNGHENI

Tehno Consulting & Design

December 2011

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ABBREVIATIONS

Selected Definitions:	Abbreviation / Synonym Definition
A.S.L.	Above Sea Level
BPS	Booster Pumping Station
WB	World Bank
IDA	International Development Association
Client	Water Supply and Sanitation Projects Implementation Unit
Auditor/Consultant	Tehno Consulting & Design
EE	Energy Efficiency
ECM	Energy Conservation Measures
EEP	Energy Efficiency Program
EMP	Energy Management Program
PS	Pumping Station
SPS	Sewage Pumping Station
MSPS	Main Sewerage Pumping Station
NWSSP	National Water Supply and Sanitation Project
RWTP	Raw Water Treatment Plant
WWTP	Waste Water Treatment Plant
O&M	Operation and Maintenance
BoQ	Bill of Quantities
VSD	Variable Speed Drive
HVAC	Heating, Ventilation, and Air Conditioning
WSS	Water Supply and Sanitation

EXECUTIVE SUMMARY

Present Energy Audit report summarizes Apa-Canal Ungheni facilities description, historical data, Auditors findings, site measurements data, analyses and ECM proposals.

Our energy audit team visited Ungheni and collected historical water and energy usage data, as well as the existing equipment operating data. As a result of the site measurements we identified several ECM, which in our opinion will provide feasible opportunities for significant energy savings.

The feasibility of each proposed ECM was estimated through a payback analysis. The simple payback period was determined after establishing Engineer's estimation of capital investments, O&M equipment costs, projected annual energy savings estimates, and the potential value of energy tariff.

Recommended ECMs

The following table presents the ranking of recommended ECMs identified for Apa-Canal Ungheni. The ECMs are ranked on a simple payback period basis.

ECM description	Annual energy savings, kWh	Annual energy savings, MDL	Capital investment cost, MDL	Simple payback period, years	Ranking
Modification of pumping at PS 1	78,752.40	141,754.3	443,850	3.1	1
Replacement of pumps at BPS Cristiuc 11	22,863.60	41,154.48	201,300	4.9	2
Replacement of pumps at BPS Nationala 43	5,299.80	9,539.64	61,050	6.4	3
Replacement of pumps at BPS Nationala 33a	1,708.20	3,074.76	61,050	19.9	4
Pumping optimization of Main SPS	-	-	-	-	-

Recommended ECMs to be included in the EMP

In order to prioritize investments from different Project towns, the indicator for relative energy saving as % of total energy consumption of each separate water utility was used as the most fair and important indicator. Thereby, the investments bringing the highest relative reduction in energy consumption in the respective towns were prioritized. This selection criterion was applied as primary one, while the secondary criterion of simple payback period was applied after preliminary sorting.

One ECM has been shortlisted for EMP investment package:

ECM description	Annual energy savings, kWh	Annual energy savings, MDL	Savings in % compared to total power consumption	Capital investment cost, MDL
Modification of pumping at PS 1	78,752	141,754	**4.3%**	**443,850**

Total investment amount for selected Ungheni ECM is **37,267 USD.**

1. INTRODUCTION

The IDA provided financing in the amount of 0.9 mln USD which will be used for investments to raise energy efficiency in 6 (six) water and wastewater utilities of Moldova. The EEP is expected to demonstrate and disseminate through energy audits and following investments the potential for increasing energy efficiency in municipal water and wastewater operations.

The program finances energy audits, hydraulic regime optimizations, and the selective rehabilitation of electromechanical equipment (equipment replacement) which are expected to increase energy efficiency in municipal water and wastewater operations in the cities Balti, Cahul, Orhei, Causeni, Floresti and Ungheni.

This Final Audit Report summarizes findings, proposals, planned activities, schedule for completion of audit components, staffing and submission deadlines of audit reports and other deliverables for Energy Audit of Water and Wastewater Utilities in 6 towns of Moldova.

The contract has been let for open international tendering for consultancy services.

The contract was awarded to Tehno Consulting & Design and became effective on 20th June 2011. The duration of the services is expected to be 6 months.

1.1 Draft Audit Report

In previous Draft Audit Report the Consultant has introduced his assessment of energy conservation measures and investment needs in the city of Ungheni. The Report includes conditional and operational analysis of existing water and wastewater facilities and energy conservation measures, as well as a financial assessment of the proposed investments.

The report also includes the Consultants proposal of ECM measures for the future EMP investments.

Furthermore, this Report includes the output from the Baseline Studies as presented in the Consultants Inception Report.

There is one separate report for each of the six cities covered by the project.

1.2 Final Audit Report

Present Final Audit Report includes comments and suggestions to the Draft Report from the World Bank experts, WSSPIU and Apa-Canal Ungheni.

The meeting with stakeholders was held on December 07, 2011. The agreed shortlist of EMP investments for Ungheni contains the following:

Table 1-1 *Agreed EMP Investments for Ungheni*

The proposed ECM description	Annual energy savings, kWh	Annual energy Consumption of Water Utility, kWh	Savings in %, as compared to total consumption	Capital investment cost, MDL	Simple payback period, years
Modification of pumping at PS 1	78 752	1 820 853	4.3%	443 850	3.1

The overall amount of proposed EMP investments for Ungheni is 443,85 0 MDL or **37,2674 USD** (USD exchange rate 11.91).

Consultant will prepare the following submittals for the selected ECM:

- BoQ and Cost estimate for Goods, Works and associated services;
- Technical Specifications for Goods and Works within proposed EMP;
- Draft EMP schedule of implementation

2. WATER SERVICES IN THE TOWN OF UNGHENI

2.1 General

The Town of Ungheni is located in the Western part of Moldova, some 105 km from Chisinau. The Town of Ungheni is the seventh largest city in Moldova and is the administrative and commercial center of agricultural rayon (district) with about 117,400 inhabitants.

There is a bridge across the Prut and a border checkpoint to Romania. There is another border town with the same name in Romania (Ungheni, Iasi), on the other side of the Prut River.

Figure 2-1 *Location of Ungheni*

Ungheni is located along the Prut River at the altitudes of 35-65 m above sea level, highest regions being situated in the Eastern part of Ungheni.

The Prut River, a tributary to the Danube River, flows (N-S) along the City. The railroad runs through the City.

2.2 Service Area Definition

The Town of Ungheni is provided with water services by a municipal operator (I.M. Apa-Canal Ungheni) covering main part of the town and several neighboring villages.

The whole Town represents a single pressure service area with private houses and several multi-storey building areas located in central part of the Town. The service area is located at 35-65 m a.s.l. and is supplied from one Main PS.

The areas of multi-storey buildings are provided with water by eight (8) booster PSs.

The estimated extent of water services in Ungheni is presented in the following figure:

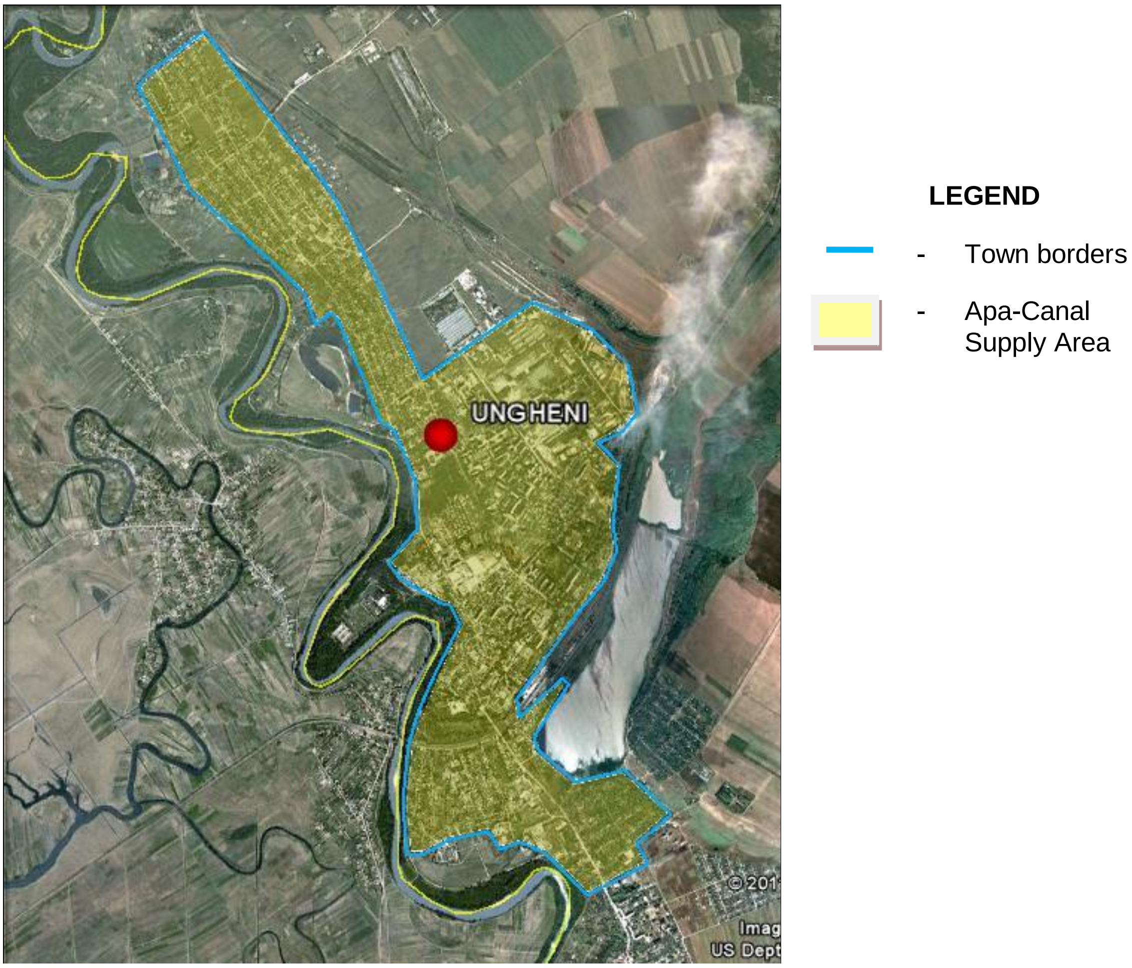

Figure 2-2 *Estimated Extent of Water Service Areas in Ungheni*

This study covers Apa-Canal operations only. The possibilities of future water supply of uncovered areas by Apa-Canal shall be studied separately.

2.3 Population

The official population records for the Town are summarized in the table below:
Table 2-1 *Resident population in Ungheni Town, as of January1 by Years*[1]

	2005	2006	2007	2008	2009	2010	2011
Ungheni Rayon	119.5	119.3	117.3	117.2	117.2	117.4	117.4
Ungheni City	40	39.9	37.9	37.8	37.9	38	38.1

As shown in the table, the official population number of the Town has been being rather stable over the last 5 years. Significant changes (especially growth) in population are not expected in the next years, as the average population growth rate for Moldova is estimated at -0.072% for 2011[2].

[1] National Bureau of Statistics of the Republic of Moldova

Notwithstanding the official statistical data, and taking into account high level of immigration, the real number of population (and consequently consumers) living in Ungheni is expected to be considerably lower. According to the City Hall data, some 32,500 people currently live in Ungheni.

2.4 Customers

The number of contracts (connections) by supply areas operated by the Apa-Canal is summarized in the following table.

Table 2-2 *Water Supply Customers – Apa-Canal Ungheni*

Supply Area	No of Water Customers (Contracts)	Estimated No. of population connected to water services (people)	No of Sewerage Customers (Contracts)	Estimated No. of population connected to sewerage (people)
Ungheni Town				
Households	12,973	**29,536**	8,511	**19,983**
Economic Agents	469		373	
Budgetary Institutions	31		27	

As can be seen from the Table, the major number of consumers are private households. In total, some 77% of the official area population is provided with water by Apa-Canal Ungheni.

This Audit Report covers ECMs for current consumption conditions only and does not envisage any considerable future extensions in terms of consumers.

Currently, only some 52% of total population and only some 67% of total water consumers are provided with sewerage services.

2.5 Preliminary Water Balance

The following table derives from information provided by the Apa-Canal.
Table 2-3 *Reported Water Balance for Ungheni Apa-Canal*

	2008		2009		2010		2011	
	Abstracted	**Sold**	**Abstracted**	**Sold**	**Abstracted**	**Sold**	**Abstracted**	**Sold**
Jan	132,384	80,663	182,547	84,982	196,072	86,048	187,558	94,038
Feb	137,799	83,857	169,640	81,120	172,696	81,083	158,992	91,503
Mar	158,275	86,961	142,949	83,255	155,272	85,926	172,790	95,368
Apr	149,474	84,388	150,889	88,540	150,592	96,386	177,320	99,720
May	172,789	107,675	180,885	113,004	176,996	110,481	205,615	122,681
Jun	219,533	139,619	208,275	123,159	207,175	131,381		
Jul	212,612	118,871	218,027	118,177	206,161	114,007		
Aug	231,537	117,156	238,487	116,261	253,712	136,636		
Sep	215,347	123,236	201,144	129,503	206,207	129,300		
Oct	186,067	101,148	203,480	104,538	195,021	114,126		
Nov	169,412	93,154	196,138	106,502	200,233	107,497		
Dec	166,308	88,646	187,775	94,067	184,324	100,595		
TOTAL	**2,151,537**	**1,225,374**	**2,280,236**	**1,243,108**	**2,304,461**	**1,293,466**	**902,275**	**503,310**

[2] Central Intelligence Agency, the World Factbook

The amount of the non-revenue water is clearly shown in the following Figure.

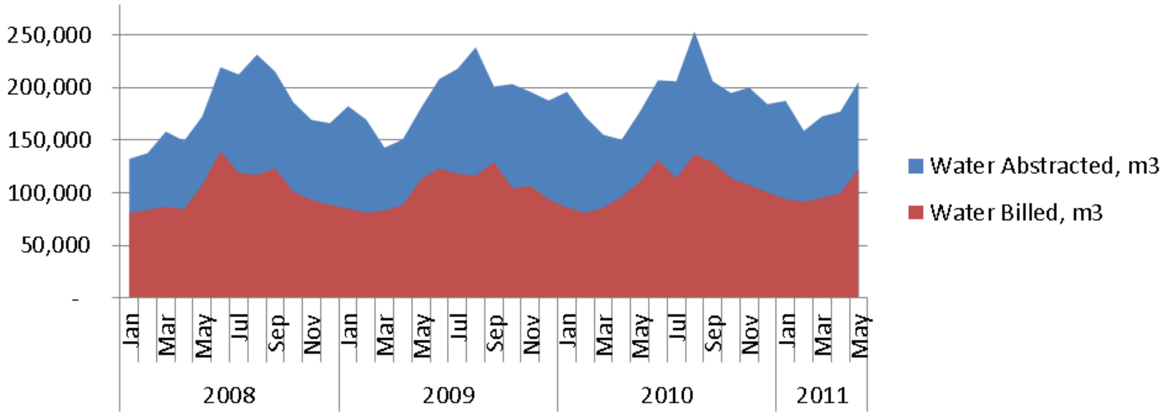

Figure 2-3 *Reported Water Balance for Ungheni Water Utility*

In respect of the water supply system, it is of note that the non-revenue water rate as estimated on the basis of the reported values over 3 years has relatively high values of 36-56% of produced water. High NRW rates are subject to this Energy Audit and a general NRW analysis is presented in the following Sections.

The reported volumes of the collected wastewater are presented in the Table below.

Table 2-4 *Collected wastewater for 2008-2010*

	2008	2009	2010
Received Wastewater, thou m^3	840.9	811.2	863.9
Including from households	521.7	540	563
Household sewerage Return rate, %	61%	58%	60%

Overall the wastewater return rate remains low reflecting the much lower level of development of wastewater services.

3. WATER SUPPLY SYSTEM

3.1 General

The town of Ungheni is provided with water from one surface water intake through Main pumping station feeding single service area.

Central part of the Town is supplied by eight (8) booster PS, covering multi-storey buildings in the area. A separate booster PS is used to provide water to a neighboring village located south of the City.

Most of networks and pressure mains are in poor condition due to its age and heavy use, generating high amounts of leakages.

3.2 Water Production

Surface water intake is located on the Prut River, some 1 km west from the Town border.

Water abstraction is organized through two (2) parallel syphon pipelines of DN500 from the river bottom and is located at elevation of some 29 m a.s.l. The inlet is protected by screens.

The abstraction facilities were built in 1970 and haven't been cleaned / repaired since. During the walk-through analysis, the Consultant noticed high level of silting of the existing inlet point, which is considered to negatively influence the raw water quality and consequently the whole treatment process.

Initially, the water was designed to be led through the syphon pipelines to the inlet chamber of the PS1, located at the Water Treatment Plant, some 600 m from the abstraction point. The inlet chamber was also used to settle turbid raw water and protect the installed pumps from damaging by abrasives. Two (2) submersible pumps were designed to pump the stored water directly to the WTP's vertical mixer.

However, due to unknown technical reasons Apa-Canal has switched to a different pumping process, using vacuum pumps to bring the raw water to the PS1 and connecting 4 (2 operating and 2 stand-by) vertical centrifugal pumps directly to the syphon pipelines. Thus, the water is currently abstracted and pumped directly to the WTP without any intermediary storage.

The pumps are installed at the elevation of some 28 m a.s.l., having the syphon total head of approx. 3m.

General data on installed pumping equipment at the PS1 are presented in the following Table.

Table 3-1 *Design parameters of the existing pumping equipment at the Main water intake in Ungheni*

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Control Panel	Operating	Year of instal-lation
					P	Voltage	Speed	cosϕ	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
1	FA 15.840-278	1	250	19.6	18.5	380	1430		39.5	Y	24	2004
2	FA 15.840-278	1	250	19.6	18.5	380	1430		39.5	Y	24	2004
3	СД450/22.5	1	450	22.5	37.0	380	1470	0.89		Y	24	2004
4	СД450/22.5	1	450	22.5	55.0	380	1470	0.89		Y	24	1981
5	BBH-12M	1	720	NA	30.0	380	980				2	2003
6	BBH-12M	1	720	NA	30.0	380	980				2	2003

As can be seen from the Table above, the vacuum pumps BBH-12M are used for up to 2 hours per day in order to recharge the syphon pipes and ensure safe start-up of the centrifugal pumps. The condition of the existing intake syphon pipes is unknown, but it is expected to be poor due to pipes age (over 30 years), generating air/groundwater seepages during suction/pumping.

The existing centrifugal pumps FA15.84 DEMI are designed for wastewater pumping and were installed as measure to protect the pump wheels from the abrasive raw water.

All pumps are operated manually.

Existing pressure mains from the PS1 are from 1970's and are made of 2 parallel steel DN400 pipelines and are considered to be in an acceptable working condition. However, being at the end of life cycle, pressure pipelines can generate considerable amounts of leakages in future and need to be monitored.

Further measurements and analysis are presented in the next Chapters.

Historical Energy Consumption

The present section represents historical energy usage and associated Apa-Canal costs. It is important to establish at least 3 years patterns of mainly electric, as well as gas usage, if relevant, in order to be able to identify areas in which energy consumption can be reduced.

Overall energy consumption in kWh for each month is shown in the following figure:

Table 3-2 *Historical Energy Consumption Reported by Apa-Canal Ungheni for 2008-2011*

Month/Year	2008	2009	2010	2011
Jan	165,284	159,223	101,912	141,748
Feb	131,236	162,221	143,341	148,483
Mar	127,598	123,638	134,765	130,735
Apr	132,215	141,578	130,503	137,530
May	135,268	129,911	127,185	134,420
Jun	163,903	156,782	164,284	172,373
Jul	163,904	166,640	166,555	
Aug	172,925	165,510	197,608	
Sep	169,316	168,858	187,811	
Oct	157,864	146,951	151,817	
Nov	143,674	145,169	153,420	
Dec	162,221	146,007	161,652	

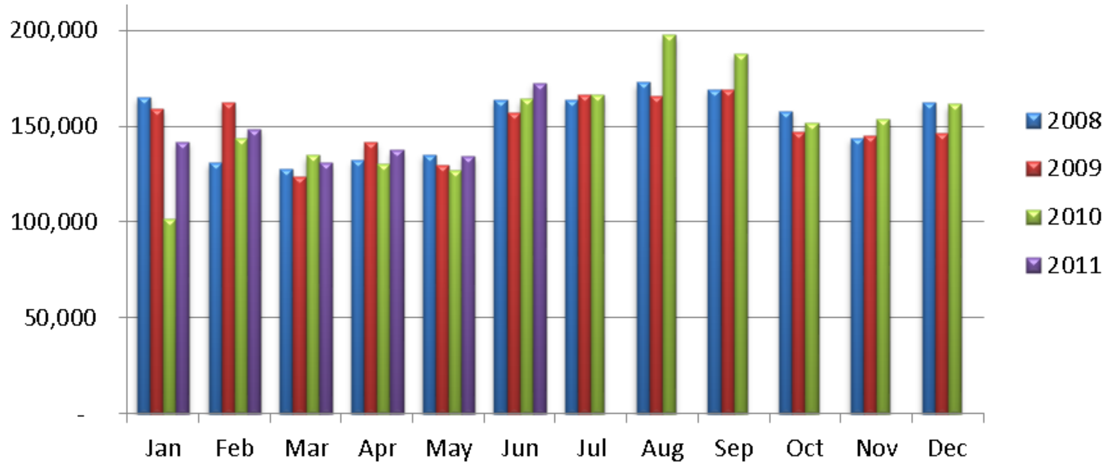

Figure 3-1 *Energy Consumption Reported by Apa-Canal Ungheni for 2008-2011*

The below Figure shows that the highest energy consumption is registered during summertime. The Consultant has carried out its assignment, including site measurements, during the most energy consuming period of operation.

The following detailed energy consumption for 2010 registered by Apa-Canal is provided in the Table below.

Table 3-3 *Historical Energy Consumption Breakdown Reported by Apa-Canal Ungheni for 2010*

	2010, kWh											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Administrative/ Workshops	2,423	3,007	2,207	2,074	1,351	2,141	93	1,137	1,339	1,709	2,168	2,425
BPS Nationala 33	101	518	969	1,058	939	976	840	911	906	820	924	858
BPS Nationala 43	608	900	900	750	768	678	952	898	769	643	735	755
Office	712	951	773	670	618	893	964	1,239	673	754	831	970
SPS Ungureanu 15 (Beresti)	39	66	62	81	112	61	59	58	50	63	64	68
BPS Boico 9	886	794	653	769	701	946	939	1,152	1,096	826	901	933
SPS Caragiale	47	70	49	73	41	48	60	53	69	48	54	57
BPS Cristiuc	2,117	2,810	2,416	2,705	3,442	4,021	3,531	4,335	4,587	2,834	3,378	3,421
Main SPS	19,912	31,060	26,927	24,028	18,600	22,440	52,440	28,320	33,640	29,580	30,180	36,840
BPS N.Iorga	-	-	-	-	-	-	-	-	-	-	-	-
BPS Romana 7	5	-	28	12	8	16	18	11	18	20	37	82
BPS Romana 26	598	834	745	845	720	632	1,008	940	968	771	896	843
BPS Romana 66	252	393	314	351	310	369	350	512	473	455	550	332
WTP, incl PS1 and PS2	69,045	94,975	92,981	91,224	94,870	126,117	100,271	152,577	137,531	108,090	106,277	106,879
WWTP	4,000	6,000	5,000	5,000	4,000	4,000	4,000	4,000	4,000	4,000	5,000	6,000
BPS Ungureanu 9	942	484	371	423	357	506	624	1,003	1,252	855	1,021	745
BPS Porumbescu 3	225	479	370	440	348	440	406	462	440	349	404	444
TOTAL	**101,912**	**143,341**	**134,765**	**130,503**	**127,185**	**164,284**	**166,555**	**197,608**	**187,811**	**151,817**	**153,420**	**161,652**

As can be seen, there are no separate power meters used for each of the intake/treatment facilities and only lump-sum energy consumption is measured.

Distribution of the energy consumption by different facilities is provided in the following Figure:

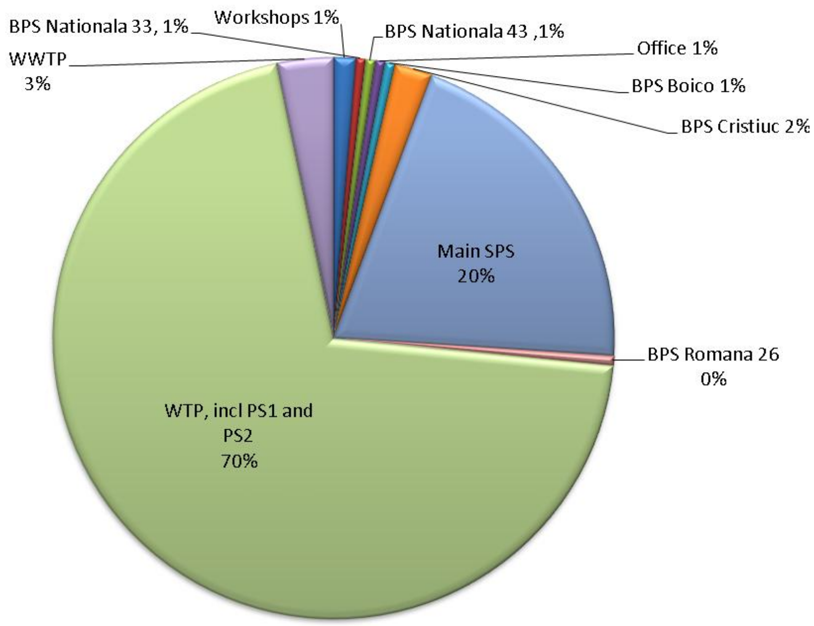

Figure 3-2 *Reported Energy Consumption for 2010*

As can be seen from the Figure above, the main energy consuming facilities are Intake and treatment (70% in total), PS1 (22%) and the Main SPS (14%). The main focus of this Energy Audit will be aimed at these major energy consumers.

3.3 Water Treatment

Since the only source of water is the Prut River, a comprehensive water treatment is done to provide drinking water quality to the customers. All treatment is done at the Water Treatment Plant located at the western border of the Town.

The WTP design capacity is 12,700 m^3/day. Currently, it is used at some 6,000 m^3/day.

The existing treatment chain consists of:

- Vertical Mixers – 2 units;
- Chemical Tanks and pumps (coagulation and chlorination process);
- Clarifiers – 4 units;
- Rapid Filters;
- Post-Chlorination;
- Treated Water Tanks – 2 units of V=600 m^3;
- Main Pumping Station (PS2)

Raw water quality, turbidity in particular, from the Prut River is significantly variable during the year, achieving its highest values of up to some 2,000 mg/l during the spring high-water season. The existing WTP is designed to treat the inlet raw water of considerably lower turbidity and basically is at a permanent risk of failure and consequent contamination of water. In order to mitigate possible pollution risks and to ensure efficient treatment of water, a number of preliminary pre-treatment settlers by the Prut River were designed and partially built during the Soviet times. Currently, these settlers are not in use, resulting in high operating costs for treatment of the raw water at the existing

WTP, and even stoppage of the WTP and consequently the whole town water supply during the period of highest water turbidity.

Main energy consuming installations at the WTP are:

- the Main PS, used to pump treated water to the town network and backwash rapid filters, and
- Chemical pumps used for coagulant and chlorine feeding.

General data on installed chemical pumping equipment are presented in the following Table.

Table 3-4 *Design parameters of the existing chemical pumping equipment at the WTP in Ungheni*

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Control Panel	Operating	Year
					P	Voltage	Speed	cosϕ	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
Dissolution												
1	BBH 1-12	3	720		30	380	975				4	1973
Feeding/Dosing												
1	НД1600/10	1	1,600	16	3	380	1430				24	1985
2	НД1000/10	1	1,000	16	2.2	380	1430				24	1982

After backwashing of rapid filters, the drained water is not recycled and is discharged directly into the sewerage network. This waste of water is considered to be inefficient energy solution and needs to be addressed in the next Chapters.

Most of the chemical pumps in use are in poor condition and require urgent replacement. Some of the existing pumps will be replaced by new chlorination equipment. A new chlorination plant at the WTP is planned to be built within next months under the National Water Supply and Sanitation Project, financed by the World Bank. This brand-new equipment is not a subject to this Audit Report.

3.4 Water Pumping – Main PS

The Main PS (also known as PS2) is used to provide water to the whole Town of Ungheni. Pumping equipment is separated into two (2) main groups – four (4) operating pumps and two (2) reserve pumps.

All pumps intake water from two (2) tanks, having volume of 600 m^3 each, located at the WTP area.

General data on installed pumping equipment are presented in the following Table.

Table 3-5 *Design parameters of the existing pumping equipment at the Main PS in Ungheni*

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Control Panel	Operating	Year of instal-lation
					P	Voltage	Speed	cosϕ	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
1	**CVE-350**	1	250	65	75	380	1430				24	2000
2	**CVE-350**	1	250	65	75	380	1430				24	2000
3	**NP 80/200V-37-2-12**	1	162	60	37	380	2954	0.9	64.9	VSD	24	2004
4	**NP 80/200V-37-2-12**	1	144	62	37	380	2958	0.9	64.9	VSD	24	2004

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Control Panel	Operating	Year of instal-lation
					P	Voltage	Speed	cosф	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
5	NP 80/200V-37-2-12	1	144	62	37	380	2958	0.9	64.9	VSD	24	2004
6	NP 80/200V-37-2-12	1	144	62	37	380	2958	0.9	64.9	VSD	24	2004
7	14NDN	1	1000	10	100	380	735				2	1973
8	16NDN	1	1500	10	160	380	1000				2	1973

The pumps deliver water through two parallel DN300 steel pressure mains directly into the distribution network. Pumps WILO are used to operate non-stop, while two (2) CVE-250 pumps are used as reserve.

The pressure mains from the Main PS to the elevated tank are made of steel pipes of DN300. In general, the whole pressure main is in obsolete condition, producing high number of bursts and consequently water leakages.

As the Main PS is the main energy consumer in Ungheni WSS, notwithstanding the fact that all pumps in use are relatively new, all pumps installed at the Main PS are subject to further analysis, presented in the next Chapters.

It is of note that Apa-Canal Ungheni doesn't have separate electric meters for each group of pumps. Therefore, only summed data on energy consumption are available.

Due to lack of separate electric meters for each of intake/treatment facilities in operation, it becomes impossible to analyze historical energy consumption of the separate pump groups at the Main PS.

3.5 Water Pumping – Booster PS

In total, there are eight (9) booster pumping stations in Ungheni:

- Ungureanu BPS;
- Cristiuc BPS;
- Boico BPS;
- Porumbescu BPS;
- Romana 64;
- Romana 26;
- Nationala 33;
- Nationala 43;
- Decebal 36.

All booster PS are located in the central part of the Town, supplied directly from the Main PS. Location of all booster PSs in use is shown in the Figure below.

Figure 3-3 *Location of the existing booster PSs in Ungheni*

All BPSs are located in the City center and are used to provide water to 5- and 9-floor apartment buildings.

The following service areas are covered by the booster stations:

Table 3-6 *Booster PSs supply areas in Ungheni*

BPS	No of floors in supplied blocks	No of blocks supplied	Population in supply area
Boico 5	9	5	876
Romana 64	9	3	336
Cristiuc 11	9	12	2,505
Romana 26	9	6	1,204
Porumbescu 3	9	4	1,137
Ungureanu 9	9	11	1,308
Nationala 33	9	1	75
Nationala 43	9	1	317
Decebal 36	9	2	516

General data on installed pumping equipment at BPSs are presented in the following Table.

Table 3-7 *Design parameters of the existing pumping equipment at BPSs in Ungheni*

Pump No	Model	Qty	Design Flow rate	Reported Operating Head	Design Motor Data					Control Panel	Operating	Year
					P	Voltage	Speed	cosφ	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
Boico 5	COR-1MVIE3202-GE	1	40	45	5.5	380	3770		10.8		24	2003
	K45/30	1	7		7.5	380						
Romana 64	COR-1MHIE1602-2G-GE	1	13.5	19	2.2	380	3500		6.3		24	2003
Cristiuc 11	COR-2MVIE1604-6/CR-EB	1	32	49	6.0	380	2900	0.86	6		24	2004
	K90/35	1	60		15	380						
Romana 26	K20/30	1	6		5.5	380	1410	0.84	8.7			
Porumbescu 3	COR-1MHIE1602-2G-GE	1	25.7	12	2.2	380	3500		6.3		24	2005
Ungureanu 9	COR-1MHIE1602-2G-GE	1	20	9	2.2	380	3500		6.3		24	2005
Nationala 33	PEDROLLO CP25/160B	2	3	32.5	2.2	380	2900	0.9	3.3		24	2005
Nationala 43	PEDROLLO CP25/160B	2	3	32.5	2.2	380	2900	0.9	3.3		24	2005

All pumps at the existing BPSs were replaced during 2003-2005 with modern energy efficient pumping equipment. It is clearly seen from the previous Sections that the total energy consumption of all existing 8 BPSs does not exceed some 5% of total consumption reported by Apa-Canal.

However, the Consultant decided to carry out additional site measurements at the existing BPSs in order to evaluate the real efficiency of the operating pumps. The results are presented in the following Sections.

3.6 Water Distribution Network

Town water distribution network is organized through a single pressure zone covering all city consumers.

Initially, the town was designed to be provided with water in mixed pressure/gravity mode from the Main PS and a 3,000 m^3 elevated buffer tank, located east of the Town at elevation of 101 m a.s.l. However, the buffer tank was taken out of operation and currently the PS2 delivers water directly to the town networks.

Multi-storey buildings and some elevated areas are supplied by eight (8) booster PSs, as described in the previous Sections.

The total network length is 80.3 km. Main data about existing water pipelines are shown in the following Table.

Table 3-8 *Existing water pipelines in Ungheni*

Diameter, mm	< 10 years, km	10-20 years, km	20-30 years, km	30-40 years, km	40-50 years, km	> 50 years, km	Total km
			Steel				
32	0.44		0.82				**1.26**
40		0.75	0.45				**1.20**
50	1.07	1.66	1.12	1.75	1.42	3.45	**10.48**
70	0.10	0.12	2.62	0.22	0.26	0.56	**3.88**
100		1.39	0.50	6.92	2.00	0.21	**11.02**
150			0.39	0.16	0.82		**1.37**
200			1.20	0.31			**1.51**
250							
300			0.64	1.51			**2.15**
Sub-Total							**32.87**
			Cast Iron				
100		0.97	0.75		0.20	4.48	**6.40**
150		0.99	0.34	3.57	0.36	2.39	**7.65**
200		3.76	0.15		0.67		**4.58**
250						1.72	**1.72**
300			1.50	9.02	9.66		**20.15**
			HDPE				
50-100	3.60						**3.60**
100	3.04	0.17		0.15			**3.36**
Total							**6.96**
							80.3

The NWSSP has recently started renovation of existing water networks in Ungheni. It is expected to replace some 10 km (out of 80 km) of network mains. Though only 12% of networks will be renovated, good energy saving potential is seen in the western and central parts of the network.

It is expected that current leakage rate is considerably high and a selective Leak Detection Campaign to prevent network leakages in the most emergency segments is subject to further Audit.

Beginning of year 2011 there were 8,094 household-meters installed, including:

- 7,489 in households;
- 78 for budget institutions; and
- 527 for economic agents.

4. SEWERAGE SYSTEM

4.1 General

Currently, Ungheni sewerage collection system consists of four (4) drain areas and three (3) SPSs, pumping collected wastewater to the existing WWTP, located some 9 km south of the town at an elevation of 36 m a.s.l.

Given to the Town geographic situation, all wastewater is collected by gravity at the lowest points of the drain areas, delivered to the Main SPS and thereafter pumped to the WWTP.

The estimated extent of sewerage drain areas in Ungheni is presented in the following figure:

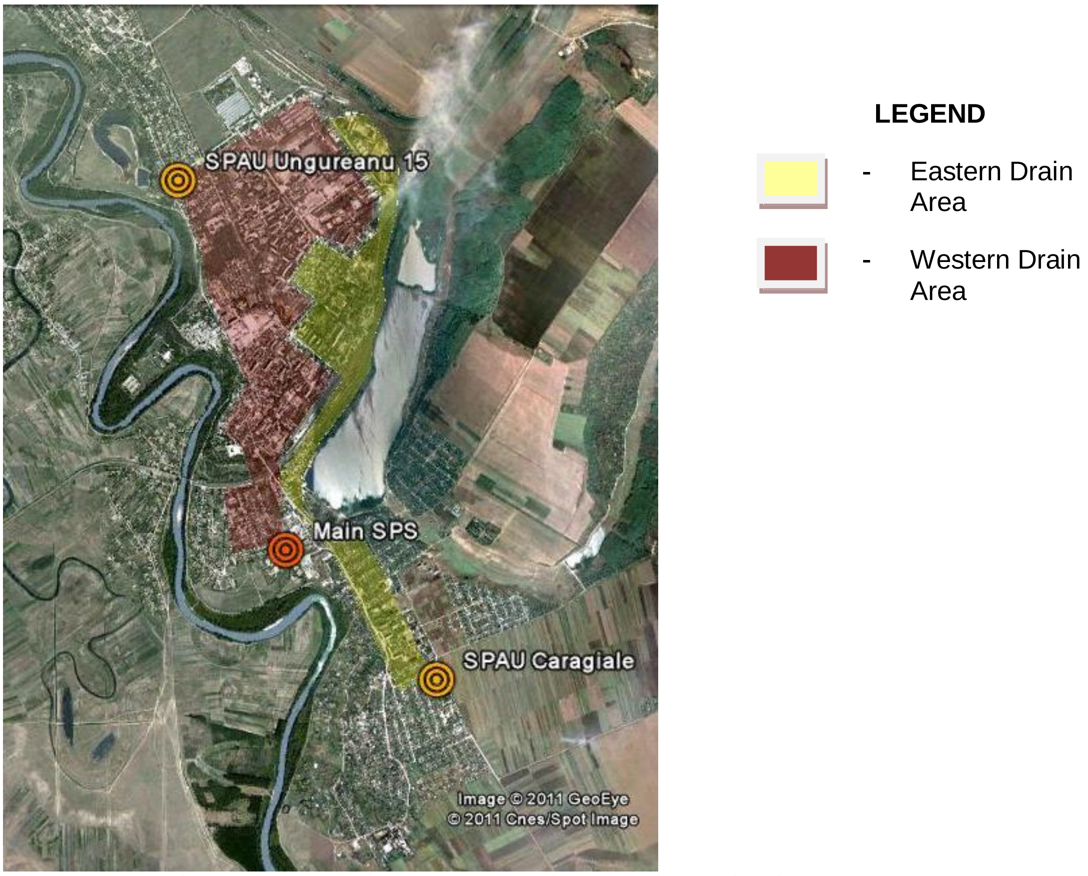

Figure 4-1 *Estimated Extent of Sewerage Drain Areas in Ungheni*

Currently, only some 52% of the Town population and some 66% of water consumers are covered by the sewerage services. Detailed information on consumers is provided in the previous Chapters.

4.2 Wastewater Collection

Town wastewater collection is separated in four (4) main drain areas, thereof collected wastewater is led to the WWTP through three (3) sewerage pumping stations.

The areas are, as follows:

- Western part – area of multi-storey blocks, private households and industry. Collected wastewater is led by the gravity collector to the Main SPS;
- Eastern part – area of multi-storey blocks, private households and industry. Collected wastewater is led by the gravity collector to the Main SPS;
- Northern part – area of private households. Collected wastewater is pumped by the Ungureanu-15 SPS to the Main SPS inlet chamber;
- Southern part – area of private households. Collected wastewater is pumped by the Caragiale SPS to the Main SPS inlet chamber.

The wastewater is collected through the central sewerage network of the town with a diameter of DN500-1000 mm and transmitted to the Main SPS. The wastewater then is pumped through two DN500 pipelines to the WWTP.

The main sewerage network originates from the 1970's and has not been renovated since. Most parts of networks are worn out generating high amounts of leakages. However, it is assumed that a considerable amount of groundwater infiltrations occur in the lower areas of the networks, dissolving pollutant content of the wastewater.

The existing sewerage gravity collection scheme is considered to be rather efficient and only interventions to the existing pumping equipment are subject to the Audit Report.

4.3 Wastewater Pumping

In total, there are three (3) wastewater PSs in use in Ungheni, as follows:

- Caragiale SPS – serving the Southern drain area;
- Ungureanu 15 SPS – serving the Northern drain area;
- Main SPS – collecting the wastewater from the whole town, including two (2) mentioned SPSs and pumping it to the WWTP.

General data on installed wastewater pumps in use are presented in the following Table.

Table 4-1 *Design parameters of the existing sewerage pumping equipment in Ungheni*

PS	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Operating	Year
					P	Voltage	Speed	cosφ	In		
			m^3/h	m	kW	V	rpm		A	hrs /day	
Ungureanu 15 SPS	CM100/65-250	1	120	7.2	7.5	380	980			24	1985
Caragiale SPS	WILO EMU FA05.32RFE	1	11.2	10.4	0.9	380	1470	0.78	3.25	24	2007
Main SPS	НГ-150-125-315	2	144	48	22	380	1470			24	1996
	СД450/56а	1	450	56	132	380	1450	0.85		24	1988
	СД450.95-2	1	450	95	250	380	1450			24	1994
	CM100/65-250	1	50	20	7.5	380	1450			24	1991
	НГ-200-150	1	100	25	7.5	380	1450			24	1990
	WILO EMU	2	180	23.4	20	380	1470		41	24	2007

PS	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Operating	Year
					P	Voltage	Speed	cosφ	In		
			m^3/h	m	kW	V	rpm		A	hrs /day	
	FA10.94E-318										

It shall be noted that both town SPSs do not represent any significant energy consumption, while the Main SPS is reported to consume some 20% of total Apa-Canal energy consumption. As can be seen, the major energy consuming facility within sewerage operations is the Main SPS. This SPS is subject to further Energy Audit analysis.

4.4 Wastewater Treatment

The existing WWTP receives wastewater from the whole Town, and is located some 10 km South of the Town, left bank of the Prut River. The WWTP inlet is situated at the elevation of some 36 m a.s.l.

The WWTP is fed with wastewater directly from the Main SPS.

WWTP was built in 1974 and has a design capacity of 15,000 m^3/day, consisting of two (2) mechanical screens, four (4) sand traps; eight (8) primary clarifiers, three (3) aeration tanks, six (6) vertical secondary sedimentation tanks and two (2) contact stabilization tanks.

Sludge is pumped by sludge pumping and blowers station and disposed at five (5) sludge drying bed;

After treatment, wastewater chlorination is done.

Currently, only rudimentary mechanical treatment stage and biological ponds are in use.

It is very difficult to appreciate the efficiency of the existing facilities, since most of energy consuming installations are taken out of operation. The existing WWTP is considered to be in a critical condition. Furthermore, according to the WB Feasibility Study, taking into consideration the condition of existing structures and machineries and insufficient process technology it could be recommended that the whole treatment plant will be replaced with new modern and more compact WWTP taken into account current and future wastewater flows and loads. In addition to above mentioned the existing WWTP is located some 15 km south from the Town Centre and wastewater is currently pumped to the treatment plant causing high energy consumption. It is recommended to find a new location for WWTP near the Town Centre so that most of the produced wastewater could be led to the treatment plant by gravity. This would bring considerable savings in pumping costs[3].

Therefore, any improvements proposed to the existing WWTP are not considered to be feasible and the existing WWTP is not a subject to this Energy Audit and an additional energy efficiency study for a newly proposed treatment technology, including possibilities of energy generation, shall be done separately.

[3] Feasibility Study for Ungheni, 2007. SWECO International AB, financed by the World Bank

5. OTHER ENERGY CONSUMPTION

The reported natural gas consumption for heating purposes is presented in the following Table.

Table 5-1 *Reported Natural gas consumption for heating purposes for 2008-2011*

	Administrative building, kWh	WTP, kWh	Garage, kWh	Total per year, kWh/year
2008	5,789	12,579	-	18,368
2009	6,241	15,181	2,424	23,846
2010	6,724	16,694	2,819	26,237
2011	4,450	12,905	1,326	18,681
TOTAL	**23,204**	**57,359**	**6,569**	

6. SITE MEASUREMENTS

6.1 Methodology

In order to assess the operating efficiency of the existing water and waste water systems and their elements and to identify energy saving potential, a comprehensive site measurement campaign was organized by the Consultant. The measurement campaign was carried out in September-October 2011.

The Consultant has performed flow measurements at all water sources, all water and sewage pumping stations.

We have also carried out flow measurements of individual water and sewage pumps to register actual pump flow rate to evaluate actual performance of pumping equipment.

Energy consumption of individual pumps was measured in details by a power analyzer. Actual power, as well as reactive, apparent, power factor, voltages and current on each phase have been measured and registered.

The Consultant's team used pressure measurements equipment at individual pumps suction and pressure sides in order to evaluate actual performance of pumps and pressure piping.

Flow Measurement Sites

Flow measuring equipment was installed at the following sites:

- Water intake PS 1;
- PS 2 at raw water treatment plant;
- BPS Cristiuc 11;
- BPS Romana 26;
- BPS Porumbescu 3;
- BPS Nationala 43;
- BPS Nationala 33a;
- BPS Ungureanu 7;
- BPS Boico 7;
- BPS Romana 64;
- SPS Main;

Flow measurements protocols are presented in the electronic external Appendix to this Report.

Pressure measurements sites

Electronic pressure transducers were installed at the following sites:

- PS 2 discharge pipe 1;
- PS 2 discharge pipe 2;
- BPS Cristiuc 11 pipe to Cristiuc str;
- BPS Cristiuc 11 pipe to Creanga str;

Pressure measurements protocol can be found in the electronic external Appendix to this Report.

Pressure manometers were installed at:

- Water intake PS 1;
- BPS Romana 26;

- BPS Porumbescu 3;
- BPS Nationala 43;
- BPS Nationala 33a;
- BPS Ungureanu 7;
- BPS Boico 7;
- BPS Romana 64;
- SPS Main;

Electrical power measurements sites

The power measurements were performed at the following sites:

- Water intake PS 1 (4 pumps);
- PS 2 at raw water treatment plant (6 pumps);
- BPS Cristiuc 11 (2 pumps);
- BPS Romana 26 (1 pump);
- BPS Porumbescu 3 (1 pump);
- BPS Nationala 43 (1 pump);
- BPS Nationala 33a (2 pumps);
- BPS Ungureanu 7 (1 pump);
- BPS Boico 7 (1 pump);
- BPS Romana 64 (1 pump);
- SPS Main (4 pumps);

Detailed power characteristic of each measurement point contains:

- frequency,
- phase voltage on each phase,
- linear voltage on each phase,
- current of each phase,
- active power consumption for each phase and all phases,
- reactive power consumption for each phase and all phases
- apparent power consumption for each phase and all phases
- power factor of each phase and all phases
- displacement factor or cos φ of each phase and all phases.

Power measurements protocols can be found in the electronic external Appendix to this Report.

Equipment used for site measurements

Power analyzer	**Qualistar CA 8334 (Chauvin-Arnoux)**
Portable flow meter	**Prosonic Flow 93T (Endress + Hausser)**
Fixed-installation flow meter big size	**DigitalFlow DF868 (GE Measurement&Control Solutions)**
Pressure transducer	**Cerabar T PMP 131 (Endress + Hausser)**
Data storage	**Memorgaph M RSG40 (Endress + Hausser)**
Non-contact infrared thermometer	**OS562 (Omega Engineering)**

All equipment used complies with the accuracy requirements and international technical standards.

6.2 Site measurement and analyses

Flow and pressure measurements at PS 2 on two pressure discharge pipelines to the city

Flow measurements started on September 20, 2011 at 13:07 and finished on September 21 at 13:06. The time interval between instant flow measurements was set to 1 minute.

Below graph illustrates the flow pattern at PS 2:

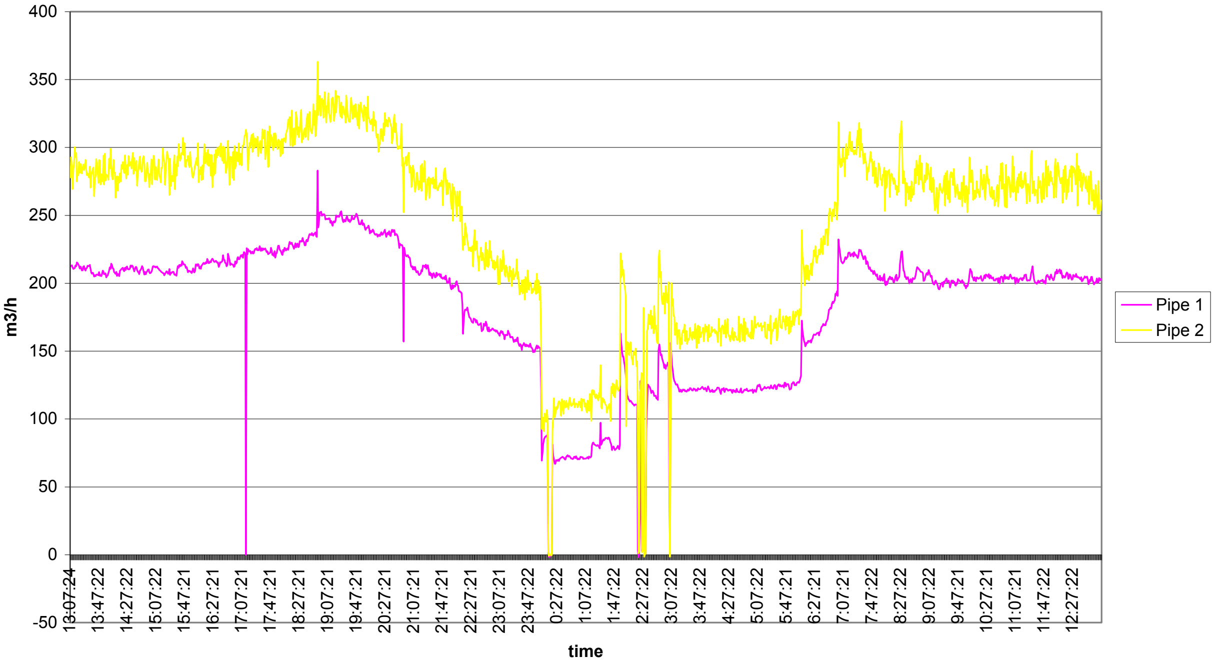

Figure 6-1 *Measured PS2 Flow Pattern*

Both pipelines deliver water to the central supply zone. Evening and morning peaks, as well as night deep are clearly visible. Pipes are interconnected within distribution network and therefore flow patterns are very similar.

Common flow pattern of PS 2 through both pipelines:

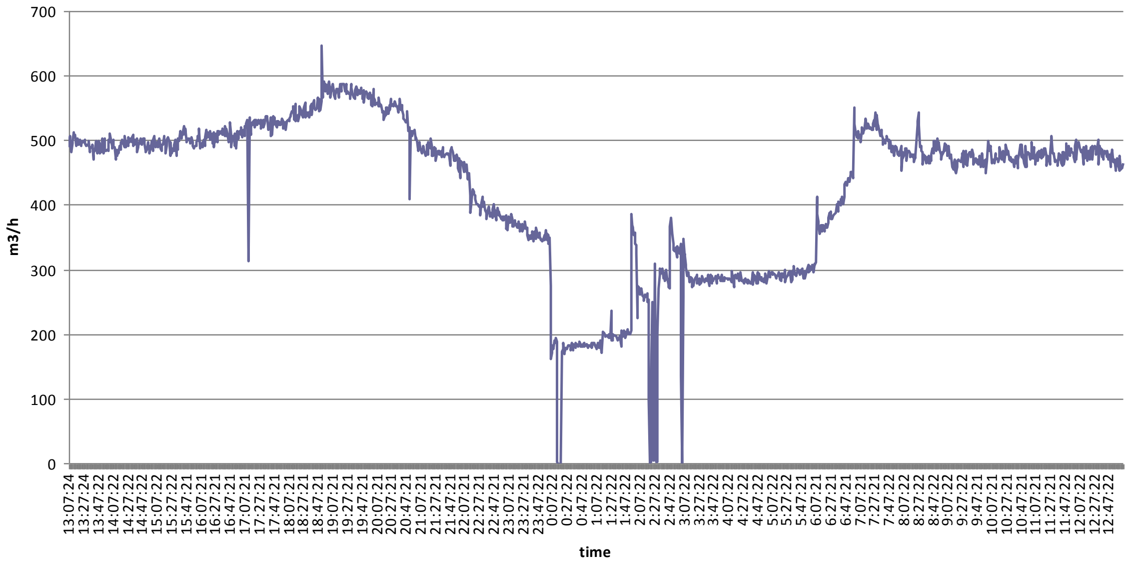

Figure 6-2 *Measured PS2 Common Flow Pattern*

Maximum evening peak is around 590 m^3/h. Minimum night flow is approx. 180 m^3/h. Daily demand peaks are served by bigger Sigma pumps CVE 350. During the night smaller Wilo pumps NP 80/200V deliver less water into the network.

Measurements of working parameters of pumping equipment showed that all pumps operate within acceptable efficiency ranges. Therefore we do not propose any ECMs for PS 2.

Pressure measurements at PS 2 started on September 20, 2011 at 13:07 and finished on September 21 at 13:06 (similar to flow measurements). The time interval between instant pressure measurement was set to 1 minute.

Below graph illustrates pressure variations in discharge pipelines at PS 2:

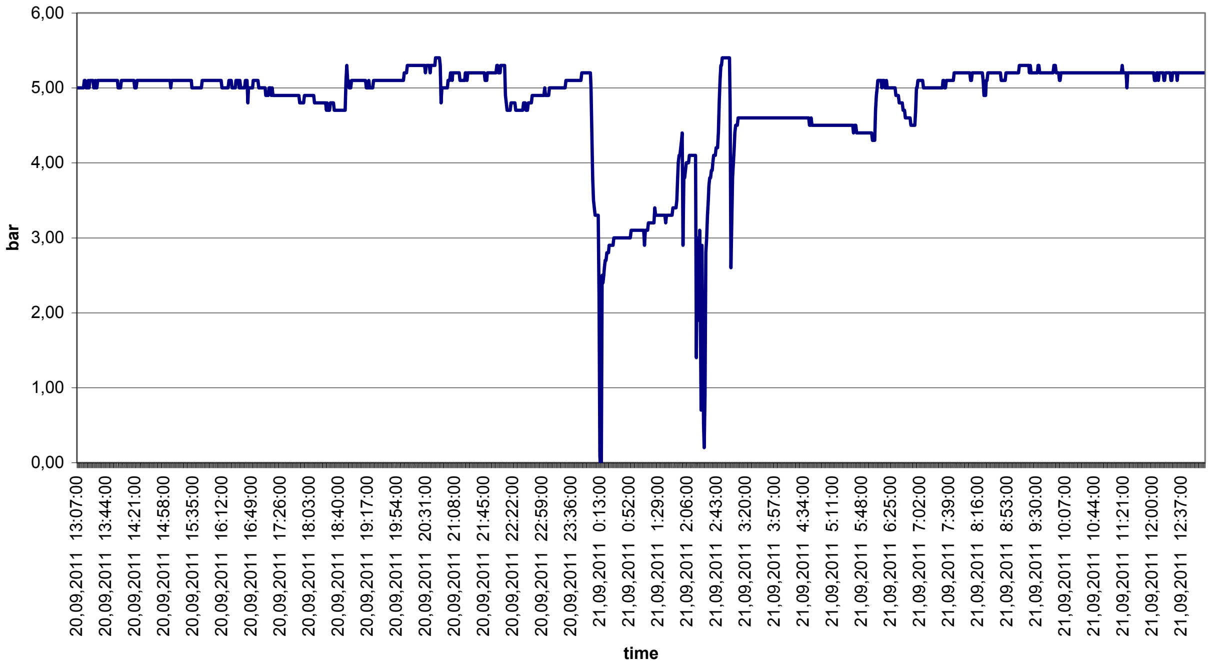

Figure 6-3 *Measured Pressure in PS2 Pressure Pipelines*

During the day pressure is maintained at approx. 5 bar and in the night is dropped to 3 bar, which corresponds to the minimum flow on above graphics.

Flow and pressure measurements at BPS Cristiuc 11 on two discharge pipelines to Creanga and Cristiuc streets

Flow measurements started on September 15, 2011 at 14:31 and finished on September 16 at 14:55. The time interval between instant flow measurements was set to 6 minutes.

Below graph illustrates the flow pattern at BPS Cristiuc 11:

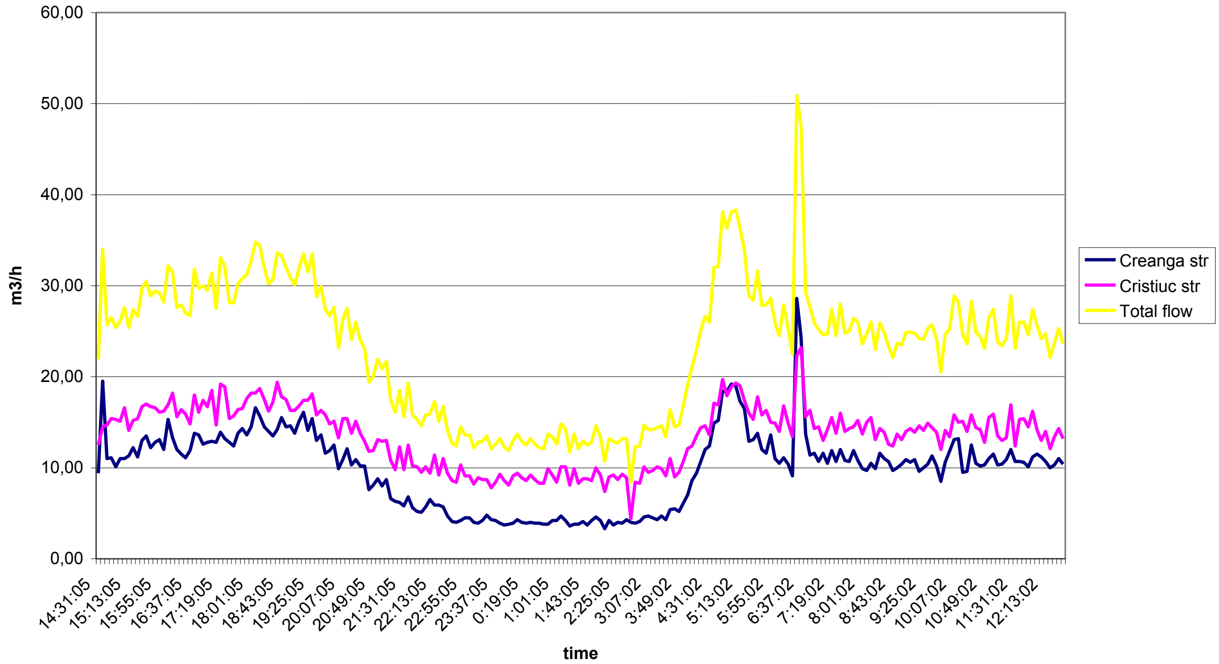

Figure 6-4 *Measured Flow Pattern for Cristiuc BPS*

Maximum morning peak is around 50 m^3/h. Minimum night flow is approx. 13 m^3/h.

Pressure measurements at BPS Cristiuc 11 started on September 15, 2011 at 16:45 and finished on September 16 at 16:02. The time interval between instant pressure measurements was set to 1 minute.

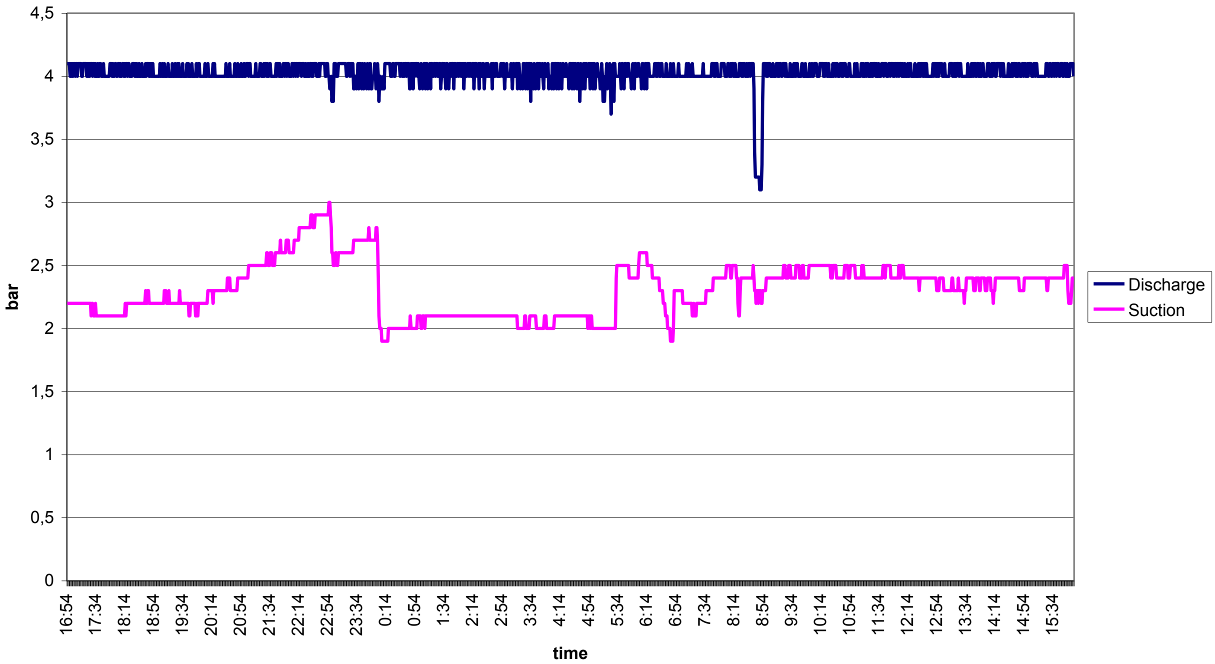

Figure 6-5 *Measured pressure in Cristiuc BPS pressure pipeline*

Discharge pressure is pre-set and kept at constant level of 4 bar. Suction pressure varies during the day and fully corresponds to the pressure trends of PS 2.

Measurements of operating parameters of pumping equipment

The summary table of design and actual operating parameters of existing pumping equipment:

Table 6-1 *Design and actual measured parameters of the existing pumping equipment in Ungheni*

		PS 1			
Design parameters	**Units**	**Pump 1 Wilo**	**Pump 2 Wilo**	**Pump 3**	**Pump 4**
Pump type		FA 15.840-278	FA 15.850-278	СД 250-22,5	СД 250-22,5
Flow	m3/h	250	250	250	250
Head	m	19.6	19.6	22.5	22.5
Impeller diameter	mm	-	-	-	-
Number of impellers		1	1	1	1
Shaft power	kW				
Pump Efficiency %	%				
Motor type		FK 202-4/27	FK 202-4/27		
Rated power	kW	18.5	18.5	37	37
Nominal voltage	V	380	380	380	380
Nominal current	A	39.5	39.5		
Rotation Speed	rpm	1430	1430	1470	1470
Cos ϕ				0.89	0.89
Motor Efficiency %	%				
Measured parameters pump					
Actual flow	m3/h	286.74	275.24	306.32	267.1
Suction pressure/dynamic level	m	2.9	2.9	2.9	2.9

Discharge pressure	m	7	7	7	7
Actual pump head	m	16.1	16.1	16.1	16.1
Active power consumption	kW	22.25	21.22	30.97	29.32
Reactive power consumption	kVAr	12.87	12.71	18.4	17.64
Apparent power	VA	25.73	24.75	36.03	34.25
Power factor		0.86	0.86	0.86	0.86
Calculated pumping efficiency					
Hydraulic power	kW	12.57	12.07	13.43	11.71
Overall pumping efficiency	%	0.57	0.57	0.43	0.40
Pump Efficiency	%				
Specific power consumption	kW/m3	0.08	0.08	0.10	0.11

Table 6-2 *Design and actual measured parameters of the existing pumping equipment in Ungheni*

		PS2							
Design parameters	**Units**	**P 1 Wilo**	**P 2 Wilo**	**P 3 Wilo**	**P 4 Wilo**	**P 5 Sigma**	**P 6 Sigma**	**P 7**	**P 8**
Pump type		NP 80/200V-37-2-12	NP 80/200V-37-2-12	NP 80/200V-37-2-12	NP 80/200V-37-2-12	CVE 350	CVE 350	14NDN	16NDN
Flow	m3/h	162	162	144	144	250	250	1000	1500
Head	m	60	60	62	62	65	65	10	10
Impeller diameter	mm					NA	NA		
Number of impellers		1	1	1	1	5	5	1	1
Shaft power	kW					NA	NA		
Pump Efficiency %	%								
Motor type									
Rated power	kW	37	37	37	37	75	75	100	160
Nominal voltage	V	380	380	380	380	380	380	380	380
Nominal current	A	64.9	64.9	64.9	64.9	NA	NA		
Rotation Speed	rpm	2950	2950	2945	2945	1450	1450	735	1000
Cos ϕ		0.9	0.9	0.9	0.9				
Motor Efficiency %	%								
Measured parameters pump									
Actual flow	m3/h	181.78	200.05	199.38	198.44	262.03	290.4	Impossible to perform measurements	Impossible to perform measurements
Suction pressure	m	3.5	3.5	3.5	3.5	3.5	3.5		
Discharge pressure	m	31	31.8	33	33.4	40.7	40.8		
Actual pump head	m	27.5	28.3	29.5	29.9	37.2	37.3		
Active power consumption	kW	39.16	37.74	41.43	41.12	67.07	68.53		
Reactive power consumption	kVAr	19.08	20.01	19.87	20.42	42.03	43.61		
Apparent power	VA	43.62	42.79	46.02	46.03	79.26	81.3		
Power factor		0,89	0,88	0,9	0,89	0,84	0,84		

Calculated pumping efficiency							
Hydraulic power	kW	13,61	15,42	16,02	16,16	26,55	29,50
Overall pumping efficiency	%	0,35	0,41	0,39	0,39	0,40	0,43
Pump Efficiency	%						
Specific power consumption	kW/m3	0,22	0,19	0,21	0,21	0,26	0,24

Table 6-3 *Design and actual measured parameters of the existing pumping equipment in Ungheni*

		BPS Cristiuc		BPS Romana 26	BPS Porumbescu 3	BPS Nationala 43	
Design parameters	**Units**	**P 1**	**P 2**	**P 1**	**P 1**	**P 1**	**P 2**
Pump type		MVI 1604/6	MVI 1604/6	K20/30	MHIE16 02-2G	CP25/1 60B	CP25/1 60B
Flow	m3/h	16	16	20	16	9	9
Head	m	36	36	30	26	25	25
Impeller diameter	mm						
Number of impellers		4	4	1	2	1	1
Shaft power	kW	2.7	2.7				
Pump Efficiency %	%						
Motor type							
Rated power	kW	3	3	4	2.2	1.1	1.1
Nominal voltage	V	380	380	380	380	380	380
Nominal current	A	6	6	8.7	6.3	3.3	3.3
Rotation Speed	rpm	2950	2950	1410	3770	2900	2900
Cos ϕ		0.86	0.86	0.84		0.9	0.9
Motor Efficiency %	%					0.75	0.75
Measured parameters pump							
Actual flow	m3/h	23.5	21.7	3.21	9.37	9.14	Impossible to perform measurements
Suction pressure/dynamic level	m	23	22.4	28	23	30	
Discharge pressure	m	28.9	31.5	38	55	48	
Actual pump head	m	5.9	9.1	10	32	18	
Active power consumption	kW	2.7	2.9	1.14	1.89	1.38	
Reactive power consumption	kVAr	1.8	1.7	3.39	2.62	1.39	
Apparent power	VA	3.28	3.37	3.6	3.53	1.97	
Power factor		0.85	0.86	0.32	0.53	0.7	
Calculated pumping efficiency							
Hydraulic power	kW	0.38	0.54	0.09	0.82	0.45	
Overall pumping efficiency	%	0.14	0.19	0.08	0.43	0.32	
Pump Efficiency	%						
Specific power consumption	kW/m3	0.11	0.13	0.36	0.20	0.15	

Table 6-4 *Design and actual measured parameters of the existing pumping equipment in Ungheni*

		BPS Nationala 33a		BPS Ungureanu 7	BPS Boico 7	BPS Romana 64	SPS Ungureanu 15	SPS Caragiale 5
Design parameters	**Units**	**P 1**	**P 2**	**P 1**	**P 1**	**P 1**	**P 1**	**P 1**
Pump type		CP25/ 160B	CP25/ 160B	MHIE1602-2G	MVIE3202	MHIE1602-2G	CM100/65-250	FA05.32 RFE
Flow	m3/h	9	9	16	32	16	50	18.5
Head	m	25	25	26	36	26	20	5
Impeller diameter	mm						255	144
Number of impellers		1	1	2	2	2	1	1
Shaft power	kW							
Pump Efficiency %	%							
Motor type								
Rated power	kW	1.1	1.1	2.2	5.5	2.2	7.5	1.3
Nominal voltage	V	380	380	380	380	380	380	380
Nominal current	A	3.3	3.3	6.3	10.8	6.3		3.25
Rotation Speed	rpm	2900	2900	3770	3500	3770	1450	1450
Cos ϕ		0.9	0.9					0.78
Motor Efficiency %	%	0.75	0.75					
Measured parameters pump								
Actual flow	m3/h	0.38	0.33	10.82	18.67	10.28	Impossible to perform measurements	Impossible to perform measurements
Suction pressure/dynamic level	m	30	30	28	25	23.5		
Discharge pressure	m	44	45	55	63.5	51.5		
Actual pump head	m	14	15	27	38.5	28		
Active power consumption	kW	0.97	0.86	1.73	4.51	1.48		
Reactive power consumption	kVAr	2.2	1.89					
Apparent power	VA	2.41	2.08	3.23	4.72	2.98		
Power factor		0.4	0.41	0.54	0.95	0.49		
Calculated pumping efficiency								
Hydraulic power	kW	0.01	0.01	0.80	1.96	0.78		
Overall pumping efficiency	%	0.01	0.02	0.46	0.43	0.53		
Pump Efficiency	%							
Specific power consumption	kW/m3	2.55	2.61	0.16	0.24	0.14		

Table 6-5 *Design and actual measured parameters of the existing pumping equipment in Ungheni*

		SPS MAIN						
Design parameters	**Units**	**P 1**	**P 2**	**P 4.1**	**P 4.2**	**P 5**	**P 7**	**P 8**
Pump type		НГ-150-125-315	СД 450/56а	НГ-150-125-299/4	НГ-125-80-388/4	СД 450/56а	FA10.94E-318	FA10.94E-318
Flow	m3/h	144	450	140	140	450	181	181
Head	m	48	56	48	48	56	23.4	23.4
Impeller diameter	mm						318	318
Number of impellers		1	1	1	1	1	1	1
Shaft power	kW							
Pump Efficiency %	%							
Motor type								
Rated power	kW	22	132	22	22	135	20	20
Nominal voltage	V	380	380	380	380	380	380	380
Nominal current	A						41	41
Rotation Speed	rpm	1470	1450	1470	1470	1450	1450	1450
Cos ϕ			0.85			0.85		
Motor Efficiency %	%							
Measured parameters pump		Impossible to perform measurements	Impossible to perform measurements					This pump is being repaired
Actual flow	m3/h			132.95	114.72	555.35	170.17	
Suction pressure/dynamic level	m			3	3	3	3	
Discharge pressure	m			23	25	46	13	
Actual pump head	m			20	22	43	10	
Active power consumption	kW			20.25	25.05	136.27	14.19	
Reactive power consumption	kVAr			12.04	12.98	63.17	5.4	
Apparent power	VA			25.18	28.25	150.21	22.87	
Power factor				0.8	0.88	0.91	0.6	
Calculated pumping efficiency								
Hydraulic power	kW			7.24	6.87	65.03	4.63	
Overall pumping efficiency	%			0.36	0.27	0.48	0.33	
Pump Efficiency	%							
Specific power consumption	kW/m3			0.15	0.22	0.25	0.08	

7. FINAL ECM PROPOSALS

7.1 Modification of pumping at PS 1

Present situation

PS 1 delivers raw water from river Prut to the treatment works. It is located at the territory of RWTP. Long suction pipeline connects PS 1 to the submerged intake chamber in the middle of Prut stream. Due to the specific design, PS 1 operates as a siphon and pumps are placed some 11 m below ground surface. Initial design anticipated siphon line, water collection chamber and submerged pumps with long shaft and motor located above the ground, but initially installed pumps operation proved to be not quite reliable, and they had been dismantled some 16 years ago.

Presently Apa-Canal uses sewage pumps dry installed in the bottom part of siphon pipeline. Usage of sewage pumps for pumping of high turbid and sandy river water is proved to be the only acceptable solution for Ungheni.

PS 1 consists of two sections. Section 1 is equipped with two Wilo sewage pumps FA 15.850-278, which operate within good efficiency range 57 %.

Section 2 is equipped with old type СД 250-22,5 sewage pumps.

In normal pumping regime one pump works in each section.

Operation of Wilo pumps FA 15.850-278 reported to be not reliable. Pump mechanical and electrical faults are frequent. To keep motor current within nominal range operators throttle discharge valve, thus reducing the flow capacity of working pump.

Measurements results

Pump no. 3 and 4

The measured actual pumping flow Q = **306.32 m^3/h**.

The measured discharge pressure **0.7 bar** at the ground level .

Pump installation depth **11 m.** Siphon positive suction head is 2.9 m.

The overall pumping head is H = 11+7+1-2.9 = **16.1 m.**

The measured active power consumption in the operating regime P_{con} = **30.97 kW.**

Calculation of pumping efficiency of pump no.3 at PS 1

The calculated hydraulic power P_{hyd} = Q x H/367.2 = **13.43 kW**

The actual pumping efficiency of existing sewage pump P_{hyd} / P_{con} = **43 %**

Existing pump operates within acceptable efficiency range for sewage pump, although pumping efficiency can be improved by installation of more efficient pump.

Actual efficiency of **pump no.4** is even less and equals to **40 %**

Proposed Improvement

We propose to substitute operation of two existing sewage pumps СД 250-22,5 and FA 15.850-278 by one new high efficient pump of horizontal dry installation (analogue S2.100.200.400.4.62L.H.285.G.N.D or similar). In order to pump turbid water from the river with high content of sand, new pump shall be sewage type. Nominal capacity of new pump will be equal to overall capacity of two existing pumps, while power consumed by new pump will be much smaller than power consumption of both existing pumps.

Rated flow = 540 m^3/h
Rated head = 19 m
Motor rated power =48 kW
Actual power at duty point =43.2 kW
Pump efficiency =72 %
Pump+motor efficiency =64.1 %

Estimation of Savings

Estimated power consumption of two existing pumps = 457,184 kWh/year

Estimated power consumption of one new pump = 378,432 kWh/year

Power saving = 78,752 kWh/year

Assuming 1.8 MDL per 1 kWh = **141,754 MDL/year**

Estimation of investment cost

Table 7-1 *Estimation of the Proposed Investment Cost*

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Horizontal dry installation pump Q=515 m^3/h, H=19 m	psc	1	18,500	18,500
2	Piping and fittings	set	1	1,000	1,000
3	Gate valve DN200	psc	1	200	200
4	Gate valve DN250	psc	1	400	400
5	Check valve DN250	psc	1	500	500
	Electrical				
6	Pump control	psc	1	2,000	2,000
7	Cables	set	1	1,500	1,500
	Auxillary				
8	Installation	Lump sum			2,000
9	Tools	set	1	200	200
10	Consumables	set	1	200	200
11	Mandatory spare parts	set	1	300	300
12	O&M manuals	set	1	100	100
	Grand total EUR				**26,900**
	Grand total MDL				**443,850**

Payback period = 3.1 years

7.2 Replacement of pumps at BPS Cristiuc 11

Present situation

BPS Cristiuc 11 boosts water to 9-story blocks along Creanga and Cristiuc streets (12 blocks and 2,500 people).

Presently two pumps MVI 1604/6 are in continuous operation and one old pump K90/35 operates during peak demand hours.
Apa Canal staff reports that pumps MVI 1604/6 are undersized and cannot serve morning/evening demand peaks.

Measurements results

Pump no. 1 and 2

Measured actual pumping flow Q = **23.5 m^3/h**.

Measured suction pressure **23 m**.

Measured discharge pressure **28.9 m**.

Overall pumping head is H = 28.9 - 23 = **5.9 m.**

Measured active power consumption in the testing regime P_{con} = **2.7 kW.**

Calculation of pumping efficiency of pump no.1

The calculated hydraulic power P_{hyd} = Q x H/367.2 = **0.38 kW**

The actual pumping efficiency of existing pump P_{hyd} / P_{con} = **14 %**

Actual efficiency of **pump no.2** is **19 %**

We consider that such a low pumping efficiency is in pump operation outside of its duty range. The actual pumping head is far away from design head of 36 m. The actual flow of 23.5 m^3/h is higher than design flow of 16 m^3/h. The working duty point is moved to the low efficiency area of pump curve. Our flow measurements indicate that even parallel operation of both pumps cannot cover the peak consumption demands, and therefore pumps are undersized in terms of flow capacity.

Proposed Improvement

We propose to install bigger pump in order to cover the actual water consumption in the supply area. New booster pump set consist of one pump (analogue GHV10/66SV2/2AG075T) with the following parameters:

Rated flow	= 60 m^3/h
Rated head	= 25 m
Motor rated power	=7.5 kW
Actual power at duty point	=6.17 kW
Pump efficiency	=72.1 %
Pump+motor efficiency	=66 %

Pump set shall be equipped with frequency converter to maintain the minimum required pressure in the system at various water demands during the day and night.

Estimation of Savings

Estimated power consumption of two existing pumps	= 40,880 kWh/year
Estimated power consumption of one new pump	= 18,016 kWh/year
Power saving	= 22,864 kWh/year
Assuming 1.8 MDL per 1 kWh	= **41,154 MDL/year**

Estimation of investment cost

Table 7-2 *Estimation of the Proposed Investment Cost*

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Booster pump Q=60 m^3/h H=25 m	set	1	6,000	6,000
2	Piping and fittings	set	1	800	800
3	Gate valve DN100	psc	3	150	450
4	Gate valve DN150	psc	3	200	600
5	Check valve DN100	psc	3	200	600
6	Pressure gauge mechanical	psc	1	100	100
	Electrical				
7	Control panel + Frequency converter (Included in item 1)	psc			
8	Earthing and cable connection	set	1	1,000	1,000
	Auxillary				
9	Installation	Lump sum			2,000
10	Tools	set	1	200	200
11	Consumables	set	1	150	150
12	Mandatory spare parts	set	1	200	200
13	O&M manuals	set	1	100	100
	Grand total EUR				**12,200**
	Grand total MDL				**201,300**

Payback period	**= 4.9 years**

7.3 Replacement of pumps at BPS Nationala 43

Present situation

BPS Nationala 43 boosts water to one 9-story block only.

Presently two pumps CP25/160B installed and one pump is in continuous operation.

Apa Canal staff reported that existing pumps are oversized and nominal flow of 9 m^3/h is much higher than needed flow for one block.

In order to run the pump within its duty range, suction and pressure lines of pump set are connected, thus ensuring recirculation of water within pumping station.

Measurements results

Pump no. 1

Measured actual pumping flow Q = **9.14 m^3/h**.

Measured suction pressure **30 m**.

Measured discharge pressure **48 m**.

Overall pumping head is H = 48 - 30 = **18 m.**

Measured active power consumption in the testing regime P_{con} = **1.38 kW.**

Calculation of pumping efficiency of pump no.1

The calculated hydraulic power P_{hyd} = Q x H/367.2 = **0.45 kW**

The actual pumping efficiency of existing pump P_{hyd} / P_{con} = **32 %**

We consider that existing pump is extremely oversized and shall be replaced by smaller unit. Recirculation of water within pumping station shall be avoided.

Proposed Improvement

We propose to install booster pump set in order to cover the actual water consumption in one block. New booster pump set consist of 2 pumps (analogue BLOCK BGM 7/A) with the following parameters:

Rated flow = 3 m^3/h
Rated head = 20 m
Motor rated power =0.775 kW

Estimation of Savings

Estimated power consumption of existing pump = 12,089 kWh/year

Estimated power consumption of new pump = 6,789 kWh/year

Power saving = 5,300 kWh/year

Assuming 1.8 MDL per 1 kWh = **9,540 MDL/year**

Estimation of investment cost

Table 7-3 *Estimation of the Proposed Investment Cost*

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Boosting pump set Q=3 m3/h H=20 m with hydrophore	psc	2	320	640
2	Piping, fittings and connection to the block plumbing	set	2	500	1,000
3	Ball valve DN50	psc	4	40	160
	Electrical				
4	Control panel and cables	set	2	400	800
5	Earthing	set	2	100	200
	Auxillary				
6	Installation	Lump sum	2	300	600
7	Mandatory spare parts	set	2	100	200
8	O&M manuals	set	1	100	100
	Grand total EUR				**3,700**
	Grand total MDL				**61,050**

Payback period = 6.4 years

7.4 Replacement of pumps at BPS Nationala 33a

Present situation

BPS Nationala 33a boosts water to one 9-story block only.

Presently two pumps CP25/160B installed and one pump is in continuous operation.

Apa Canal staff reported that existing pumps are oversized and nominal flow is much higher than needed flow for one block.

Measurements results

Pump no. 1 and 2

Measured actual pumping flow Q = **0.38 m³/h**.

Measured suction pressure **30 m**.

Measured discharge pressure **44 m**.

Overall pumping head is H = 44 - 30 = **14 m.**

Measured active power consumption in the testing regime P_{con} = **0.97 kW.**

Calculation of pumping efficiency of pump no.1

The calculated hydraulic power P_{hyd} = Q x H/367.2 = **0.01 kW**

The actual pumping efficiency of existing pump P_{hyd} / P_{con} = **1 %**

Pump no. 2 efficiency is **2 %**

We consider that existing pumps are extremely oversized and shall be replaced by smaller units.

Proposed Improvement

We propose to install booster pump set in order to cover the actual water consumption in one block. New booster pump set consist of 2 pumps (analogue BLOCK BGM 7/A) with the following parameters:

Rated flow	= 3 m^3/h
Rated head	= 20 m
Motor rated power	=0.775 kW

Estimation of Savings

Estimated power consumption of existing pump	= 8,497 kWh/year
Estimated power consumption of new pump	= 6,789 kWh/year
Power saving	= 1,708 kWh/year
Assuming 1.8 MDL per 1 kWh	= **3,075 MDL/year**

Estimation of investment cost

Please see ECM no 3. Grand total Investment cost = 61,050 MDL

Payback period	**= 19.9 years**

7.5 Pumping optimization of Main SPS

Present situation

At SPS main there are 8 pumps of different parameters. Pumps no.3 and 6 do not operate.

In general there are three groups of working pumps:
First group consist of two pumps no. 2 and 5. Pump type СД450/56а. These pumps are the biggest ones and operate during high sewage inflow. Only one pump from the group operates at a time.
Second group consist of two pumps no. 4.1 and 4.2. Pump type НГ-150-125-299/4 and НГ-125-80-388/4. These two pumps always run in parallel.

Third group consist of recently installed Wilo submerged pumps of type FA10.94E-318 (pump no.7 and 8). We consider installation scheme of these pumps unacceptable, as they are submerged in screen chamber of pumping station, which was flooded for that purpose. Since pumps are installed higher than wet chamber bottom, sludge is constantly settled and operators have to run existing pumps in dry pumping room to evacuate settled sludge from the sump.

Figure 7-1 *Main SPS in Ungheni*

Moreover flow velocities during pumping of Wilo pumps in pressure sewage lines DN500 are much lower than minimum recommended 0.7 m/s in order to avoid settlement of sediments in the pipes.

Present pumping regime varies depending of volumes of inlet sewage. Operation of sewage pumps is in alternating of working pumping groups.

Measurements results

First group (pump no 5)

The measured actual pumping flow Q = **555.35 m^3/h**.

The measured discharge pressure **46 m**. Suction pressure in collection sump **3 m.**

The overall pumping head is H = **43 m.**

The measured active power consumption of one pump in the operating regime P_{con} = **136.27 kW.**

Calculation of pumping efficiency of pump no 5

The calculated hydraulic power P_{hyd} = Q x H/367.2 = **65.03 kW**

The actual pumping efficiency of first pumping group P_{hyd} / P_{con} = **48 %**

It was not possible to perform measurements of pump no 2

Second group (pump no 4.1 and 4.2)

The measured actual pumping flow Q = **132.95 m3/h**.

The measured discharge pressure **23 m**. Suction pressure in collection sump **3 m.**

The overall pumping head is H = **20 m.**

The measured active power consumption of two pumps in the operating regime P_{con} = **20.25 kW.**

Calculation of pumping efficiency of pump 4.1

The calculated hydraulic power P_{hyd} = Q x H/367,2 = **7.24 kW**

The actual pumping efficiency of second pumping group P_{hyd} / P_{con} = **36 %**

Pump 4.2 efficiency is **27 %**

Third group (pump no 7)

The measured actual pumping flow Q = **170.17 m3/h**.

The measured discharge pressure **13 m**. Suction pressure in collection sump **3 m.**

The overall pumping head is H = **10 m.**

The measured active power consumption of one pump in the operating regime P_{con} = **14.19 kW.**

Calculation of pumping efficiency of pump 7

The calculated hydraulic power P_{hyd} = Q x H/367.2 = **4.63 kW**

The actual pumping efficiency of third pumping group P_{hyd} / P_{con} = **33 %**

Pump no 8 was not measured due to repair works.

Proposed Improvement

We recommend not to use pumping groups 2 and 3 since the most efficient pumping group is the first group of pump no 2 and 5. Moreover low velocities in the sewage trunk main DN500 shall be increased to minimum allowed 0.7 m/s or 540 m^3/h (one pipeline).

We strongly recommend to use dry sewage pumps only, as submerge Wilo pumps do not operate efficiently even in comparison with old pumps. Current submerged installation is not appropriate to the design concept of SPS Main.

Since pumps no. 2 and 5 work within acceptable efficiency range, we do not recommend replacement of pumping equipment at SPS Main.

7.6 Other Recommendations – Water Treatment Improvement

During its assignment, the Consultant also paid attention to the existing water system deficiencies, which could not be covered by this assignment, because some of facilities were either unfinished or taken out of operation and therefore didn't have any energy consumption. However, we understand that in future the existing water system will inevitably require important improvements and the Consultant has developed a number of recommendations for possible low-energy consuming investments, which, once the additional facilities are put into operation, however will probably result in overall energy consumption increase. Therefore, these recommendations are not included in the ECMs and are expected to provide a general advice to Apa-Canal on possible future system improvements.

The abstracted raw water quality, turbidity in particular, from the Prut River is significantly variable during the year, achieving its highest values of up to some 2,000 mg/l during the spring high-water season. The existing WTP in use is designed to treat the inlet raw water of considerably lower turbidity and basically is at a permanent risk of failure and consequent contamination of water.

Currently, the existing treatment system requires a considerably high consumption of chemicals and high-turbid water causes frequent back-washing of the rapid filters. The backwashing is done by using treated water from the Main PS reservoirs. Furthermore, after backwashing the drained water is simply discharged into sewerage network, without any recycling. The described arrangement results in high operating costs for treatment of the raw water at the existing WTP, and even stoppage of the WTP and consequently the whole town water supply during the period of highest water turbidity (spring time).

In order to mitigate possible pollution risks and to ensure efficient treatment of water, a number of preliminary pre-treatment settlers by the Prut River were designed and partially built during the Soviet times. Currently, these settlers are not in use.

General geographic situation is shown in the following Figure.

Figure 7-2 *Location of the Water Treatment Facilities in Ungheni*

In order to generally improve the town water supply system, the Consultant recommends finalizing the construction of the preliminary settlers and including of these settlers in the treatment chain of the WTP. The settlers are located at the same elevation as the WTP and therefore an additional pumping from the settlers to the WTP inlet will be required. However, it is expected to have a great impact over the raw water quality and will consequently reduce the consumption of coagulants and the number of back-washing cycles required. Furthermore, this will ensure the quality of drinking water during the high-turbid waters period and the WTP will not be disconnected, as it is currently practiced.

The Consultant has visited the existing unfinished settlers and concluded that an additional detailed technical study of the structures and pipelines shall be done in order to assess the current physical condition of the basins and the amount of necessary works/investments to be done.

Also, these basins could be used for recycling of the discharged water after backwashing of filters. However, an additional sand trap for the used water is recommended to be used before the water is returned to the settlers.

These recommendations are related to the engineering Best Practices and however are left to Apa-Canal discretion. It is recommended, before the investments are approved, a feasibility study and detailed design to be prepared.

7.7 Summary of the Proposed ECMs.

Current Energy Consumption - before Improvements

Table 7-4 *Current Energy Consumption – Before Improvements*

No	Before						
	Site	Pump type	Rated power, kW	Actual power, kW	Working hours per day	Energy used, kWh/year	Overall energy used, kWh/year
1	PS 1	CD 250-22,5	37	30.97	24	271,297.20	457,184.40
		FA 15.850-278	18.5	21.22	24	185,887.20	
2	BPS Cristiuc	MVI 1604/6	3	2.7	20	19,710.00	40,880.00
		MVI 1604/6	3	2.9	20	21,170.00	
3	BPS Nationala 43	CP25/160B	1.1	1.38	24	12,088.80	
4	BPS Nationala 33a	CP25/160B	1.1	0.97	24	8,497.20	

Estimated Energy Consumption - after Improvements

Table 7-5 *Estimated Energy Consumption – After Improvements*

No	After					
	Site	Pump type (analogue)	Rated power, kW	Actual power, kW	Working hours per day	Energy used, kWh/year
1	PS 1	S2.100.200.400.4.62L.H.285.G.N.D	48	43.2	24	378,432.00
2	BPS Cristiuc	GHV10/66SV2/2AG075T	7.5	6.17	8	18,016.40
3	BPS Nationala 43	BLOCK BGM 7/A	0.775	0.775	24	6,789.00
4	BPS Nationala 33a	BLOCK BGM 7/A	0.775	0.775	24	6,789.00

7.8 Estimated Energy Savings and simple payback period

Table 7-6 *Estimation of a Simple Payback Period*

No	Site	ECM effect				
		Energy savings, kWh/year	Tariff rate, MDL/kWh	Cost savings, MDL/year	Invesment cost, MDL	Payback period, years
1	PS 1	78752.40	1.80	141,754.3	443,850	3.1
2	BPS Cristiuc	22863.60	1.80	41,154.48	201,300	4.9
3	BPS Nationala 43	5299.80	1.8	9,539.64	61,050	6.4
4	BPS Nationala 33a	1708.20	1.8	3,074.76	61,050	19.9

7.9 Analysis of the Energy Saving Measures proposed by Apa-Canal and Recommendations

In the inception phase Apa Canal Ungheni submitted to the Consultant a list of ECM proposed to be implemented within EMP:

Table 7-7 *Initially Proposed ECM by Ungheni Apa-Canal*

Description	Existing equipment	Needed equipment	Expected savings, %
Installation of 7 motor protection systems at city pumping stations	-	-	-
Replacement of reactive power manual compensators by 3 automation compensators	VEM	SACPR 120 kVA 2 units 160 kVA 1 unit	6
Replacement of contactors at PS and SPS	APU-50 AM, ABM-1000	Motorized contactors	-

Auditor's activities focused mainly on pumping optimization and increasing of efficiencies of pumping equipment. Our recommendations are based on actual measurements of working parameters of existing equipment.

Two of three initial ECM proposals are deemed to strengthen reliability of pumping installations only, so no energy savings were anticipated.

Compensation of reactive power is one of the possible ECM, which can be reflected in further studies.

After submission of Draft Audit Report Apa-Canal Ungheni additionally proposed five measures to be considered in the Audit report:

1. Replacement of high voltage (10 kV) cable 2000 m at RWTP. The reason of replacement is deterioration of existing cable. This measure is deemed to be out of the scope of Energy Audit, since replacement of cable will not bring to direct savings of energy. Possible savings would be the elimination of cable repair costs only.

2. Construction of roofing at 10 kV switchgear at RWTP. This measure is deemed to be out of the scope of Energy Audit, since this measure will strengthen reliability of power supply but not bring to any savings of energy.

3. Installation of reactive power compensators 160 kVAr with 7 steps automatic regulation at RWTP. Our measurements of main working pumps at RWTP showed quite high power factor (approx. 0.9). Installation of modern automatic 7 steps compensators could be one of possible future ECM.

4. Installation of reactive power compensators 120 kVAr with 7 steps automatic regulation at Main SPS. Our measurements of Wilo submersible pumps at Main SPS showed quite low power factor 0,6. Our recommendation is to use dry pumps no. 2 and 5 with high power factor (0.91 at pump no.5). Installation of modern automatic 7 steps compensators could be one of possible future ECM.

5. Replacement of existing equipment at BPS Romana 26.

BPS Romana 26 delivers water to six 9-story blocks. Our measurements results:

Pump K20/30

The measured actual pumping flow Q = **3.21 m^3/h**.

The measured discharge pressure **38 m**. The measured suction pressure **28 m.**

The overall pumping head is H = **10 m.**

The measured active power consumption of one pump in the operating regime P_{con} = **1.14 kW.**

Calculation of pumping efficiency of pump

The calculated hydraulic power P_{hyd} = Q x H/367.2 = **0.09 kW**

The actual pumping efficiency of first pump P_{hyd} / P_{con} = **8 %**

Conclusion: Existing pump operates very inefficiently and its replacement is highly required.

Nevertheless our estimation of required water demand for 6 blocks is around **20 m^3/h.** Installation of new pump with higher flow will not bring to savings of energy. We recommend to perform further detailed investigations of water supply regime at Romana 26 in order to select the proper pumping equipment.