WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

Interreg
Greece-Bulgaria
WATER RESCUE
European Regional Development Fund
EUROPEAN UNION

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.2.1 Ex Ante Evaluation report** *Joint Deliverable*
Sub-Deliverables integrated	**D.5.1.1, D.5.2.1., D.5.4.1, D.5.5.1, D.5.6.1**
Project Beneficiary No	**PB2, PB3**
Beneficiary Institution	**Municipal Water Supply and Sewerage Company of Thermi** **University of Thessaly-Special Account Funds for Research-Department of Civil Engineering**

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Chapter 1. Introduction: The WATER RESCUE project in brief

1.1 The Project in brief

WATER RESCUE project's concept is based on the common cross-border (CB) water management problems in the two international river basin districts (RBDs) shared between Greece & Bulgaria (Struma-Strymonas; Maritsa-Evros). The common CB problems include water resources quality & quantity being at risk due to natural and human activities and climate change conditions. The consequence is that water bodies fail to meet the good ecological status (GES) (recorded in the river basin management plans-RBMP). In particular, drinking water faces significant risks due to the deteriorated water resources quality while at the same time significant water volume is lost in the water distribution networks (WDNs). The project aims at the sustainable and efficient management of drinking water supply by increasing drinking water use efficiency in WDNs and improving water quality in the whole water supply cycle (from the source and back to the environment). Good Ecological Status can be achieved by improving water quality and reducing water abstraction and can be maintained by taking climate change adaptation measures. The project focuses in drinking water supply management suffering from high Non-Revenue Water (NRW) levels and deteriorated water quality jeopardizing the drinking water consumers' safety and health and their quality of life. Urban water volumes end up to the sewerage networks while wastewater treatment plants are a pressure to water resources quality. Surface water bodies are both used for drinking water abstraction and are the final recipient of treated effluents. Thus, their ecological status is affected by both water quantities abstracted and water quality in the whole water supply cycle (from the resource to the water supply and the wastewater treatment plant and back to the environment).

1.2 Theme of the Project

WATER RESCUE project is expected to achieve Non-Revenue Water/water losses reduction by upgrading and adapting already developed methodologies, technologies and tools including Water Balance assessment and Performance Indicators, hydraulic simulation models, decision support systems and GIS tools. Additionally, WATER RESCUE is expected to achieve water quality improvement across the entire water supply chain (from the water intake point and the raw water treatment plant, back to the environment after the waste water treatment plant) through constant monitoring of water quality parameters in real time, water quality simulation models (including water age) and automatic chlorination systems on line and in line. Climate change impacts will be assessed to finally propose and adopt measures for climate change adaptation. WATER RESCUE has a clear innovative character since the methodologies and tools are integrated and do not tackle individual problems. It is the first time that integrated methodologies will be adapted to include the entire drinking water supply cycle. These methodologies/tools will serve as Early - Warning Systems both for water quantity and quality. WATER RESCUE results will improve drinking water management. At the same time as drinking water is involved, the consumers' safety and health are safeguarded and their quality of life is improved. Non-Revenue Water reduction will increase water resources efficiency, since less water will be abstracted from surface and groundwater bodies and reduce energy consumption as water and energy are interconnected in water supply systems (water-energy nexus). Drinking water quality will be improved through real time monitoring of water quality parameters across the entire water supply chain, from the water intake points, to the water treatment plant and the water distribution network, back to the environment through the wastewater treatment plant. Thus, drinking water quality will be safeguarded from its source up to the consumer's tap. As wastewater effluents return to water resources, their quality monitoring prevents water resources degradation due to this pressure. Water and energy resources efficiency will be promoted and the ability of the cross-border area to adapt to climate change conditions will be improved as all possible natural and man-made pressures will be evaluated, including climate change conditions. Water saving will be accomplished through water losses reduction and increase of the environmental awareness of the public. The quality of life is expected to be upgraded with special emphasis to the protection of the natural environment. Joint policy recommendation guidelines and papers will be developed. Good governance, transparency and participation of all stakeholders in the design, implementation and monitoring of these policies is expected. Know-how and technology transfer will take place not only among the beneficiaries but also in the stakeholders' network that will be developed.

1.3 Project Objectives

The project's main objective is the sustainable cross –border drinking water supply management aiming at water resources efficiency and conservative use through:

1. Adaptation of a joint methodological framework for water resources management (qualitatively and quantitatively) in relation to the climate change and the natural and human activities and reduction of the water resources vulnerability;

2. Increase water use efficiency through the reduction of Non-Revenue Water and water losses in the water supply networks by implementing measures tackling NRW causes;

3. Improve water quality and safety in the whole drinking water supply cycle, from the water resources to the water distribution network and back to the environment through the continuous monitoring of water quality parameters in real time and the in-line disinfection to reduce the risk of low chlorine residuals and excessive concentrations of THMs (toxic substances causing cancer);

4. Increase innovative technologies use through the integrated management of water resources including GIS-based applications; hydraulic simulation models & decision support systems;

5. Development of "green behavior", increase water saving & reduce water consumption through public awareness campaigns.

WP	Task	Leader	Duration	Nov 2017	Dec 2017	Jan 2018	Feb 2018	Mar 2018	Apr 2018	May 2018	June 2018	July 2018	Aug 2018	Sept 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019	May 2019	June 2019	July 2019	Aug 2019	Sept 2019	Oct2 019	Nov2 019
WP1: Project Management & Coordination	1.1 Preparation activities	LB	10/11/2017-9/11/2019																									
	1.2 Project Management																											
	1.3 Self evaluation																											
	1.4 Steering committee meetings																											
	1.5 Audit Costs																											
WP2: Project Communication & Dissemination	2.1 Project Communication Plan	LB	10/11/2017-9/11/2019																									
	2.2 Project Website																											
	2.3 Publication & Dissemination Material																											
	2.4 Awareness events																											
	2.5 Final events Awareness Events																											
WP3: Current Status Analysis & Assessment	3.1 Climate change impacts asssessment	PB5	10/11/2017-9/11/2018																									
	3.2 Water Audit																											
	3.3 Water quality																											
WP4: Common Methodology & Tools	4.1 Cross border water resources vulnerability assessment	PB3	10/11/2017-9/5/2019																									
	4.2 Water use efficiency																											
	4.3 Water quality																											
WP5: Pilot Actions	5.1 Ex Ante evaluation	PB2	10/11/2017-9/11/2019																									
	5.2 Pilot actions implementation																											
	5.3 Workshops & transfer visits																											
	5.4 Ex Post evaluation																											
WP6: Policy Recommendation	6.1 Joint water efficiency policy recommendation	PB4	2/5/2019-9/11/2019																									
	6.2 Joint water quality policy recommendation																											

Figure 1.1. WATER RESCUE timetable

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1.4 The Project structure and timetable

The project consists of six work packages:

- WP1: Project Management and Coordination (duration: 24 months)
- WP2: Project Communication and Dissemination (duration: 24 months)
- WP3: Current Status Analysis & Assessment (duration: 12 months)
- WP4: Common Methodology and Tools (duration: 18 months)
- WP5: Pilot Actions (duration: 24 months)
- WP6: Policy Recommendation (duration: 6 months)

The initial total project duration was 24 months but an extension was given and the final total duration is 30 months, from 10/11/2017 to 9/05/2020 (Figure 1).

1.5 Project Beneficiaries

Lead Beneficiary is the Municipal Water and Sewerage Company of Komotini (Greece); Beneficiary 2 is the Municipal Water and Sewerage Company of Thermi (Greece); Beneficiary 3 is the University of Thessaly-Special Account Funds for Research-Department of Civil Engineering (Greece); Beneficiary 4 is the Municipality of Kardzhali (Bulgaria); Beneficiary 5 is the Municipality of Gotse Delchev (Bulgaria); and Beneficiary 6 is the Municipal Water and Sewerage Company of Thermaikos (Greece).

Table 1. WATER RESCUE beneficiaries

PB #	PP name	City	Country
PB1	Municipal Water Supply and Sewerage Company of Komotini	Komotini	Greece
PB2	Municipal Water Supply and Sewerage Company of Thermi	Thermi	Greece
PB3	University of Thessaly-Special Account Funds for Research-Department of Civil Engineering	Volos	Greece
PB4	Municipality of Kardzhali	Karddzhali	Bulgaria
PB5	Municipality of Gotse Delchev	Gotse Delchev	Bulgaria
PB6	Municipal Water Supply and Sewerage Company of Thermaikos	Neoi Epivates	Greece

1.6 The present deliverable

1.6.1 The subject of the present deliverable

The present deliverable refers to WP5.1., and specifically Water audit and water quality assessment for each beneficiary pilot case. This deliverable includes parameters for the water networks such as: general data and characteristics for the water distribution network (population; area; km of pipes; etc.), parameters to estimate the water balance (SIV; consumption; seasonal fluctuations; etc.), parameters for specific indicators (PIs) regarding water efficiency (NRW by volume; real losses per km; ILI; ALI; etc.). Also parameters and PIs related to water quality are also assessed. The assessment is done prior to the implementation of the pilot action.

1.6.2 The approach applied developing the present deliverable

As the topics the WATER RESCUE project is dealing with, need precise knowledge of the way water supply and distribution systems operate, it was made clear, even during the kick-off meeting of the project, held in Komotini in January 2018 that WATER RESCUE beneficiaries, beyond their common agreement to work closely together, should be guided by the scientific beneficiary, University of Thessaly, to ensure the prompt delivery of what was expected by the WATER RESCUE project. Thus, the University of Thessaly, prepared the

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methodology and the questionnaires for this task. University of Thessaly supplied the software water audit tool WB/PI_CalcUTH (developed by the University of Thessaly) to all beneficiaries to use it for the estimation of the Water Balance and the Performance Indicators. Municipal Water Supply and Sewerage Company of Thermi (PB2) as the WP Leader took over the responsibility to prepare the joint deliverable of Phase 5.1.

Regarding the implementation of Phase 5.1., the beneficiaries reported on the ex ante evaluation of their Water Supply System(s) (WSS) regarding water use efficiency and water quality. University of Thessaly (PB3) provided a questionnaire consisting of the following chapters: (a) Introduction; (b) for the beneficiaries with pilot action referring to water use efficiency b1)Water Balance Assessment; (b2) Performance Indicators; (c) for the beneficiary referring to water quality (c1) Water Quality Assessment of the water distribution network; (c2) Performance Indicators. All beneficiaries provided their deliverables to the WP leader, who properly elaborated the data in order to prepare the joint deliverable. The WP leader together with the University of Thessaly (PB3) prepared the respective deliverable D5.1.

Chapter 2. Water Audit Methodology in Drinking Water Supply Systems

2.1 The Water Balance

The International Standard IWA Water Balance (WB) is a useful tool of "best practice" (Lambert, 1999). The IWA WB is a diagnostic approach, well acknowledged, which has been implemented in cases all around the world. It estimates NRW values and allocate the water volume which enters the water distribution network to its uses (several kinds of consumption or water losses).

The principal components definitions of the IWA WB are the following (Lambert et al., 1999; Farley and Trow, 2003) (Table 2.1):

Table 2.1: The WB variables, their symbols and meaning

Symbol	Variable	Meaning
A3	System Input Volume	the annual volume of water entering the system or part of the system
A14	Authorized Consumption	The annual water volume, metered and unmetered, used by registered customers who are authorized to use water
A21	Non-Revenue Water (NRW)	the difference between system input volume and billed authorized consumption
A13	Unbilled Authorized Consumption	The water volume legally consumed but not billed due to the policy of the water utility: metered and unmetered. It includes: fire-fighting, flushing of mains and sewers, cleaning of suppliers' storage tanks, water taken from hydrants, water used for cleaning streets, watering of municipal gardens, public fountains, frost protection, water, building, etc.
A18	Apparent Losses	The water volumes consumed but not registered due to metering errors or/and theft and illegal use.
A16	Unauthorized consumption	Water volume illegally used due to illegal connections, water theft, etc. It reasonable managed systems should not exceed 1% of the system input volume
A17	Customer metering errors	Include: (a) random errors due to accounting procedures such as misread meters, incorrect estimates for stopped meters, computer programming errors, etc. and (b) systematic errors due to under-registration or over-registration of customer meters.
A19	Real Losses	Annual water volumes lost through leaks, breaks or tanks' overflows. When leakage data are available, real losses can be estimated by performing the "bottom up" approach. Real losses consist of (Alegre et al., 2006): ✓ Real losses on raw water mains and at the treatment works; ✓ Leakage on transmission and/or distribution mains; ✓ Leakage and overflows at transmission and/or distribution storage tanks; and ✓ Leakage on service connections up to the measurement point.

Following the initial launch of the International Standard IWA Water Balance, McKenzie et al. (2007) and Kanakoudis and Tsitsifli (2010) proposed two amendments. The first one (by McKenzie et al. (2007))

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introduces the water billed but not paid for element, which is a common issue in low income countries where the consumers cannot afford to pay their water bills. The second amendment (by Kanakoudis & Tsitsifli (2010)) introduced the concept of “Minimum Charge Difference” (MCD) which is actually water losses recovered by the water utilities and thus provide revenues (Figure 2.1). MCD is not actual water volumes consumed. MCD refers to the amount of money water utilities recover through their pricing policies and in particular through the fixed charge the water utilities charge to their consumers regardless their water consumption.

<table>
<tr><td rowspan="8">System Input Volume (A3)</td><td rowspan="5">Authorized Consumption (A14=A10+A13)</td><td rowspan="3">Billed Authorized Consumption (A10=A8+A9)</td><td>Billed Metered Consumption (A8)</td><td rowspan="3">Revenue Water (A20=A8+A9)</td><td rowspan="2">Revenue Water (water billed & paid for) (A24=A8+A9-A23)</td></tr>
<tr><td rowspan="2">Billed Un-Metered Consumption (A9)</td></tr>
<tr><td>Water billed but NOT PAID for (apparent NRW) A23</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption (A13=A11+A12)</td><td>Unbilled Metered Consumption (A11)</td><td rowspan="5">Non-Revenue Water (NRW) (A21=A3-A20)</td><td rowspan="4">Accounted for Non-Revenue Water (A26=A3-A24-A23-A25)</td></tr>
<tr><td>Unbilled Un-Metered Consumption (A12)</td></tr>
<tr><td rowspan="3">Water Losses (A15=A3-A14)</td><td rowspan="2">Apparent Losses (A18=A16+A17)</td><td>Unauthorized Consumption (A16)</td></tr>
<tr><td>Customer Meter Inaccuracies & Data Handling Errors (A17)</td></tr>
<tr><td colspan="2">Real Losses (A19=A15-A18)</td><td>Water Losses generating revenues (MCD) A25</td></tr>
</table>

Figure 2.1. The 2nd modified Water Balance (Kanakoudis & Tsitsifli, 2010)

2.2 The concept of MCD

Usually water utilities charge the fixed charge to their consumers by following two pricing policies:

- the fixed charge is expressed in water volume: there is a minimum water volume charged (threshold), either consumed or not. When the actual water use is below that “threshold”, a minimum use is being charged for, resulting in a difference between the actual metered consumption level and the billed one.

- the fixed charge is expressed in monetary units: there is a minimum charge. Water consumption charge is added to this fixed charge.

2.3 Calculating the MCD

The exact calculation method will be given in the deliverable 4.2

2.4 How to estimate the Water Balance

The steps for the new modified water balance development are (Figure 2.2):

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Step 1	•Determination of the System Input Water Volume (A3)
Step 2	•Determination of the Billed Metered Use (A8) and Billed Unmetered Use (A9). Calculation of Billed Authorized Use (A10=A8+A9) and Revenue Water (A20=A8+A9).
Step 3	•Determination of Water Billed but not paid for (A23). Calculation of Water Billed and Paid For (A24=A20-A23).
Step 4	•Calculation of Non-Revenue Water (A21=A3-A23-A24)
Step 5	•Determination of Minimum Charge Difference (A25). Calculation of Accounted For Non-Revenue Water (Minimum Charge Difference has been deducted) (A26=A21-A25).
Step 6	•Determination of Unbilled Metered Consumption (A11) and Unbilled Unmetered Consumption (A12). Calculation of Unbilled Authorized Consumption (A13=A11+A12).
Step 7	•Calculation of Authorized Consumption (A14=A10+A13).
Step 8	•Calculation of Water Losses (A15=A3-A14).
Step 9	•Determination of Unauthorized Consumption (A16) and Customer meter Inaccuracies and data handling errors (A17). Calculation of the Apparent Losses (A18=A16+A17)
Step 10	•Calculation of Real Losses (A19=A15-A18)

Figure 2.2. The steps for the estimation of the new modified water balance (Kanakoudis and Tsitsifli, 2015)

1. Determination of the System Input Water Volume (A3)
2. Determination of the Billed Metered Use (A8) and Billed Unmetered Use (A9). Calculation of Billed Authorized Use (A10=A8+A9) and Revenue Water (A20=A8+A9).
3. Determination of Water Billed but not paid for (A23). Calculation of Water Billed and Paid For (A24=A20-A23).
4. Calculation of Non-Revenue Water (A21=A3-A23-A24)
5. Determination of Minimum Charge Difference (A25). Calculation of Accounted For Non-Revenue Water (Minimum Charge Difference has been deducted) (A26=A21-A25).
6. Determination of Unbilled Metered Consumption (A11) and Unbilled Unmetered Consumption (A12). Calculation of Unbilled Authorized Consumption (A13=A11+A12).
7. Calculation of Authorized Consumption (A14=A10+A13).
8. Calculation of Water Losses (A15=A3-A14).
9. Determination of Unauthorized Consumption (A16) and Customer meter Inaccuracies and data handling errors (A17). Calculation of the Apparent Losses (A18=A16+A17).
10. Calculation of Real Losses (A19=A15-A18).

The necessary variables for the estimation of the new modified water balance are given in Table 2.2.

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Table 2.2: Necessary IWA variables for the new modified water balance estimation

IWA Variable		Meaning
A3	System input volume	The water volume input of the global system during the assessment period
A5	Exported raw water	Total volume of raw water transferred to other water undertaking or to another system from the same supply area during the assessment period
A8	Billed metered consumption	Total amount of billed metered authorised consumption (including exported water) during the assessment period
A9	Billed unmetered consumption	Total amount of billed unmetered authorised consumption (including exported water) during the assessment period
A11	Unbilled metered consumption	Total amount of unbilled metered authorised consumption (including exported water) during the assessment period
A12	Unbilled unmetered consumption	Total amount of unbilled unmetered authorised consumption (including exported water) during the assessment period
A16	Unauthorised cosnumption	Total amount of unauthorised water consumption during the assessment period, including water theft.
A17	Metering inaccuracies water losses	Total amount of water consumed during the assessment period, but unaccounted-for due to metering inaccuracies
A23	Non Recoverd Water	Water volume billed but never paid by the consumers
A25	MCD (Recovered Real Losses)	Difference between water volume billed to the customers and water volume registered by their water meters

To estimate the WB is a hard thing to do as many variables are not metered and also the water utilities do not keep data records. In order to estimate some of the usually not metered variables, there are some tips and tricks used based on the international literature and on the experience. Of course, each water supply network is different and its specific characteristics should be taken into consideration. Sometimes water managers have an idea of the values of some variables.

Tip 1: to estimate the billed metered consumption the period used in the calculation should be consistent with the auditing period

Tip 2: to estimate the billed unmetered consumption, the household customers or the points of consumption should be determined. Then, a pilot project during a small time period can be implemented. For commercial customers the pilot project should be more precise

Tip 3: unbilled unmetered consumption should not be overestimated. In Australia it is 0.5% of SIV, in the UK it is 1.25% of the SIV. IWA suggests that unbilled authorized consumption should not be less than 1% of SIV

Tip 4: Unauthorized consumption in the UK is 0.25% of SIV and in Australia 0.1% of SIV. In general, it should not exceed 1% of SIV.

Tip 5: Customer meter inaccuracies (household) in the UK are 3.3% of the household consumption and 4.7% of the non-household consumption. In Australia under-registration is 2% of the household consumption and 2% of the non-household consumption.

Tip 6: IWA considers that apparent losses can range from 0 to 10% of SIV for direct pressure systems but for systems with customer tanks they are more.

2.5 Performance Indicators

Performance indicators measure the provided services efficiency and effectiveness and are the result of several variables combination. IWA has recorded 170 performance indicators (Alegre et al, 2016). The

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performance indicators consist of general indicators providing an overview of the efficiency and effectiveness and detailed indicators dealing with specific aspects of the utility functionally. They are divided in 6 groups: water resources (WR); Personnel (Pe); Quality of Services (QS); Operational (Op); Physical (Ph); and Economic and Financial (Fi) (Table 2.3). 232 variables are used to calculate the 170 PIs (Alegre et al., 2016). The variables are divided in 8 groups (A to H).

Table 2.3. PIs groups (Alegre et al., 2016)

PIs	PIs no.	PIs	PIs no.	PIs	PIs no.
Water Resources	**4**	**Operational**	**44**	**Economic and financial**	**47**
Personnel	**26**	Inspection & maintenance of physical assets	6	Revenues	3
Total Personnel	2	Instrumentation calibration	5	Costs	3
Personnel per main function	7	Electrical & signal transmission equipment inspection	3	Composition of running costs per type of costs	5
Technical services personnel per activity	6	Vehicle availability	1	Composition of running costs per main function of the water utility	5
Personnel qualification	3	Mains, valves and service connection rehabilitation – pumps rehabilitation	7	Composition of running costs per technical function activity	6
Personnel training	3	Operational water losses	7	Composition of capital costs	2
Personnel health & safety	4	Failure	6	Investment	3
Overtime work	1	Water metering	4	Average water charges	2
Quality of service	**34**	Water quality monitoring	5	Efficiency	9
Service coverage	5	**Physical**	**15**	Leverage	2
Public taps and standpipes	4	Treatment	1	Liquidity	1
Pressure & continuity of supply	8	Storage	2	Profitability	4
Quality of supplied water	5	Pumping	4	Economic Water losses	2
Service connection and meter installation & repair	3	Transmission & distribution	2		
		Meters	4		
Customer complaints	9	Automation & Control	2		

Regarding Water Quality evaluation, the Performance Indicators are:

Table 2.4. PIs for water quality evaluation

Performance Indicators		Units
Op40	Tests carried out	%
Op41	Aesthetic tests carried out	%
Op42	Microbiological tests carried out	%
Op43	Physical-chemical tests carried out	%
Op44	Radioactivity tests carried out	%
QS11	Bulk supply adequacy	%
QS18	Quality of supplied water	%
QS19	Aesthetic tests compliance	%
QS20	Microbiological tests compliance	%
QS21	Physical-chemical tests compliance	%
QS22	Radioactivity tests compliance	%

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Chapter 3. Results – Discussion

The analysis is based on pilot case basis. Each beneficiary with a pilot case (PB1, PB2, PB4, PB5, PB6), evaluated the water efficiency and water quality of his pilot area (whole water network or a part of it), before the implementation of the pilot action (ex-ante).

3.1. PB1 – Municipal Water Supply and Sewerage Company of Komotini, Greece

3.1.1. General description

Municipal Water Supply and Sewerage company of Komotini (DEYAK) supplies with water the municipality of Komotini, located in the Water District of Thrace (EL12). The people supplied with water is 65,000. The area covered is 385.3 km^2 and the average altitude is 45m. The total pipes' length is 400 km consisting of pipes from PE (with diameters 90-450mm) and from steel (with diameters 600mm). The water pipes network is old enough. The average operating pressure is 4 atm and the total number of water meters is 48,500. The number of service connections is about 17,000. The billing period is 2 months for the city of Komotini and 4 months for the municipal districts. The river basin where water is taken from is the river basin of Komotini – Loutro Evrou stream (area 1,958.3Km^2). Water is taken from Vosvozis river (EL1209R0000010085N) and the groundwater system of Rodopi (EL1200120). All the information is given in Table 3.1.1.

Table 3.1.1. General data for the city of Komotini

Data (base year 2017)	
Total population served	65,000
Total area covered (km^2)	385.3
Total pipes' length (km)	549
Mean altitude (m)	45
Mean operating pressure (Atm)	4.0
Types of pipes (material, diameters)	PE (90-450mm) and steel (600mm)
No. of water meters	48,500
No. of service connections	17,000
Billing period	2 months for Komotini city; 4 months for municipal districts
River Basin where water is taken from	Komotini – Loutro Evrou stream

The water supply system consists from a group of 10 boreholes and the water supply from Simvola (surface water body). 58.1% of the water abstracted comes from boreholes and 49.1% comes from Simvola.

3.1.2. Water Balance assessment for the water distribution network

The WB for the water distribution network of Komotini city has been elaborated for 2017 and 2018. Specifically, the WB has been elaborated for the whole year. The water utility provided data regarding the water entering the network and the water volume billed and consumed. The water volume consumed but not billed and unauthorized consumption and meters' errors are not known for the network. The water consumed but not billed is assumed to be 1% of the SIV. Meter inaccuracies and under-registration are estimated to be 15% of the billed metered consumption and unauthorized consumption is assumed to be 1% of SIV. Based on those data and assumptions, the Water Balance of the whole water utility of Komotini is given in Figures 3.1.1 and 3.1.2.

<table>
<tr><td rowspan="7">System Input Volume
(A3)
5.885.000</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
2.898.576</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
2.839.726</td><td>Billed Metered Consumption
(A8)
2.839.726</td><td rowspan="2">Revenue Water
(A20=A8+A9)
2.839.726</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
58.850</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non Revenue Water (NRW)
(A21=A3-A20)
3.045.274</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
58.850</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
2.986.424</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
484.809</td><td>Unauthorized Consumption
(A16)
58.850</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
425.959</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
2.501.615</td></tr>
</table>

Figure 3.1.1. The Water Balance for the whole water supply network of Komotini city for 2017

<table>
<tr><td rowspan="7">System Input Volume
(A3)
5.885.000</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
3.252.004</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
3.193.154</td><td>Billed Metered Consumption
(A8)
3.193.154</td><td rowspan="2">Revenue Water
(A20=A8+A9)
3.193.154</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
58.850</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non Revenue Water (NRW)
(A21=A3-A20)
2.691.846</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
58.850</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
2.632.996</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
537.823</td><td>Unauthorized Consumption
(A16)
58.850</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
478.973</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
2.501.615</td></tr>
</table>

Figure 3.1.2. The Water Balance for the whole water supply network of Komotini city for 2018

3.1.3. Water Audit - Performance Indicators

Based on the data provided above, the following Performance Indicators are estimated for the water supply network of Komotini city.

Table 3.1.2. Performance Indicators for the water supply network of Komotini (2017 & 2018)

Performance Indicators		2017	2018	Units
WR1	Inefficiency of use or water resources	35.6	42.5	%
Op23	Water losses per connection	154.88	175.67	m^3/connection/year
Op24	Water losses per mains length	18.03	20.45	m^3/km/year
Op26	Apparent losses per system input volume	9.14	8.24	%
Op27	Real Losses per connection	337.66	403.16	L/connection/day when system is pressurised
Op28	Real Losses per mains length	14,350.50	17,134.35	L/km/day when system is pressurised
Op29	ILI	6.56	7.84	-
Op39	Unmetered water	45.74	51.75	%
Fi46	Non-revenue water by volume	45.74	51.75	%

From Table 3.1.2, NRW is 35.6% of the System Input Volume (SIV) for 2017 and 42.5% for 2018. Apparent losses as % of SIV is 9.14% for 2017 and 8.24% for 2018. Real Losses in 2017 are 42.51% of SIV and 337.66 L/connection/day while in 2018 real losses are 35.6% of SIV and 413.16 L/connection/day. ILI is 6.56 in2017 and 7.84 in 2018. It is obvious that NRW levels are high for this network and this is mostly due to real losses.

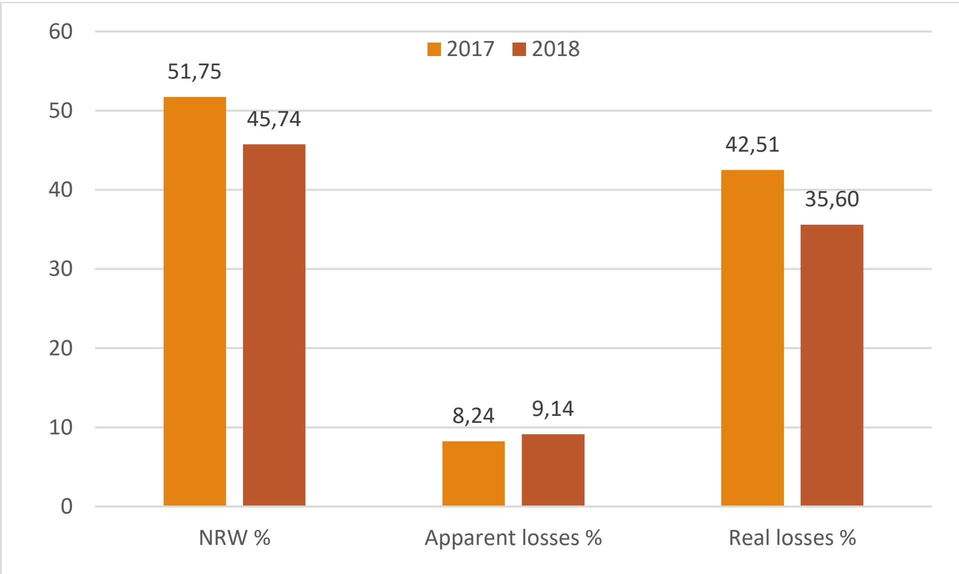

Figure 3.1.3. NRW, apparent losses and real losses as % of SIV for 2017 and 2018

3.1.4. Conclusions

The water distribution system of Komotini supplies with water 65,000 people through 400 Km of pipes and 48,500 water meters. The total area covered is 385.3 Km^2. The mean operating pressure is 4 atm. The water audit showed that NRW levels are 51.75% of the SIV for 2017 and 45.78% for 2018. Apparent losses are 8.24% of SIV and real losses are 42.51% of SIV for 2017 while for 2018 apparent losses are 9.14% and real losses 35.60%. Real losses expressed as L/Km/day are 14,350 for 2017 and 17,134 for 2018. Water losses in m^3/Km/year are 18.03 (2017) and 20.45 (2018). NRW levels are quite high and are mainly due to real losses. For these reasons the water utility is necessary to perform pilot activities to reduce real losses and in particular to improve the speed and quality of repairs pillar.

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3.2. PB2 – Municipal Water Supply and Sewerage Company of Thermi, Greece

3.2.1. General description

Municipal Water Supply and Sewerage Company of Thermi (DEYA Thermis) is the water utility supplying with water the area of Thermi including several municipal districts: Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Agia Paraskevi, Agios Antonios, Lakkia, Peristera and Livadi. The area covered by DEYA Thermis is 1559.34 Km^2. The area's altitude ranges from 0-200m. The water meters (active) are 25,786 supplying with water a population of 53,070 people (2011 census). The total pipes' length is about 700Km and the pipes are made of PE (60%) and PVC (40%). The pipes are installed since 1970 until now. The average operating pressure is about 5 atm (Table 3.2.1).

DEYA Thermis is supplying the municipal district of Thermi with water from groundwater boreholes from three groundwater subsystems: down flow of Antemountas; Thermi – N. Risio; and Cholomontas – Oreokastro (Chalkidiki river basin). DEYA Thermis water abstraction is allocated in the groundwater systems as shown in Table 3.2.2. The major water volume (97.8%) comes from the subsystems of Anthemountas down flow and Thermi – N. Risio. The first subsystem is assessed in bad quantitative and chemical status, while the second is assessed in good quantitative and chemical status. Only 2.1% of water volume comes from the Cholomontas - Oreokastro subsystem which is found to be in good chemical and quantitative status.

Table 3.2.1. General data of the water supply network of DEYA Thermis (base year 2017)

General data	
Total population served	53,070
Total area covered (Km^2)	1,559.34
Total pipes' length (Km)	700
Mean altitude (m)	0-200
Mean operating pressure (atm)	5
Types of pipes (material, diameters, lengths)	PE (60%); PVC (40%)
Age of pipes (per material, diameter)	Since 1970
No. of water meters	25,786
Billing Period	Every 3 months
River Basin where water is taken from	Chalkidiki river basin

Table 3.2.2. Water availability, average annual abstraction and DEYA Thermis abstraction of three groundwater systems (source: RBMP, 2017)

Groundwater subsystem	Towns supplied with water	Water availability (10^6 m^3)	Average annual abstraction (10^6 m^3)	DEYA Thermis (m^3)	Chemical status	Quantitative status
Down flow of Anthemountas	Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Ag. Paraskevi	33.6	37.02	7,187,700	Bad	Bad
Thermi – N. Risio	Thermi, Mikra, N. Redestos, Ag. Antonios, Lakkia				Good	Good

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Cholomontas - Oreokastro	Peristera, Livadi	99	81.64	158,500	Good	Good

3.2.2. Water Balance assessment for the water distribution network

The WB for the whole water distribution network of Thermi has been elaborated for 2017 and 2018. Specifically, the WB has been elaborated for the whole year and also per 4-month periods (as the billing period is 4 months). The water utility provided data regarding the water entering the network, the water volume billed and consumed, and the water volume consumed but not billed. Unauthorized consumption is not known for the network, but it is assumed that it represents 1% of the system input volume (entering the network). Meter inaccuracies and under-registration is also not known. According to the utility's knowledge for the network, meters errors are estimated to be 10% of the billed metered consumption.

Based on the available data and on the estimations made, the WB has been elaborated (Figures 3.2.1-3.2.8).

<table>
<tr><td rowspan="7">System Input Volume
(A3)
1.306.553</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.033.145</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
967.817</td><td>Billed Metered Consumption
(A8)
967.817</td><td rowspan="2">Revenue Water
(A20=A8+A9)
967.817</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
65.328</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
338.736</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
65.328</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
273.408</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
109.847</td><td>Unauthorized Consumption
(A16)
13.066</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
96.782</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
163.561</td></tr>
</table>

Figure 3.2.1. IWA International WB for Thermi water distribution network for the 1st 4-month period of 2017

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

<table>
<tr><td rowspan="7">System Input Volume
(A3)
1.341.222</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.060.559</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
993.498</td><td>Billed Metered Consumption
(A8)
993.498</td><td rowspan="2">Revenue Water
(A20=A8+A9)
993.498</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
67.061</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
347.724</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
67.061</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
280.663</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
112.762</td><td>Unauthorized Consumption
(A16)
13.412</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
99.350</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
167.901</td></tr>
</table>

Figure 3.2.2. IWA International WB for Thermi water distribution network for the 2nd 4-month period of 2017

<table>
<tr><td rowspan="7">System Input Volume
(A3)
1.362.964</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.077.751</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
1.009.603</td><td>Billed Metered Consumption
(A8)
1.009.603</td><td rowspan="2">Revenue Water
(A20=A8+A9)
1.009.603</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
68.148</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
353.361</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
68.148</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
285.213</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
114.590</td><td>Unauthorized Consumption
(A16)
13.630</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
100.960</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
170.623</td></tr>
</table>

Figure 3.2.3. IWA International WB for Thermi water distribution network for the 3rd 4-month period of 2017

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

System Input Volume (A3) **1.271.948**	**Authorized Consumption** (A14=A10+A13) **1.005.781**	**Billed Authorized Consumption** (A10=A8+A9) **942.184**	**Billed Metered Consumption** (A8) **942.184**	**Revenue Water** (A20=A8+A9) **942.184**
			Billed Unmetered Consumption (A9) **0**	
		Unbilled Authorized Consumption (A13=A11+A12) **63.597**	**Unbilled Metered Consumption** (A11) **0**	**Non-Revenue Water (NRW)** (A21=A3-A20) **329.764**
			Unbilled Unmetered Consumption (A12) **63.597**	
	Water Losses (A15=A3-A14) **266.167**	**Apparent Losses** (A18=A16+A17) **106.938**	**Unauthorized Consumption** (A16) **12.719**	
			Customer Meter Inaccuracies and Data Handling Errors (A17) **94.218**	
		Real Losses (A19=A15-A18) **159.229**		

Figure 3.2.4. IWA International WB for Thermi water distribution network for the 1st 4-month period of 2018

System Input Volume (A3) **1.349.577**	**Authorized Consumption** (A14=A10+A13) **1.067.166**	**Billed Authorized Consumption** (A10=A8+A9) **999.687**	**Billed Metered Consumption** (A8) **999.687**	**Revenue Water** (A20=A8+A9) **999.687**
			Billed Unmetered Consumption (A9) **0**	
		Unbilled Authorized Consumption (A13=A11+A12) **67.479**	**Unbilled Metered Consumption** (A11) **0**	**Non-Revenue Water (NRW)** (A21=A3-A20) **349.890**
			Unbilled Unmetered Consumption (A12) **67.479**	
	Water Losses (A15=A3-A14) **282.411**	**Apparent Losses** (A18=A16+A17) **113.464**	**Unauthorized Consumption** (A16) **13.496**	
			Customer Meter Inaccuracies and Data Handling Errors (A17) **99.969**	
		Real Losses (A19=A15-A18) **168.947**		

Figure 3.2.5. IWA International WB for Thermi water distribution network for the 2nd 4-month period of 2018

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

<table>
<tr><td rowspan="7">System Input Volume
(A3)
1.495.264</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.182.366</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
1.107.603</td><td>Billed Metered Consumption
(A8)
1.107.603</td><td rowspan="2">Revenue Water
(A20=A8+A9)
1.107.603</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
74.763</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
387.661</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
74.763</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
312.898</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
125.713</td><td>Unauthorized Consumption
(A16)
14.953</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
110.760</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
187.185</td></tr>
</table>

Figure 3.2.6. IWA International WB for Thermi water distribution network for the 3rd 4-month period of 2018

<table>
<tr><td rowspan="7">System Input Volume
(A3)
4.010.739</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
3.171.455</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
2.970.918</td><td>Billed Metered Consumption
(A8)
2.970.918</td><td rowspan="2">Revenue Water
(A20=A8+A9)
2.970.918</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
200.537</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
1.039.821</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
200.537</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
839.284</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
337.199</td><td>Unauthorized Consumption
(A16)
40.107</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
297.092</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
502.085</td></tr>
</table>

Figure 3.2.7. IWA International WB for Thermi water distribution network for 2017

<table>
<tr><td rowspan="7">System Input Volume
(A3)
4.116.789</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
3.255.313</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
3.049.474</td><td>Billed Metered Consumption
(A8)
3.049.474</td><td rowspan="2">Revenue Water
(A20=A8+A9)
3.049.474</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
205.839</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
1.067.315</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
200.537</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
861.476</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
346.115</td><td>Unauthorized Consumption
(A16)
41.168</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
304.947</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
515.361</td></tr>
</table>

Figure 3.2.8. IWA International WB for Thermi water distribution network for 2018

All the above data are gathered at the following Table 3.2.3.

The results show that NRW is about 25% of the water volume entering the network. Almost 50% of the NRW are real losses. Specific performance indicators are calculated in the next chapter.

3.2.3. Water Audit - Performance Indicators

Based on the data above, several performance indicators (PIs) have been calculated for 2017 and 2018, annually and per 4-month periods. The PIs are given in the Table 3.2.4.

The results show that there is no variation among the 4-month periods. NRW by volume (as % of SIV) is 25.93% for both years. Apparent losses are 8.41% of SIV and real losses are 12.52% of SIV. Real losses expressed as lt/Km/day are 1,965.11 for 2017 and 2,017.07 for 2018. Water losses in m^3/Km/year are 3.28 (2017) and 3.37 (2018).

NRW levels are quite high and are mainly due to real losses. However, as estimations are used to calculate the apparent losses, the water utility is necessary to perform pilot activities to estimate both unauthorized use (illegal connections, water theft, etc.) and also meter under-registration.

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Table 3.2.3. WB data for 4-month periods of 2017 – 2018 and annually

m^3	1st 2017	2nd 2017	3rd 2017	1st 2018	2nd 2018	3rd 2018	2017	2018
System Input Volume	1.306.553	1.341.222	1.362.964	1.271.948	1.349.577	1.495.264	4.010.739	4.116.789
Authorized Consumption	1.033.145	1.060.559	1.077.751	1.005.781	1.067.166	1.182.366	3.171.455	3.255.313
Billed Authorized Consumption	967.817	993.498	1.009.603	942.184	999.687	1.107.603	2.970.918	3.049.474
Billed Metered Consumption	967.817	993.498	1.009.603	942.184	999.687	1.107.603	2.970.918	3.049.474
Billed Un Metered Consumption	0	0	0	0	0	0	0	0
Unbilled Authorized Consumption	65.328	67.061	68.148	63.597	67.479	74.763	200.537	205.839
Unbilled Metered Consumption	0	0	0	0	0	0	0	0
Unbilled Unmetered Consumption	65.328	67.061	68.148	63.597	67.479	74.763	200.537	205.839
Revenue Water	967.817	993.498	1.009.603	942.184	999.687	1.107.603	2.970.918	3.049.474
Water Losses	273.408	280.663	285.213	266.167	282.411	312.898	839.284	861.476
Apparent Losses	109.847	73.022	84.302	88.094	103.468	125.713	337.199	346.115
Unauthorized Consumption	13.066	13.412	13.630	12.719	13.496	14.953	40.107	41.168
Meter Inaccuracies & Data Handling Errors	96.782	59.610	70.672	75.375	89.972	110.760	297.092	304.947
Real Losses	163.561	207.641	200.911	178.073	178.943	187.185	502.085	515.361
Non-Revenue Water	338.736	347.724	353.361	329.764	349.890	387.661	1.039.821	1.067.315

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Table 3.2.4. PIs for 2017 and 2018 annually and per 4-month periods

Performance Indicator		1st 2017	2nd 2017	3rd 2017	1st 2018	2nd 2018	3rd 2018	2017	2018	Units
WR1	Inefficiency of use or water resources	12,52	12,52	12,52	12,52	12,52	12,52	12,52	12,52	%
Op24	Water losses per mains length	4,34	4,45	4,53	4,22	4,48	4,97	3,28	3,37	m^3/km/year
Op25	Apparent losses	8,41	8,41	8,41	8,41	8,41	8,41	8,41	8,41	%
Op26	Apparent losses per system input volume	8,41	8,41	8,41	8,41	8,41	8,41	8,41	8,41	%
Op28	Real losses per mains length	2.596,20	2.665,09	2.708,30	2.527,45	2.681,69	2.971,19	1.965,11	2.017,07	lt/km/day when system is pressurised
Op39	Unmetered water	25,93	25,93	25,93	25,93	25,93	25,93	25,93	25,93	%
Fi46	Non-revenue water by volume	25,93	25,93	25,93	25,93	25,93	25,93	25,93	25,93	%
	Real Losses (% SIV)	12,52	15,48	14,74	14,00	13,26	12,52	12,52	12,52	%

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3.2.4. Water Quality Assessment of the water distribution network

The water utility of Thermi uses groundwater sources for water supply. The utility conforms with the national and European legislation regarding drinking water quality. Disinfection is applied as water treatment at the boreholes or at the water tanks. At the boreholes, chlorine is injected to the borehole supply pipe. At the water tanks, chlorine is added inside the water tank.

The major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background.

Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater.

Regarding chlorination, the water utility implements the national legislation. There are 29 chlorination points, given in Table 3.2.5. Chlorination takes place is tanks, in boreholes, pumping stations and in other sites.

Table 3.2.5. Chlorination types and sites for DEYA Thermis

Network	Chlorination point	Chlorination type	Comments
Lida Maria	Tank	3	The automatic system is out of order
Toumba	Foiros Sideras	2	
Litsa small	Foiros Sideras	2	
Litsa large	Foiros Sideras	2	
Hayat	Tank	1	
Triadi up tank	Pumping station Triadi	1	
Triadi down tank	Pumping station building site	1	
N. Redestos big tank	Tank	1	The automatic system is out of order
N. Redestos small tank	Tank	1	
Filothei	Tank	1	
Tagarades	Preselection tank	4	
N. Risio	Tank	1	
Vasilika	Borehole BA1	1	
Lakkia	Borehole ΛΑ1	1	
Kato Peristera	Borehole	1	
Peristera source	In the network	5	
Up tank Peristera	Church Peristera spring	6	
Down tank Peristera	Tank	6	
Livadi	Borehole	1	
Agios Antonios	St John	3	
Monopigado	St John	3	
Souroti	Tank	3	
Agia Paraskevi	Tank	1	
Kardia	cistern	2	
Trilofos Kotroni	Conjunction & 4 SEASON	1 & 2	The automatic system is extracted
Trilofos Profitis Ilias	Conjunction	1	The automatic system is extracted
Plagiari	Upper tank & down tank in the summer	3 & 7	
Kato Sholari	Conjunction	1	The automatic system is extracted
Ano Sholari	Conjunction	1	The automatic system is extracted

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Meaning of chlorination type:
1: Chlorination pump connected to the borehole
2: Chlorination pump connected to the pump
3: Chlorination pump connected to the sensor
4: Automatic chlorination system
5: Solid chlorine
6: 24hours continuous electricity
7: works with timer

3.2.5. Water Quality - Performance Indicators

The water utility applies all the necessary tests for water quality. Performance indicators for those tests are estimated and presented in Table 3.2.6.

Table 3.2.6. PIs regarding water quality

Performance Indicators		2017	2018	Units
Op40	Tests carried out	100	100	%
Op41	Aesthetic tests carried out	100	100	%
Op42	Microbiological tests carried out	100	100	%
Op43	Physical-chemical tests carried out	100	100	%
Op44	Radioactivity tests carried out	100	100	%
QS11	Bulk supply adequacy	100	100	%
QS18	Quality of supplied water	96,61017	97,76358	%
QS19	Aesthetic tests compliance	100	100	%
QS20	Microbiological tests compliance	95,55556	97,26027	%
QS21	Physical-chemical tests compliance	96,77419	96,77419	%
QS22	Radioactivity tests compliance	100	100	%

In general, the water utility elaborates all necessary tests. Some of the tests are not in compliance with the legislation, specifically microbiological tests and physical – chemical tests. However, the percentage is very high, showing that there are only a few cases with non-compliance.

3.2.6. Conclusions

The water distribution system of Thermi supplies with water 53,070 people through 700 Km of pipes and 25,786 water meters. The total area covered is 1,559Km^2. The mean operating pressure is 5 atm. The water audit showed thath NRW levels are about 25% of the SIV for 2017 and 2018. Apparent losses are 8.41% of SIV and real losses are 12.52% of SIV. Real losses expressed as lt/Km/day are 1,965.11 for 2017 and 2,017.07 for 2018. Water losses in m^3/Km/year are 3.28 (2017) and 3.37 (2018). NRW levels are quite high and are mainly due to real losses. However, as estimations are used to calculate the apparent losses, the water utility is necessary to perform pilot activities to estimate both unauthorized use (illegal connections, water theft, etc.) and also meter under-registration.

Regarding water quality, the major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background. Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater. Regarding chlorination, the water utility implements the national legislation. There are 29 chlorination points, in tanks, boreholes, pumping stations and in other sites. However, some of these systems are not functional. In general, the water utility elaborates all necessary tests. Some of the tests are not in compliance with the legislation, specifically

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microbiological tests and physical – chemical tests. However, the percentage is very high, showing that there are only a few cases with non-compliance.

3.3. PB3 – University of Thessaly – Special Account Funds for Research – Civil Engineering Department, Greece

3.3.1. General description

The University of Thessaly does not have its pilot case. However, based on the project's application form, PB3 is responsible for updating the hydraulic simulation model of the LB and develop the hydraulic simulation model for the water distribution network of PB2.

Specifically, PB3 will update the already developed hydraulic simulation model to segment it into zones and develop its quality model.

PB3 will develop the hydraulic simulation model of the distribution network of PB2. For this reason PB3 will use WATER GEMS hydraulic simulation software.

3.4. PB4 – Municipality of Kardzhali, Bulgaria

3.4.1. General description

The water supply and distribution system of Kardzhali supplies with water 55,019 people, through 19,854 service connections. The mean operating pressure is 4-5 atm (Table 3.4.1). The average age of the pipes are 35 years. The billing period is monthly. Water is taken from Borovitsa river, the dam of Borovitsa and Perpereshka river. Data for the pipes are given in Table 3.4.2.

Table 3.4.1. General data of the water supply network of Kardzhali (base year 2017)

General data	
Total population served	55,019
Mean operating pressure (atm)	4-5
No. of service connections	19,854
Billing Period	monthly
River Basin where water is taken from	Borovitsa river, dam of Borovitsa, Perpereshka river.

Table 3.4.2. Pipes data for water supply network of Kardzhali

MUNICIPALITY	length of the water supply network			
	in the settlements		out of populated areas	
	Φ ≤300 мм	Φ > 300 мм	Φ ≤ 300 мм	с Φ > 300 мм
	км	км	км	км
MUNICIPALITY KARDZHALI	171171	7608	143539	33380
Incl.				

ethericity	**97668**	**7608**	**122202**	**33380**
steel	**11975**		**12811**	
PEPP and PVC	**61528**		**8526**	

3.4.2. Water Balance assessment and water quality evaluation for the water distribution network

On the territory of the company there are three dispatching systems equipped with a program for control of pumping stations and reservoirs (SKADA) - Kardzhali, Krumovgrad and Kirkovo. 12 PCs located in areas where there is no radio signal coverage are not covered. The plan of the Company is a phased inclusion of these vehicles.

In newly constructed WWTP Kardzhali and Momchilgrad there is a three-stage "SKADA" system, which provides fully automated management, including and remote.

At the Pazardzhik town of Kardzhali was put into operation in 1990. there is a partially built automation. The PIP currently under development envisages a major repairs to the WWTP, including the construction of a three-tier "SCADA" system.

At the entrances of Kardzhali and Momchilgrad, as well as large water mains are installed induction flow meters, which signal constantly in the dispatch stations. The program of the company envisages additionally mounted on such flowmeters in separate zones as well as at the entrances of the larger settlements. They are designed to be mounted on pressure sensors with remote reading.

In order to locate accidents on the main water supply from Borovitsa dam to the town of Kardzhali with a length of 25 km. another 4pcs are provided. pressure sensors with remote reading from dispatcher point. One sensor is currently installed.

SCADA on-board report for control and management of feed water from the HP and HP

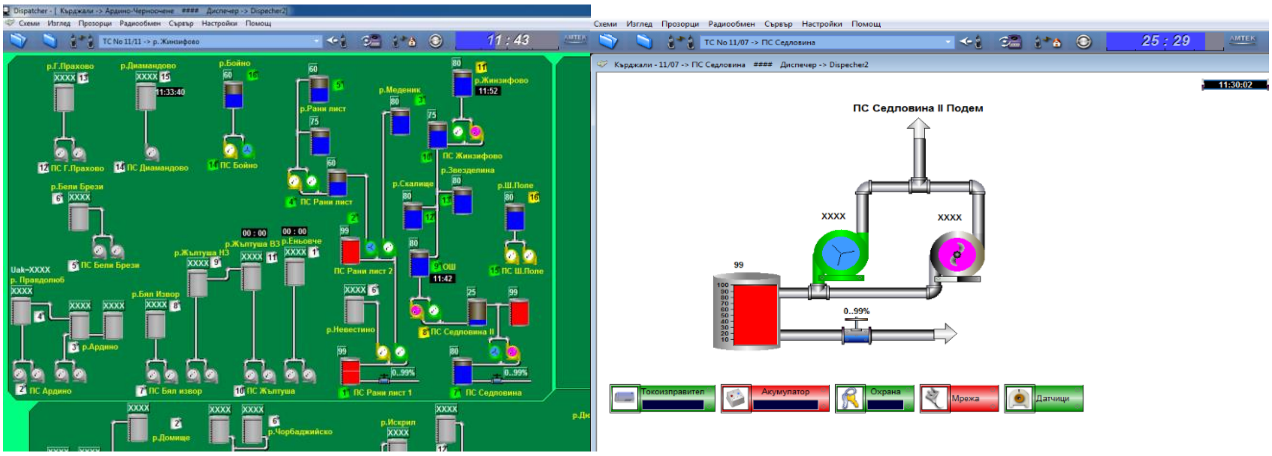
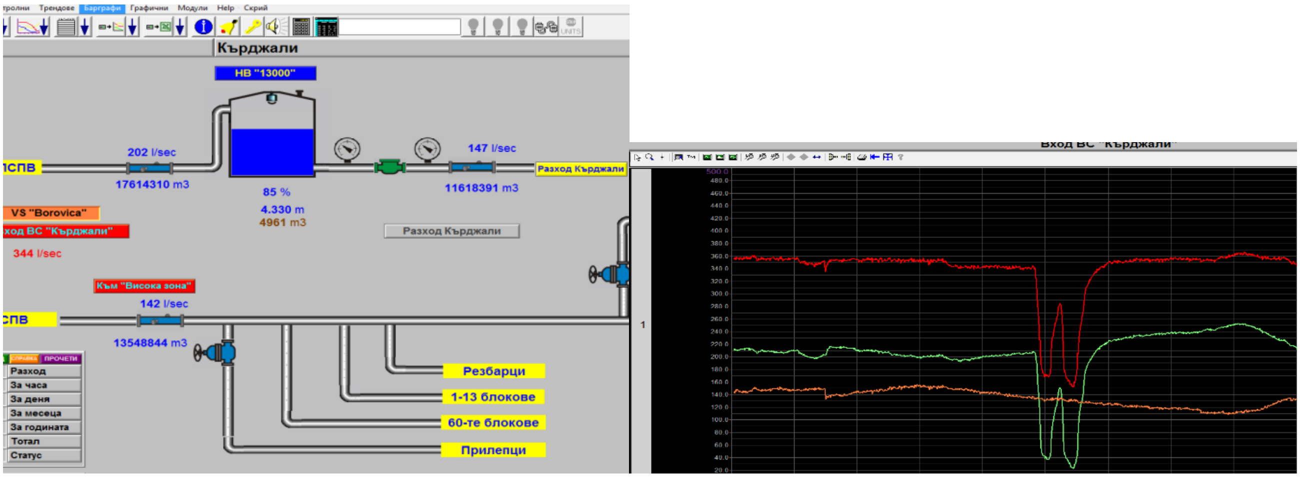


Figure 3.4.1. SCADA for HP control and management

Flow meters for monitoring incoming water in Kardjali from the Encez PWN and zone water meters.



At the inlet and outlet of the WWTP there are installed automatic sampling systems and flowmeters for recording the input and output water. All water and sludge purification processes are automated and controlled by a SCADA (Data Dispatch Control and Data Collection System). The WWTP is capable of being controlled by the PLCs of the programmable logic controllers or manually controlled on each section to ensure continuous operation in case of a SCADA system failure or any device.

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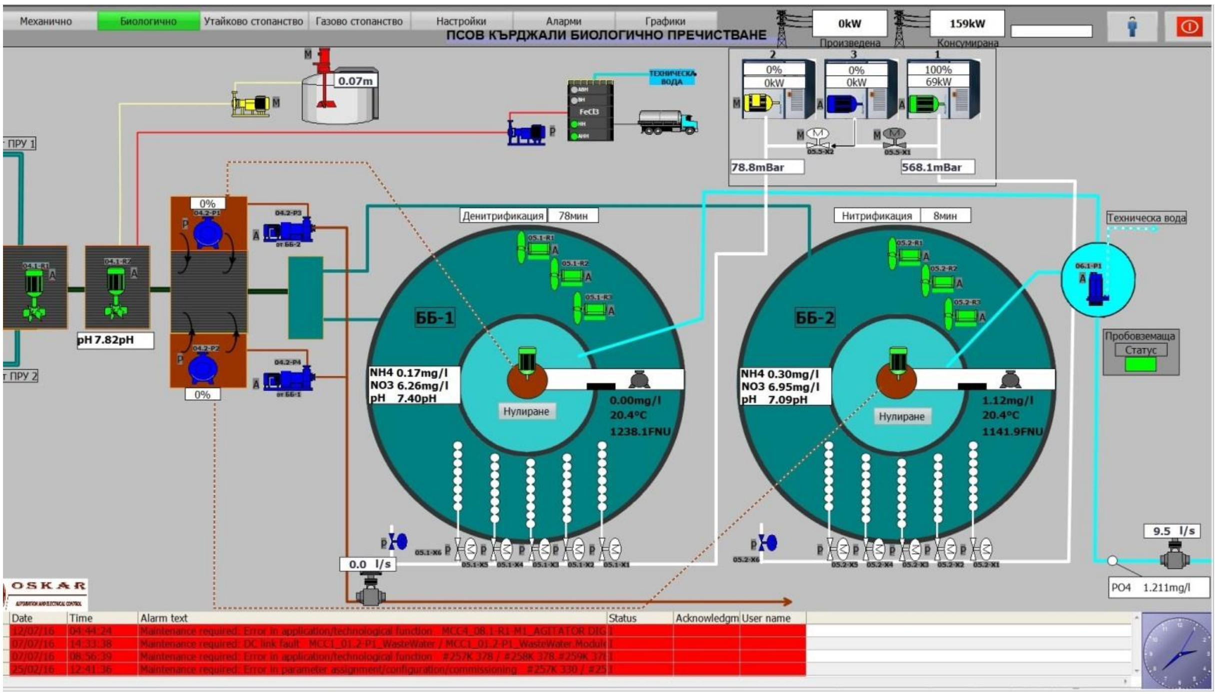

Figure 3.4.2. SCADA for Biological Steps

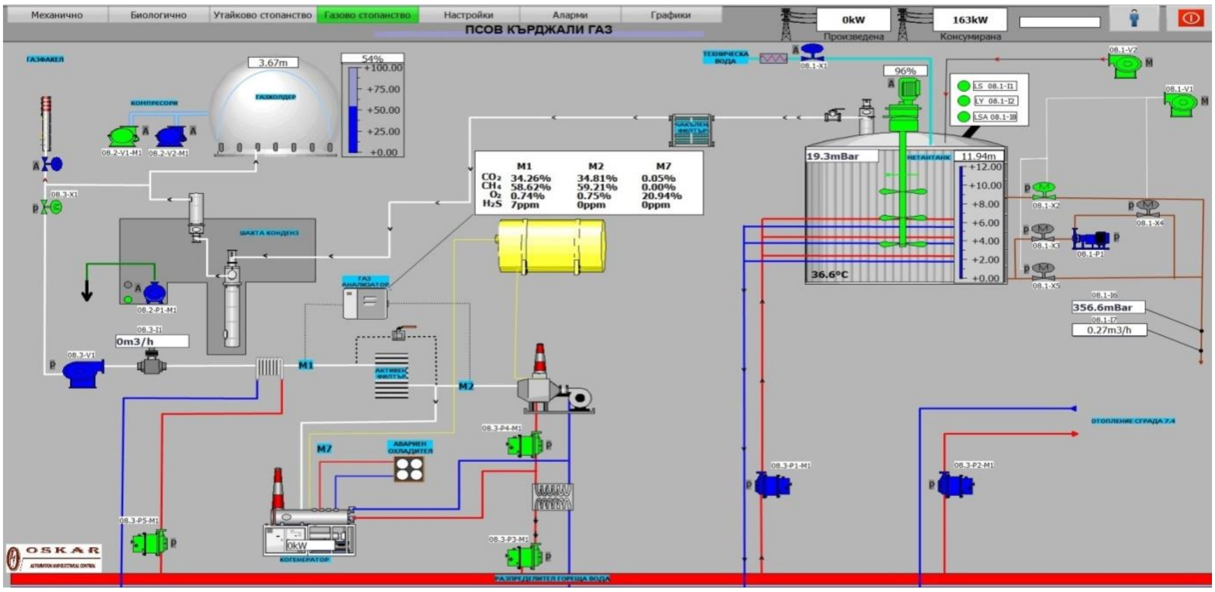

Figure 3.4.3. SCADA Gas Holding

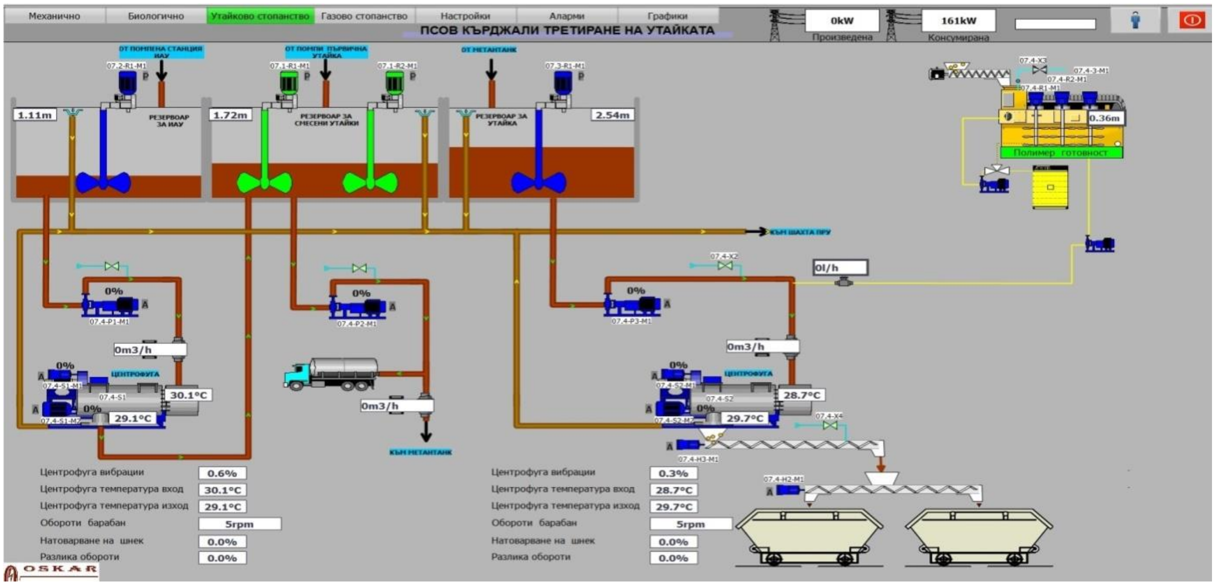

Figure 3.4.4. SCADA Sludge Holding

Water consumption by month for 2017 is given in Table 3.4.3.

Table 3.4.3. Water consumption by month

January	February	March	April	May	June	July	August	September	October	November	December
191,996	205,375	204,161	207,366	220,022	222,179	256,392	265,212	273,326	249,817	211,004	187,214

For the WB assessment, the assumptions made are:

- Billed unmetered consumption is zero
- Unbilled metered and unmetered consumption is considered negligible (zero)
- There are no data on unauthorized consumption and meters inaccuracies.

Based on the available data, only revenue water and NRW can be assessed. Revenue Water is 3,113,260m^3/year and NRW is 1,568,740m^3/year, for 2017. As the water utility does not have flowmeters to record the water intake volumes, it selected the installation of such flowmeters as part of its pilot action.

3.4.3. Water Audit - Performance Indicators

The performance indicators calculated for water use efficiency are: inefficiency of use of water resources and unmetered water (Table 3.4.4).

Table 3.4.4. PIs for water use efficiency for Kardzhali

PIs	Kardhali	Units
Inefficiency of use of water resources	33,50	%
Unmetered water	33,50	%
NRW per SIV	33,50	%

The results show unmetered water is 33.5% of the total water volume entering the network. NRW level is 33.5% of SIV.

3.4.4. Water Quality - Performance Indicators

The water utility applies all the necessary tests for water quality. Performance indicators for those tests are estimated and presented in Table 3.4.5.

Table 3.4.5. PIs regarding water quality

Performance Indicators		2017	Units
Op40	Tests carried out	100	%
Op41	Aesthetic tests carried out	100	%
Op42	Microbiological tests carried out	100	%
Op43	Physical-chemical tests carried out	100	%
QS18	Quality of supplied water	98,65997	%
QS19	Aesthetic tests compliance	98,91892	%
QS20	Microbiological tests compliance	97,90576	%
QS21	Physical-chemical tests compliance	99,04306	%

In general, the water utility elaborates all necessary tests. Some of the tests are not in compliance with the legislation, specifically aesthetic tests, microbiological tests and physical – chemical tests. However, the percentage is very high, showing that there are only a few cases with non-compliance.

3.4.5. Conclusions

The water supply and distribution system of Kardzhali supplies with water 55,019 people, through 19,854 service connections. The mean operating pressure is 4-5 atm. The average age of the pipes are 35 years. The billing period is monthly. Water is taken from Borovitsa river, the dam of Borovitsa and Perpereshka river. NRW level is 35.5% of SIV. Only three water efficiency PIs are estimated. Unmetered water and the inefficiency of water resources' use are calculated and are 35.5% of SIV. PIs for water quality are calculated. All tests are carried out. However, there is not compliance with all tests but the percentages are high.

3.5. PB5 – Municipality of Gotse Delchev, Bulgaria

3.5.1. General description

Pilot actions will take place in sub DMA called Dunav. Due to specificity of the areas covered mainly from 4-5 floors blocks, DMA has high level of non-revenue water with relatively short main pipeline and small number of service connections.

DMA Level (2018 base year)

- Total population served = 1 650
- Total area covered (Km^2) = 0,20
- Total pipes' length (Km) = 1.140
- Mean altitude (m) = 525
- Mean operating pressure (atm) = 4,5
- Types of pipes (material, diameters, lengths) =

Material	Diameter	Length
Steel (main pipeline)	200 mm	1 141 m
Brass (service connections)	32 mm	539 m

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- Age of pipes (per material, diameter) =

Material	Diameter	Age
Steel (main pipeline)	200 mm	>30 years
Brass (service connections)	32 mm	>30 years

- No. of service connections = 49
- Billing Period = monthly
- River Basin where water is taken from = Mesta river basin

3.5.2. Water Balance assessment for the water distribution network

The water balance for the pilot case is given in Figure 3.5.1.

<table>
<tr><td rowspan="7">System Input Volume
(A3)
213.938</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
72.588</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
72.588</td><td>Billed Metered Consumption
(A8)
72.588</td><td rowspan="2">Revenue Water
(A20=A8+A9)
72.588</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
0</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
141.380</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
0</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
141.350</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
33.278</td><td>Unauthorized Consumption
(A16)
8.278</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
25.000</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
124.827</td></tr>
</table>

Figure 3.5.1. IWA International WB for Dunav DMA for 2018

From water balance provided following trends can be seen

- The share of water losses from system input water is extremely high – 62.1%.
- The share of unbilled authorized consumption is assumed to be zero (0).
- Apparent losses are 23.54% from total amount of water losses.
- Real losses are the major part of the NRW, representing 58.34% of SIV and 88.29% of NRW.

3.5.3. Water Audit - Performance Indicators

- NRW by volume (Fi46) (%) = 66,08%
- NRW by cost (Fi47) (%) = 1,5%
- Water Losses per connection (Op23) (m3/connection/year) = 2884.69
- Water Losses per mains length (Op24) (m3/Km/year) = 339.7
- Apparent Losses (Op25) (%) = 15,55%
- Apparent Losses per SIV (Op26) (%) = 15,55%

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- Real Losses per connection (Op27) (lt/connection/day when system is pressurized) = 6 979.42
- Real Losses per mains length (Op28) (lt/km/day when system is pressurized) = 299 992.79
- UARL = 3 294,59
- ILI = 115.41
- ALI = 9,17
- Inefficiency of use of water resources = 38.35%

3.5.4. Conclusions

Values of all indicators calculated can be assessed as extremely high. Two major problems can be distinguish:

- **High level of real (physical) water losses** – values of all relevant indicators calculated are much above average for the country. For example average ILI index calculated for Bulgaria by European Commission in Reference Document – Good Practices on Leakage Management WFD CIS WG PoM is 13,50 and value for the pilot area is 90. Regarding other two indicators which assess real losses in the area – Real losses per connection and Real losses per mains length their values are extremely high due to high level of real losses distributed at small length of main pipe lines in the area (just 1,14 km) and small number of service connection (just 49) which mainly serve 5-6 floors buildings with apartments. Main reason for the high level of real losses is technical condition of main pipe line providing water for the area. It is steel pipe diameter 200 mm installed in more than 30 years ago. Pipeline is without any kind of corrosion protection due to this many small defects (hidden leakages) have formed along its entire length. In addition on a monthly averagely one burst is repaired by the Water Operator. Practically all soft measures which can be used for water loss reduction including pressure management at the entrance of pilot area are already applied. It seems that the only effective way for reduction of real (physical) water losses is replacement of main pipeline and service connections for the buildings.
- **High level of apparent (commercial) water losses** – except high level of real water losses apparent losses in the pilot area level of apparent losses is also worryingly high. Values of apparent losses and ALI are much higher than average for the Water Utility of Blagoevgrad. There are two main reasons for this – condition of bulk water meters in blocks (installed in basements of buildings and owed by Water Operator) and inability of all domestic water meters due to lack of a system for remote water meters reading.

3.6. PB6 – Municipal Water Supply and Sewerage Company of Thermaikos, Greece

3.6.1. General description

The water utility of Thermaikos has set the whole water supply network as the pilot case. The general data of the pilot case are given in Table 3.6.1.

Table 3.6.1. General data of the water supply network of DEYA Thermaikos (base year 2017)

General data	
Total population served	50,264
Total area covered (Km^2)	135.5
Total pipes' length (Km)	654
Mean altitude (m)	55
Mean operating pressure (atm)	3
Types of pipes (material, diameters, lengths)	PVC, asbestos cement
Age of pipes (per material, diameter)	PVC: 33 years; asbestos cement: >55 years

No. of service connections	32,656
River Basin where water is taken from	Chalkidiki river basin

3.6.2 Water Balance assessment for the water distribution network

The water balance for 2017 is given in Figure 3.6.1.

<table>
<tr><td rowspan="7">System Input Volume
(A3)
3.581.107</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
2.557.934</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
2.557.934</td><td>Billed Metered Consumption
(A8)
2.557.934</td><td rowspan="2">Revenue Water
(A20=A8+A9)
2.557.934</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
0</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
1.023.173</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
0</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
1.023.173</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
25.580</td><td>Unauthorized Consumption
(A16)
25.580</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
0</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
997.594</td></tr>
</table>

Figure 3.6.1. Water Balance for DEYA Thermaikos (2017)

- The share of water losses from system input water is relatively high – 28.57%.
- The share of real losses from total amount of water losses is extremely high – 97.50%.
- Apparent losses take really small amount of water losses – 2.50%
- Real challenge in Municipal water supply and sewerage company of Thermaikos is to manage with high amount which real losses take from system water input – 27.86%

3.6.3. Water Audit - Performance Indicators

Based on the data above, PIs have been calculated for the pilot case (Table 3.6.2.).

Table 3.6.2. PIs for 2017

Performance Indicator		2017	Units
WR1	Inefficiency of use or water resources	27.86	%
Op23	Water losses per connection	31.33	m^3/connection/day
Op24	Water losses per mains length	4.29	m^3/km/year
Op25	Apparent losses	0.71	%
Op26	Apparent losses per system input volume	0.71	%
Op27	Real losses per connection	83.69	L/connection/day when system is pressurized
Op28	Real losses per mains length	4,179.10	L/km/day when system is pressurized

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Op29	ILI	2.17	
Op39	Unmetered water	28.57	%
Fi46	Non-revenue water by volume	28.57	%

From Table 3.6.2, NRW is 28.57% of the System Input Volume (SIV) for 2017 from which apparent losses as % of SIV is 0.71%. Real losses are 83.69 L/connection/day and 4,179.1 L/Km/day. ILI is 2.17. It is obvious that NRW levels are high for this network and this is mostly due to real losses.

3.6.4. Conclusions

The water distribution system of Thermaikos supplies with water 50,264 people through 654 Km of pipes and 32,656 service connections. The total area covered is 135.5 Km^2. The mean operating pressure is 3 atm. The water audit showed that NRW level is 28.57% of the SIV for 2017. Apparent losses are 0.71% of SIV and real losses are 27.86% of SIV for 2017. Real losses expressed as L/Km/day are 4,179 and water losses in m^3/Km/year are 4.29 (2017). NRW levels are quite high and are mainly due to real losses. For these reasons the water utility is necessary to perform pilot activities to reduce real losses and in particular to improve the speed and quality of repairs pillar.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Chapter 4. Discussion & Conclusions

4.1 Pilot Areas Description

The beneficiaries involved in pilot actions are DEYA Komotinis (PB1), DEYA Thermis (PP2), University of Thessaly (PB3), Municipality of Kardzhali (PB4), Municipality of Gotse Delchev (PB5) and DEYA Thermaikos (PB6).

The Water Utility of Komotini supplies with water the municipality of Komotini, located in the Water District of Thrace (EL12). The people supplied with water is 65,000 for Komotini city through 400 km of pipes' length. The average operating pressure is 4 atm and the total number of water meters is 48,500. Municipal Water Supply and Sewerage Company of Thermi (DEYA Thermis) is the water utility supplying with water the area of Thermi including several municipal districts of a total population of 53,070 people through 25,786 active water meters. The total pipes' length is about 700Km and the average operating pressure is about 5 atm. The University of Thessaly does not have its pilot case. However, based on the project's application form, PB3 is responsible for developing the hydraulic simulation model for the water distribution network of PB2. The water supply and distribution system of Kardzhali supplies with water 55,019 people, through 19,854 service connections. The mean operating pressure is 4-5 atm. The average age of the pipes are 35 years. Pilot actions will take place in sub DMA called Dunav, for the Municipality of Gotse Delchev. The DMA has high levels of non-revenue water. The total population of 1,650 people is supplied with water through 1,140 Km of pipes at a mean operating pressure of 4.5 atm. The number of connections are 49. The water utility of Thermaikos selected as its pilot case the total water distribution network. 50,264 people are supplied with water through 654 Km of pipes and 32,656 service connections. The mean operating pressure is 3 atm (Table 4.1).

4.2 Water Balance assessment for the water distribution network

The assessment of Water Balance is done in the pilot areas addressing water use efficiency. All of them used the Standard IWA WB. The WB assessment results are shown in Table 4.2.

For the comparison of the WB components, the data for 2017 are taken into consideration (Table 4.2). For DEYA Komotinis the water balance and PIs assessment revealed that NRW level in 2017 is 3,045,274m^3, representing 51.75% of SIV. The water balance assessment revealed that at the pilot area of DEYA Thermis, NRW level in 2017 is 1,039,821 m^3, representing 25.93% of SIV. Kardzhali water supply system, the NRW is 1,568,740 m^3, representing 33.51% of SIV. In Gotse Delchev pilot area, NRW level in 2017 is 141,350 m^3, representing 66.07% of SIV. In Thermaikos pilot area, the water balance showed that NRW level in 2017 is 1,023,173 m^3 /year representing 28.57% of SIV.

Further analysis of the WB assessment and the performance indicators will be given in the next paragraphs.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Table 4.1. Pilot areas' characteristics

General Data	Komotini (GR)	Thermi (GR)	Kardzhali (BG)	Gotse Delchev (BG)	Thermaikos (GR)
Total population served	65,000	53,070	55,019	1,650	50,264
Total area covered (Km^2)	385.3	1,559.34		0.20	135.5
Total pipes' length (Km)	400	700		1,140	654
Mean altitude (m)	45	0-200	4-5	525	55
Mean operating pressure (atm)	4.0	5		4.5	3
Type / age of pipes (per material, diameter)	PE (90-450mm) and steel (600mm)	PE (60%); PVC (40%); since 1970	Steel and PVC. Average 35 years	Steel (200mm): 1,141m; brass (32mm): 539m. Age >30 years	PVC: 33 years; asbestos cement: >55 years
No. of service connections	17,000		19,854	49	32,656
No. of water meters		25,786			

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Table 4.2. WB components for the pilot areas for 2017

	Komotini (GR)	Thermi (GR)	Kardzahli (BG)	Gotse Delchev (BG)	Thermaikos (GR)
System Input Volume	5.885.000	4.010.739	4.682.000	213.938	3.581.107
Authorized Consumption	2.898.576	3.171.455	3.113.260	72.588	2.557.934
Billed Authorized Consumption	2.839.726	2.970.918	3.113.260	72.588	2.557.934
Billed Metered Consumption	2.839.726	2.970.918	0	72.588	2.557.934
Billed Unmetered Consumption	0	0	0	0	0
Unbilled Authorized Consumption	58.850	200.537	0	0	0
Unbilled Metered Consumption	0	200.537	0	0	0
Unbilled Unmetered Consumption	58.850	0	0	0	0
Revenue Water	2.839.726	2.970.918	3.113.260	72.588	2.557.934
Water Losses	2.986.424	839.284	1.568.740	141.350	1.023.173
Apparent Losses	484.809	337.199	N/A	33.278	25.580
Unauthorized Consumption	58.850	40.107	N/A	8.278	25.580
Meter and Metering Errors	425.959	297.092	N/A	25.000	0
Real Losses	2.501.615	502.085	N/A	108.072	997.593
Non-Revenue Water	3.045.274	1.039.821	1.568.740	141.350	1.023.173

4.3 Water Quality assessment for the water distribution network

The beneficiaries whose pilot cases are about water quality are DEYA Thermis (PB2) and Municipality of Kardzhali (PB4). In Thermi, groundwater is used for the supply of the municipality. The major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background. Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater. The water utility decided to implement a pilot action installing automated chlorination devices. There are 29 chlorination points taking place in boreholes, pumping stations and in other sites. Some of the chlorination devices do not work properly or at all, causing problems at the efficient chlorination of the water supply network.

Municipality of Kardzhali selected as its pilot action the supply of laboratory equipment in order to perform as many water analyses as possible. Current laboratory equipment limits the number of indicators tested and requires much of the research to be outsourced, which involves a long time for sample analysis and high costs. The laboratory equipment provided in the project will enable the investigation of a large number of indicators required by the relevant drinking water quality regulations, will enable the rapid and timely analysis of the samples, as well as the measurement with high accuracy and correctness.

4.4 Performance Indicators

IWA performance indicators (PIs) are calculated for all pilot cases.

Regarding water use efficiency, in Komotini pilot case water losses per mains length are 18.03m^3/Km/year. Real losses are the major part of NRW representing 42.51% of SIV or 337.66L/connection/day and 14,350L/Km/day. Apparent losses represent 8.24% of SIV. ILI value for 2017 is 6.56. In DEYA Thermis pilot area water losses per mains length are 3.28 m^3/Km/year. Real losses are the major part of NRW representing 12.52% of SIV or 1,965.11L/Km/day. Apparent losses represent 8.41% of SIV. In the pilot case of Gotse Delchev water losses per mains length are 339.7m^3/Km/year. Real losses are the major part of NRW representing 50.52% of SIV or 6,979.42L/connection/day and 299,992L/Km/day. Apparent losses represent 15.55% of SIV. ILI value for 2017 is 66.08 showing that there is excessive leakage. In Thermaikos pilot area water losses are 4,029m^3/Km/year. Real losses are the major part of NRW representing 27.86% of SIV or 83.69L/connection/day and 4,179.1L/Km/day. Apparent losses represent 0.71% of SIV. ILI value for 2017 is 2.17.

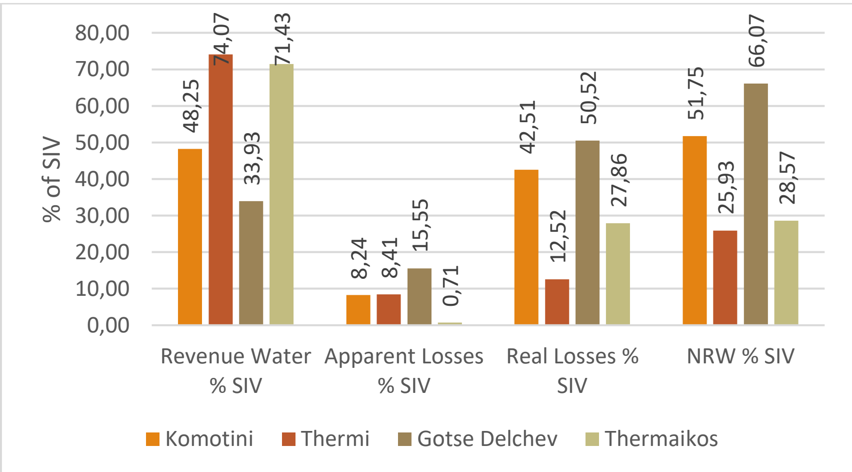

Figure 4.1. Revenue Water, Apparent losses, real losses, NRW as % of SIV for 2017

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

The results showed (Figure 4.1) that Revenue water levels are high for Thermi (74.07% of SIV) followed by Thermaikos pilot area (71.43%) while Gotse Delchev pilot area has the lowest revenue water level (33.93%). NRW levels are high for Gotse Delchev pilot case (66.07%) followed by Komotini (51.75%) while Thermi has the lowest NRW level (25.93%). Real losses as % of SIV are high for Gotse Delchev (50.52%) followed by Komotini (42.51%) while the lowest value is the one of Thermi (12.52%). Real losses as % of NRW are high for Thermaikos (97.5%) followed by Komotini (82.15%) while the lowest one is from Thermi (48.29%) (Figure 4.2).

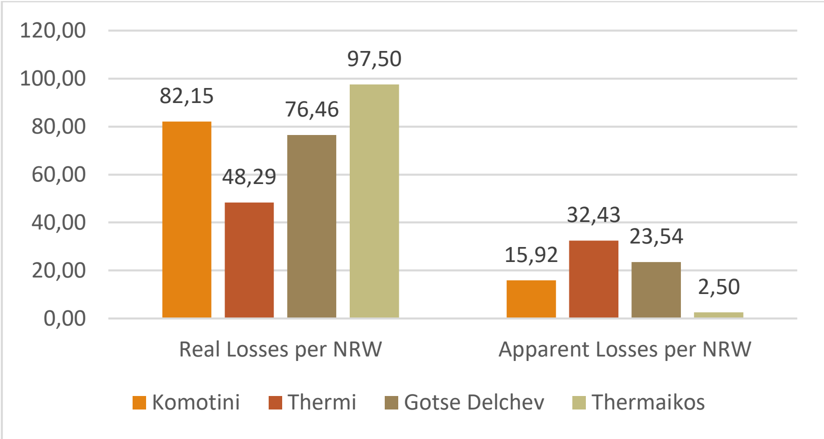

Figure 4.2. Apparent losses and Real losses % of NRW for 2017

Regarding apparent losses (Figure 4.1) the highest values are the ones from Gotse Delchev (15.55% of SIV) followed by Thermi (8.41%) and the lowest one is from Thermaikos (0.71%). Water losses per mains length highest value is the one from Gotse Delchev (339.7m^3/Km/year) followed by Komotini (18.03) and the lowest one is from Thermi (3.28 m^3/Km/year) (Figure 4.3a). Real losses per mains length highest value is the one from Gotse Delchev (299,993 L/Km/day) followed by Komotini (14.35) while the lowest one is from Thermi (1.965L/Km/day) (Figure 4.3b). However, it must be noted that assumptions are made for the WB assessment and the estimation of the PIs. As water utilities do not record water volumes entering the water supply system, some of the results might be different. This is why some beneficiaries selected to install flowmeters as their pilot cases.

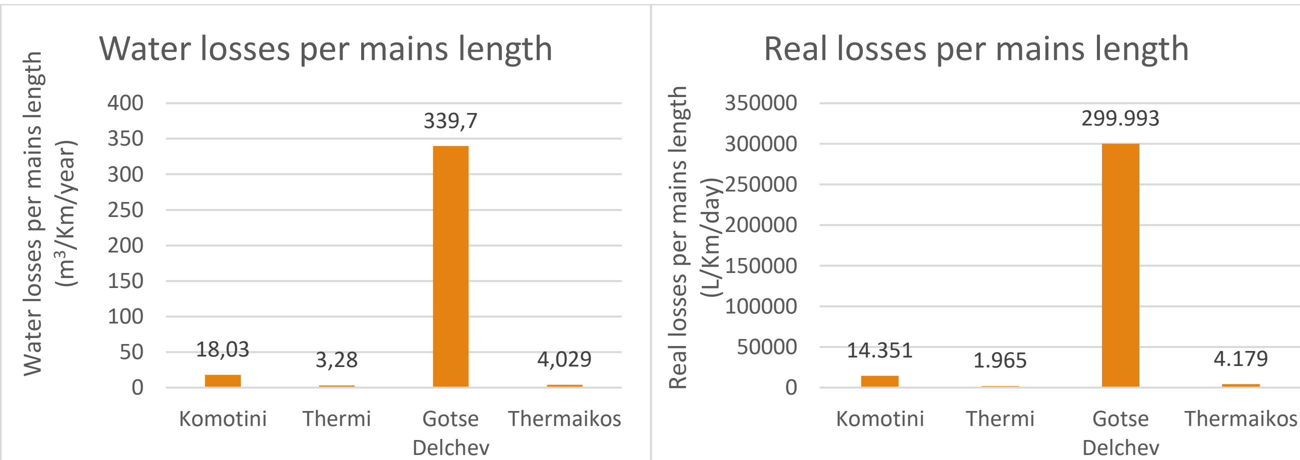

Figure 4.3. (a) Water losses per mains length; (b) real losses per mains length

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Inefficiency of use of water resources values are high for Gotse Delchev (58.35%) followed by Komotini (35.6%) and low for Thermi (12.52%) (Table 4.3).

Regarding PIs related to water quality, Kardzhali and Thermi estimated the PIs regarding the tests carried out, aesthetic test carried out, microbiological tests carried out and physical chemical tests carried out. The values for these PIs are 100% for each PI and each pilot case. Quality of supplied water PI takes the value of 96.61% for Thermi and 98.66% for Kardzhali. Aesthetic tests compliance is 100% for Thermi and 98.92% for Kardzhali. In Thermi pilot area microbiological tests compliance is 95.56% while in Kardzhali pilot area the same PI is 97.91%. Last, physical-chemical tests compliance takes the value of 96.77% for Thermi and 99.04% for Kardzhali (Table 4.3).

Table 4.3. PIs for the pilot areas

Performance Indicators	**Units**	**Komotini (GR)**	**Thermi (GR)**	**Kardzahli (BG)**	**Gotse Delchev (BG)**	**Thermaikos (GR)**
Inefficiency of use of water resources	%	35.60	12.52	33.51	58.35	27.86
Water losses per connection	m^3/conn/day	154.88	N/A	N/A	2,884.69	31.33
Water losses per mains length	m^3/Km/year	18.03	3.28	N/A	339.70	4.03
Apparent losses	%	9.14	8.41	N/A	15.55	0.71
Apparent losses per system input volume	%	9.14	8.41	N/A	15.55	0.71
Real losses per connection	L/conn/day	337.66	N/A	N/A	6,979.42	83.69
Real losses per mains length	L/Km/day	14,350.5	1965,11	N/A	299,992.8	4,179.1
Infrastructure Leakage Index (ILI)	-	6.56	N/A	N/A	115.42	2.17
Unmetered water	%	45.74	N/A	33.51	66.08	28.57
Non-revenue water by volume	%	45.74	25.93	33.51	66.08	28.57
Revenue Water as % of SIV	%	48.25	74.07	66.49	33.93	71.43
Real Losses as % of SIV	%	42.51	12.52	N/A	50.52	27.86
Real Losses as % of NRW	%	82.15	48.29	N/A	76.46	97.50
Apparent Losses as % of NRW	%	15.92	32.43	N/A	23.54	2.50
Tests carried out	%	N/A	100	100	N/A	N/A
Aesthetic tests carried out	%	N/A	100	100	N/A	N/A
Microbiological tests carried out	%	N/A	100	100	N/A	N/A
Physical-chemical tests carried out	%	N/A	100	100	N/A	N/A
Quality of supplied water	%	N/A	96.61	98.66	N/A	N/A
Aesthetic tests compliance	%	N/A	100	98.92	N/A	N/A
Microbiological tests compliance	%	N/A	95.56	97.91	N/A	N/A
Physical-chemical tests compliance	%	N/A	96.77	99.04	N/A	N/A

From all the data provided it is evident that all pilot areas face significant NRW levels. Real losses are the major part of NRW. The results show that in all cases NRW reduction measures are necessary with emphasis on the reduction of real losses. As some of the data reliability is in question, the water volumes supplied and consumed should be metered in a more efficient way.

Regarding water quality, the two beneficiaries with pilot cases related to water quality carry out all the necessary tests as the legislation is very strict. However the compliance to the required values range from 95.56% to 96.77% for Thermi and from 97.91% to 99.04% in Kardzhali. Measures to improve the compliance to the necessary tests and perform all kinds of analyses are required.

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Appendix A: Beneficiaries' reports

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.1.1 Ex ante evaluation report** *Questionnaire*
Project Beneficiary No	**LB/PB1**
Beneficiary Institution	**Municipal Water Supply and Sewerage Company of Komotini**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

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The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Name of the organization/institution: Municipal Water Supply and Sewerage Company of Komotini
Beneficiary number: LB/PB1

1 Introduction

Municipal Water Supply and Sewerage company of Komotini (DEYAK) supplies with water the municipality of Komotini, located in the Water District of Thrace (EL12). The people supplied with water is 65,000. The area covered is 385.3 km^2 and the average altitude is 45m. The total pipes' length is 400 km consisting of pipes from PE (with diameters 90-450mm) and from steel (with diameters 600mm). The water pipes network is old enough. The average operating pressure is 4 atm and the total number of water meters is 48,500. The number of service connections is about 17,000. The billing period is 2 months for the city of Komotini and 4 months for the municipal districts. The river basin where water is taken from is the river basin of Komotini – Loutro Evrou stream (area 1,958.3Km^2). Water is taken from Vosvozis river (EL1209R000010085N) and the groundwater system of Rodopi (EL1200120). All the information is given in Table 1.

Table 1. General data for the city of Komotini (base year 2017)

Data (base year 2017)	
Total population served	65,000
Total area covered (km^2)	385.3
Total pipes' length (km)	400
Mean altitude (m)	45
Mean operating pressure (Atm)	4.0
Types of pipes (material, diameters)	PE (90-450mm) and steel (600mm)
No. of water meters	48,500
No. of service connections	17,000
Billing period	2 months for Komotini city; 4 months for municipal districts
River Basin where water is taken from	Komotini – Loutro Evrou stream

The water supply system consists from a group of 10 boreholes and the water supply from Simvola (surface water body). 58.1% of the water abstracted comes from boreholes and 49.1% comes from Simvola. Boreholes are used from July to October.

Water Audit (for PBs with pilot action referring to water use efficiency)

2 Water Balance assessment for the water distribution network

The WB for the water distribution network of Komotini city has been elaborated for 2017 and 2018. Specifically, the WB has been elaborated for the whole year. The water utility provided data regarding the water entering the network and the water volume billed and consumed. The water volume consumed but not billed and unauthorized consumption and meters' errors are not known for the network. The water consumed but not billed is assumed to be 1% of the SIV. Meter inaccuracies and under-registration are estimated to be 15% of the billed metered consumption and unauthorized consumption is assumed to be 1% of SIV. Based on those data and assumptions, the Water Balance of the whole water utility of Komotini is given in Figures 2 and 3.

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<table>
<tr><td rowspan="7">System Input Volume
(A3)
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(A14=A10+A13)
2.898.576</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
2.839.726</td><td>Billed Metered Consumption
(A8)
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(A20=A8+A9)
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(A9)
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(A13=A11+A12)
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(A11)
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(A12)
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(A15=A3-A14)
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(A18=A16+A17)
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(A16)
58.850</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
425.959</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
2.501.615</td></tr>
</table>

Figure 2. The Water Balance for the whole water supply network of Komotini city for 2017

<table>
<tr><td rowspan="7">System Input Volume
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5.885.000</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
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(A10=A8+A9)
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(A8)
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(A20=A8+A9)
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<tr><td colspan="2">Real Losses
(A19=A15-A18)
2.501.615</td></tr>
</table>

Figure 3. The Water Balance for the whole water supply network of Komotini city for 2018

3 Performance Indicators

Based on the data provided above, the following Performance Indicators are estimated for the water supply network of Komotini city.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Table 2. Performance Indicators for the water supply network of Komotini (2017 & 2018)

Performance Indicators		2017	2018	Units
WR1	Inefficiency of use or water resources	35.6	42.5	%
Op23	Water losses per connection	154.88	175.67	m^3/connection/year
Op24	Water losses per mains length	18.03	20.45	m^3/km/year
Op26	Apparent losses per system input volume	9.14	8.24	%
Op27	Real Losses per connection	337.66	403.16	L/connection/day when system is pressurised
Op28	Real Losses per mains length	14,350.50	17,134.35	L/km/day when system is pressurised
Op29	ILI	6.56	7.84	-
Op39	Unmetered water	45.74	51.75	%
Fi46	Non-revenue water by volume	45.74	51.75	%

From Table 2, NRW is 35.6% of the System Input Volume (SIV) for 2017 and 42.5% for 2018. Apparent losses as % of SIV is 9.14% for 2017 and 8.24% for 2018. Real Losses in 2017 are 42.51% of SIV and 337.66 L/connection/day while in 2018 real losses are 35.6% of SIV and 413.16 L/connection/day. ILI is 6.56 in2017 and 7.84 in 2018. It is obvious that NRW levels are high for this network and this is mostly due to real losses.

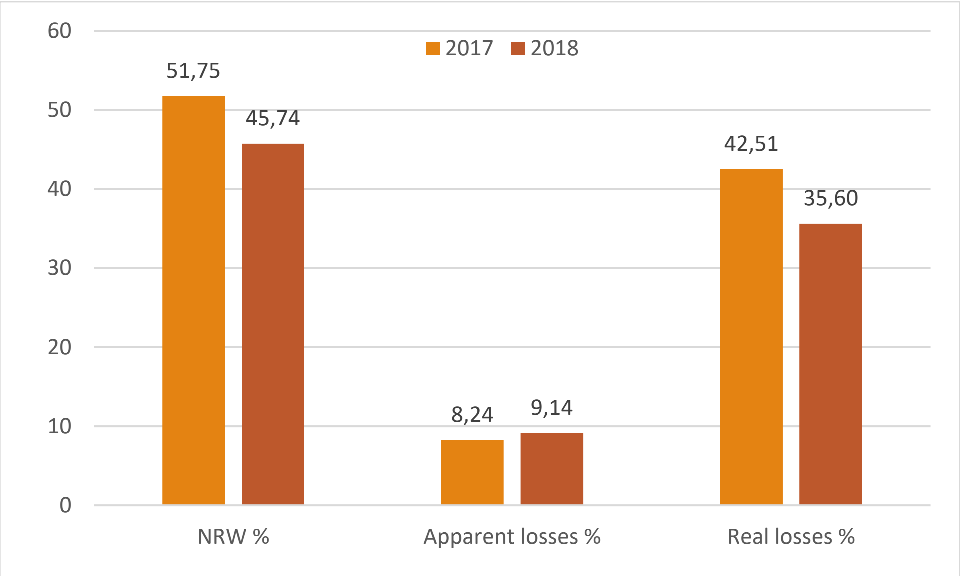

Figure 4. NRW, apparent losses and real losses as % of SIV for 2017 and 2018

4 Comments

Please provide any comments.

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Appendix A:

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.2.1 Ex ante evaluation report** *Questionnaire*
Project Beneficiary No	**PB2**
Beneficiary Institution	**Municipal Water Supply and Sewerage Company of Thermi**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

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The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Name of the organization/institution: Municipal Water Supply and Sewerage Company of Thermi
Beneficiary number: PB2

1 Introduction

Municipal Water Supply and Sewerage Company of Thermi (DEYA Thermis) is the water utility supplying with water the area of Thermi including several municipal districts: Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Agia Paraskevi, Agios Antonios, Lakkia, Peristera and Livadi. The area covered by DEYA Thermis is 1559.34 Km^2. The area's altitude ranges from 0-200m. The water meters (active) are 25,786 supplying with water a population of 53,070 people (2011 census). The total pipes' length is about 700Km and the pipes are made of PE (60%) and PVC (40%). The pipes are installed since 1970 until now. The average operating pressure is about 5 atm.

DEYA Thermis is supplying the municipal district of Thermi with water from groundwater boreholes from three groundwater subsystems: down flow of Antemountas; Thermi – N. Risio; and Cholomontas – Oreokastro (Chalkidiki river basin). DEYA Thermis water abstraction is allocated in the groundwater systems as shown in Table 2. The major water volume (97.8%) comes from the subsystems of Anthemountas down flow and Thermi – N. Risio. The first subsystem is assessed in bad quantitative and chemical status, while the second is assessed in good quantitative and chemical status. Only 2.1% of water volume comes from the Cholomontas - Oreokastro subsystem which is found to be in good chemical and quantitative status.

Table 1. General data of the water supply network of DEYA Thermis (base year 2017)

General data	
Total population served	53,070
Total area covered (Km^2)	1,559.34
Total pipes' length (Km)	700
Mean altitude (m)	0-200
Mean operating pressure (atm)	5
Types of pipes (material, diameters, lengths)	PE (60%); PVC (40%)
Age of pipes (per material, diameter)	Since 1970
No. of water meters	25,786
Billing Period	Every 3 months
River Basin where water is taken from	Chalkidiki river basin

Table 2. Water availability, average annual abstraction and DEYA Thermis abstraction of three groundwater systems (source: RBMP, 2017)

Groundwater subsystem	Towns supplied with water	Water availability (10^6 m^3)	Average annual abstraction (10^6 m^3)	DEYA Thermis (m^3)	Chemical status	Quantitative status
Down flow of Anthemountas	Thermi, Mikra, N. Redestos, Tagarades, N. Risio, Vasilika, Souroti, Ag. Paraskevi	33.6	37.02	7,187,700	Bad	Bad
Thermi – N.	Thermi, Mikra, N.				Good	Good

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Risio	Redestos, Ag. Antonios, Lakkia					
Cholomontas - Oreokastro	Peristera, Livadi	99	81.64	158,500	Good	Good

Water Audit (for PBs with pilot action referring to water use efficiency)

2 Water Balance assessment for the water distribution network

The WB for the whole water distribution network of Thermi has been elaborated for 2017 and 2018. Specifically, the WB has been elaborated for the whole year and also per 4-month periods (as the billing period is 4 months). The water utility provided data regarding the water entering the network, the water volume billed and consumed, and the water volume consumed but not billed. Unauthorized consumption is not known for the network, but it is assumed that it represents 1% of the system input volume (entering the network). Meter inaccuracies and under-registration is also not known. According to the utility's knowledge for the network, meters errors are estimated to be 10% of the billed metered consumption.

Based on the available data and on the estimations made, the WB has been elaborated (Figures 1-8).

<table>
<tr><td rowspan="7">System Input Volume
(A3)
1.306.553</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.033.145</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
967.817</td><td>Billed Metered Consumption
(A8)
967.817</td><td rowspan="2">Revenue Water
(A20=A8+A9)
967.817</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
65.328</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
338.736</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
65.328</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
273.408</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
109.847</td><td>Unauthorized Consumption
(A16)
13.066</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
96.782</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
163.561</td></tr>
</table>

Figure 1. IWA International WB for Thermi water distribution network for the 1st 4-month period of 2017

<table>
<tr><td rowspan="7">System Input Volume
(A3)
1.341.222</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.060.559</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
993.498</td><td>Billed Metered Consumption
(A8)
993.498</td><td rowspan="2">Revenue Water
(A20=A8+A9)
993.498</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
67.061</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
347.724</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
67.061</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
280.663</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
112.762</td><td>Unauthorized Consumption
(A16)
13.412</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
99.350</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
167.901</td></tr>
</table>

Figure 2. IWA International WB for Thermi water distribution network for the 2nd 4-month period of 2017

<table>
<tr><td rowspan="7">System Input Volume
(A3)
1.362.964</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
1.077.751</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
1.009.603</td><td>Billed Metered Consumption
(A8)
1.009.603</td><td rowspan="2">Revenue Water
(A20=A8+A9)
1.009.603</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
68.148</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
353.361</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
68.148</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
285.213</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
114.590</td><td>Unauthorized Consumption
(A16)
13.630</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
100.960</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
170.623</td></tr>
</table>

Figure 3. IWA International WB for Thermi water distribution network for the 3rd 4-month period of 2017

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

System Input Volume (A3) 1.271.948	Authorized Consumption (A14=A10+A13) 1.005.781	Billed Authorized Consumption (A10=A8+A9) 942.184	Billed Metered Consumption (A8) 942.184	Revenue Water (A20=A8+A9) 942.184
			Billed Unmetered Consumption (A9) 0	
		Unbilled Authorized Consumption (A13=A11+A12) 63.597	Unbilled Metered Consumption (A11) 0	Non-Revenue Water (NRW) (A21=A3-A20) 329.764
			Unbilled Unmetered Consumption (A12) 63.597	
	Water Losses (A15=A3-A14) 266.167	Apparent Losses (A18=A16+A17) 106.938	Unauthorized Consumption (A16) 12.719	
			Customer Meter Inaccuracies and Data Handling Errors (A17) 94.218	
		Real Losses (A19=A15-A18) 159.229		

Figure 4. IWA International WB for Thermi water distribution network for the 1st 4-month period of 2018

System Input Volume (A3) 1.349.577	Authorized Consumption (A14=A10+A13) 1.067.166	Billed Authorized Consumption (A10=A8+A9) 999.687	Billed Metered Consumption (A8) 999.687	Revenue Water (A20=A8+A9) 999.687
			Billed Unmetered Consumption (A9) 0	
		Unbilled Authorized Consumption (A13=A11+A12) 67.479	Unbilled Metered Consumption (A11) 0	Non-Revenue Water (NRW) (A21=A3-A20) 349.890
			Unbilled Unmetered Consumption (A12) 67.479	
	Water Losses (A15=A3-A14) 282.411	Apparent Losses (A18=A16+A17) 113.464	Unauthorized Consumption (A16) 13.496	
			Customer Meter Inaccuracies and Data Handling Errors (A17) 99.969	
		Real Losses (A19=A15-A18) 168.947		

Figure 5. IWA International WB for Thermi water distribution network for the 2nd 4-month period of 2018

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

System Input Volume (A3) **1.495.264**	**Authorized Consumption** (A14=A10+A13) **1.182.366**	**Billed Authorized Consumption** (A10=A8+A9) **1.107.603**	**Billed Metered Consumption** (A8) **1.107.603**	**Revenue Water** (A20=A8+A9) **1.107.603**
			Billed Unmetered Consumption (A9) **0**	
		Unbilled Authorized Consumption (A13=A11+A12) **74.763**	**Unbilled Metered Consumption** (A11) **0**	**Non-Revenue Water (NRW)** (A21=A3-A20) **387.661**
			Unbilled Unmetered Consumption (A12) **74.763**	
	Water Losses (A15=A3-A14) **312.898**	**Apparent Losses** (A18=A16+A17) **125.713**	**Unauthorized Consumption** (A16) **14.953**	
			Customer Meter Inaccuracies and Data Handling Errors (A17) **110.760**	
		Real Losses (A19=A15-A18) **187.185**		

Figure 6. IWA International WB for Thermi water distribution network for the 3rd 4-month period of 2018

System Input Volume (A3) **4.010.739**	**Authorized Consumption** (A14=A10+A13) **3.171.455**	**Billed Authorized Consumption** (A10=A8+A9) **2.970.918**	**Billed Metered Consumption** (A8) **2.970.918**	**Revenue Water** (A20=A8+A9) **2.970.918**
			Billed Unmetered Consumption (A9) **0**	
		Unbilled Authorized Consumption (A13=A11+A12) **200.537**	**Unbilled Metered Consumption** (A11) **0**	**Non-Revenue Water (NRW)** (A21=A3-A20) **1.039.821**
			Unbilled Unmetered Consumption (A12) **200.537**	
	Water Losses (A15=A3-A14) **839.284**	**Apparent Losses** (A18=A16+A17) **337.199**	**Unauthorized Consumption** (A16) **40.107**	
			Customer Meter Inaccuracies and Data Handling Errors (A17) **297.092**	
		Real Losses (A19=A15-A18) **502.085**		

Figure 7. IWA International WB for Thermi water distribution network for 2017

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

<table>
<tr><td rowspan="7">System Input Volume
(A3)
4.116.789</td><td rowspan="4">Authorized Consumption
(A14=A10+A13)
3.255.313</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)
3.049.474</td><td>Billed Metered Consumption
(A8)
3.049.474</td><td rowspan="2">Revenue Water
(A20=A8+A9)
3.049.474</td></tr>
<tr><td>Billed Unmetered Consumption
(A9)
0</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
205.839</td><td>Unbilled Metered Consumption
(A11)
0</td><td rowspan="5">Non-Revenue Water (NRW)
(A21=A3-A20)
1.067.315</td></tr>
<tr><td>Unbilled Unmetered Consumption
(A12)
200.537</td></tr>
<tr><td rowspan="3">Water Losses
(A15=A3-A14)
861.476</td><td rowspan="2">Apparent Losses
(A18=A16+A17)
346.115</td><td>Unauthorized Consumption
(A16)
41.168</td></tr>
<tr><td>Customer Meter Inaccuracies and Data Handling Errors
(A17)
304.947</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)
515.361</td></tr>
</table>

Figure 8. IWA International WB for Thermi water distribution network for 2018

All the above data are gathered at the following Table 3.

The results show that NRW is about 25% of the water volume entering the network. Almost 50% of the NRW are real losses. Specific performance indicators are calculated in the next chapter.

3 Performance Indicators

Based on the data above, several performance indicators (PIs) have been calculated for 2017 and 2018, annually and per 4-month periods. The PIs are given in the Table 4.

The results show that there is no variation among the 4-month periods. NRW by volume (as % of SIV) is 25.93% for both years. Apparent losses are 8.41% of SIV and real losses are 12.52% of SIV. Real losses expressed as lt/Km/day are 1,965.11 for 2017 and 2,017.07 for 2018. Water losses in m^3/Km/year are 3.28 (2017) and 3.37 (2018).

NRW levels are quite high and are mainly due to real losses. However, as estimations are used to calculate the apparent losses, the water utility is necessary to perform pilot activities to estimate both unauthorized use (illegal connections, water theft, etc.) and also meter under-registration.

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Table 3. WB data for 4-month periods of 2017 – 2018 and annually

m^3	1st 2017	2nd 2017	3rd 2017	1st 2018	2nd 2018	3rd 2018	2017	2018
System Input Volume	1.306.553	1.341.222	1.362.964	1.271.948	1.349.577	1.495.264	4.010.739	4.116.789
Authorized Consumption	1.033.145	1.060.559	1.077.751	1.005.781	1.067.166	1.182.366	3.171.455	3.255.313
Billed Authorized Consumption	967.817	993.498	1.009.603	942.184	999.687	1.107.603	2.970.918	3.049.474
Billed Metered Consumption	967.817	993.498	1.009.603	942.184	999.687	1.107.603	2.970.918	3.049.474
Billed Un Metered Consumption	0	0	0	0	0	0	0	0
Unbilled Authorized Consumption	65.328	67.061	68.148	63.597	67.479	74.763	200.537	205.839
Unbilled Metered Consumption	0	0	0	0	0	0	0	0
Unbilled Unmetered Consumption	65.328	67.061	68.148	63.597	67.479	74.763	200.537	205.839
Revenue Water	967.817	993.498	1.009.603	942.184	999.687	1.107.603	2.970.918	3.049.474
Water Losses	273.408	280.663	285.213	266.167	282.411	312.898	839.284	861.476
Apparent Losses	109.847	73.022	84.302	88.094	103.468	125.713	337.199	346.115
Unauthorized Consumption	13.066	13.412	13.630	12.719	13.496	14.953	40.107	41.168
Meter Inaccuracies & Data Handling Errors	96.782	59.610	70.672	75.375	89.972	110.760	297.092	304.947
Real Losses	163.561	207.641	200.911	178.073	178.943	187.185	502.085	515.361
Non-Revenue Water	338.736	347.724	353.361	329.764	349.890	387.661	1.039.821	1.067.315

Table 4. PIs for 2017 and 2018 annually and per 4-month periods

Performance Indicator		1st 2017	2nd 2017	3rd 2017	1st 2018	2nd 2018	3rd 2018	2017	2018	Units
WR1	Inefficiency of use or water resources	12,52	12,52	12,52	12,52	12,52	12,52	12,52	12,52	%
Op24	Water losses per mains length	4,34	4,45	4,53	4,22	4,48	4,97	3,28	3,37	m^3/km/year
Op25	Apparent losses	8,41	8,41	8,41	8,41	8,41	8,41	8,41	8,41	%
Op26	Apparent losses per system input volume	8,41	8,41	8,41	8,41	8,41	8,41	8,41	8,41	%
Op28	Real losses per mains length	2.596,20	2.665,09	2.708,30	2.527,45	2.681,69	2.971,19	1.965,11	2.017,07	lt/km/day when system is pressurised
Op39	Unmetered water	25,93	25,93	25,93	25,93	25,93	25,93	25,93	25,93	%
Fi46	Non-revenue water by volume	25,93	25,93	25,93	25,93	25,93	25,93	25,93	25,93	%
	Real Losses (% SIV)	12,52	15,48	14,74	14,00	13,26	12,52	12,52	12,52	%

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Water Quality Evaluation

4 Water Quality assessment for the water distribution network

The water utility of Thermi uses groundwater sources for water supply. The utility conforms with the national and European legislation regarding drinking water quality. Disinfection is applied as water treatment at the boreholes or at the water tanks. At the boreholes, chlorine is injected to the borehole supply pipe. At the water tanks, chlorine is added inside the water tank.

The major problem faced regarding water quality is the increased value of some physical-chemical parameters that sometimes is near the allowable maximum values of the legislation. The cause of this problem is the groundwater geological background.

Another problem is the excessive increase of turbidity which is due to the excessive abstraction of the groundwater.

Regarding chlorination, the water utility implements the national legislation. There are 29 chlorination points, given in Table 5. Chlorination takes place is tanks, in boreholes, pumping stations and in other sites.

Table 5. Chlorination types and sites for DEYA Thermis

Network	Chlorination point	Chlorination type	Comments
Lida Maria	Tank	3	The automatic system is out of order
Toumba	Foiros Sideras	2	
Litsa small	Foiros Sideras	2	
Litsa large	Foiros Sideras	2	
Hayat	Tank	1	
Triadi up tank	Pumping station Triadi	1	
Triadi down tank	Pumping station building site	1	
N. Redestos big tank	Tank	1	The automatic system is out of order
N. Redestos small tank	Tank	1	
Filothei	Tank	1	
Tagarades	Preselection tank	4	
N. Risio	Tank	1	
Vasilika	Borehole BA1	1	
Lakkia	Borehole ΛA1	1	
Kato Peristera	Borehole	1	
Peristera source	In the network	5	
Up tank Peristera	Church Peristera spring	6	
Down tank Peristera	Tank	6	
Livadi	Borehole	1	
Agios Antonios	St John	3	
Monopigado	St John	3	
Souroti	Tank	3	
Agia Paraskevi	Tank	1	
Kardia	cistern	2	
Trilofos Kotroni	Conjunction & 4 SEASON	1 & 2	The automatic system is extracted
Trilofos Profitis Ilias	Conjunction	1	The automatic system is extracted

Plagiari	Upper tank & down tank in the summer	3 & 7	
Kato Sholari	Conjunction	1	The automatic system is extracted
Ano Sholari	Conjunction	1	The automatic system is extracted

Meaning of chlorination type:
1: Chlorination pump connected to the borehole
2: Chlorination pump connected to the pump
3: Chlorination pump connected to the sensor
4: Automatic chlorination system
5: Solid chlorine
6: 24hours continuous electricity
7: works with timer

5 Performance Indicators

The water utility applies all the necessary tests for water quality. Performance indicators for those tests are estimated and presented in Table 6.

Table 6. PIs regarding water quality

Performance Indicators		2017	2018	Units
Op40	Tests carried out	100	100	%
Op41	Aesthetic tests carried out	100	100	%
Op42	Microbiological tests carried out	100	100	%
Op43	Physical-chemical tests carried out	100	100	%
Op44	Radioactivity tests carried out	100	100	%
QS11	Bulk supply adequacy	100	100	%
QS18	Quality of supplied water	96,61017	97,76358	%
QS19	Aesthetic tests compliance	100	100	%
QS20	Microbiological tests compliance	95,55556	97,26027	%
QS21	Physical-chemical tests compliance	96,77419	96,77419	%
QS22	Radioactivity tests compliance	100	100	%

In general, the water utility elaborates all necessary tests. Some of the tests are not in compliance with the legislation, specifically microbiological tests and physical – chemical tests. However, the percentage is very high, showing that there are only a few cases with non-compliance.

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Appendix A:

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

Interreg
Greece-Bulgaria
WATER RESCUE
European Regional Development Fund

EUROPEAN UNION

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.4.1 Ex ante evaluation report** *Questionnaire*
Project Beneficiary No	**PB4**
Beneficiary Institution	**Municipality of Kardzhali**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

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3 Performance Indicators 3
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4 Water Quality assessment for the water distribution network 4
5 Performance Indicators 4
6 Comments 4
Appendix A: 5

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Name of the organization/institution: Municipality of Kardzhali
Beneficiary number: PB4

1 Introduction

Please describe your water distribution network, where the pilot action will take place.

Water Utility Level (2017 base year)

- Total population served =
- Total area covered (Km^2) =
- Total pipes' length (Km) =
- Mean altitude (m) =
- Mean operating pressure (atm) =
- Types of pipes (material, diameters, lengths) =
- Age of pipes (per material, diameter) =
- No. of service connections =
- Billing Period =
- River Basin where water is taken from =

Water Audit (for PBs with pilot action referring to water use efficiency)

2 Water Balance assessment for the water distribution network

Please provide the Water Balance of the water distribution network (you can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN") for the period of 2017 and 2018

3 Performance Indicators

Please estimate the following performance indicators (at least). You can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN"

- NRW by volume (Fi46) (%) =
- NRW by cost (Fi47) (%) =
- Water Losses per connection (Op23) (m3/connection/year) =
- Water Losses per mains length (Op24) (m3/Km/year) =
- Apparent Losses (Op25) (%) =
- Apparent Losses per SIV (Op26) (%) =
- Real Losses per connection (Op27) (lt/connection/day when system is pressurized) =
- Real Losses per mains length (Op28) (lt/km/day when system is pressurized)
- UARL =
- ILI =
- ALI =
- Other (related to your pilot action – you can use the WB/PI Calc-UTH tool)

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Water Quality Evaluation (for PBs with pilot action referring to water quality)

4 Water Quality assessment for the water distribution network

Please provide the major water quality problems faced. Why you have chosen to implement a pilot action for water quality?

5 Performance Indicators

Please estimate the following performance indicators (at least). You can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN"

- Tests carried out (Op40) (%) =
- Aesthetic tests carried out (Op41) (%) =
- Microbiological tests carried out (Op42) (%) =
- Physical-chemical tests carried out (Op43) (%) =
- Radioactivity tests carried out (Op44) (%) =
- Quality of supplied water (QS18) (%) =
- Aesthetic tests compliance (QS19) (%) =
- Microbiological tests compliance (QS20) (%)
- Physical-chemical tests compliance (QS21) (%) =
- Radioactivity tests compliance (QS22) (%) =
- Water quality complaints (QS30) (%) =
- Other (related to your pilot action – you can use the WB/PI Calc-UTH tool)

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

6 Comments

Please provide any comments.

Appendix A:

1 Introduction

Please describe your water distribution network.

Water Utility Level (2017 base year)

- Total population served = 55019
- Total area covered (Km^2) =
- Total pipes' length (Km) =
- Mean altitude (m) =
- Mean operating pressure (atm) = 4-5 atm.
- Types of pipes (material, diameters, lengths) =
- Age of pipes (per material, diameter) = average age 35 years
- No. of service connections = 19854
- Billing Period = monthly
- River Basin where water is taken from = Borovitsa River / dam. Borovitsa / Perpereshka River

- Types of pipes (material, diameters, lengths)

MUNICIPALITY	length of the water supply network			
	in the settlements		out of populated areas	
	Ф ≤300 мм	Ф > 300 мм	Ф ≤ 300 мм	с Ф > 300 мм
	км	км	км	км
MUNICIPALITY KARDZHALI	171171	7608	143539	33380
Incl.				
ethericity	97668	7608	122202	33380
steel	11975		12811	
PEPP and PVC	61528		8526	

-

Water Audit

2 Network's current (operation, control and monitoring) status

Water Utility Level

- Are there any pressure zones established? If yes, do provide further details.

e.g. how many are they?; which is the mean altitude level difference?; how much part (% of total pipes' length; % of total population served) of the network do they cover (mean value and total value)?; etc. (wherever available, please do provide proofs e.g. sketches, diagrams, designs, photos) - NO

- Are there any DMAs established? If yes, do provide further details

e.g. how many are they?; which is the mean zone altitude level difference?; how much part (% of total pipes' length; % of total population served) of the network do they cover?; how much is their average size; how much population do they serve as a mean value?; etc. (wherever available, please do provide proofs e.g. sketches, diagrams, designs, photos)

- Is there a SCADA system in place? If yes do provide further details.

e.g. type, number and mean density of data collection stations; number and mean density of telecontrol stations etc. (wherever available, please do provide proofs e.g. sketches, diagrams, designs, photos)

- Yes

SKADA systems - current state, systems implementation

On the territory of the company there are three dispatching systems equipped with a program for control of pumping stations and reservoirs (SKADA) - Kardzhali, Krumovgrad and Kirkovo. 12 PCs located in areas where there is no radio signal coverage are not covered. The plan of the Company is a phased inclusion of these vehicles.

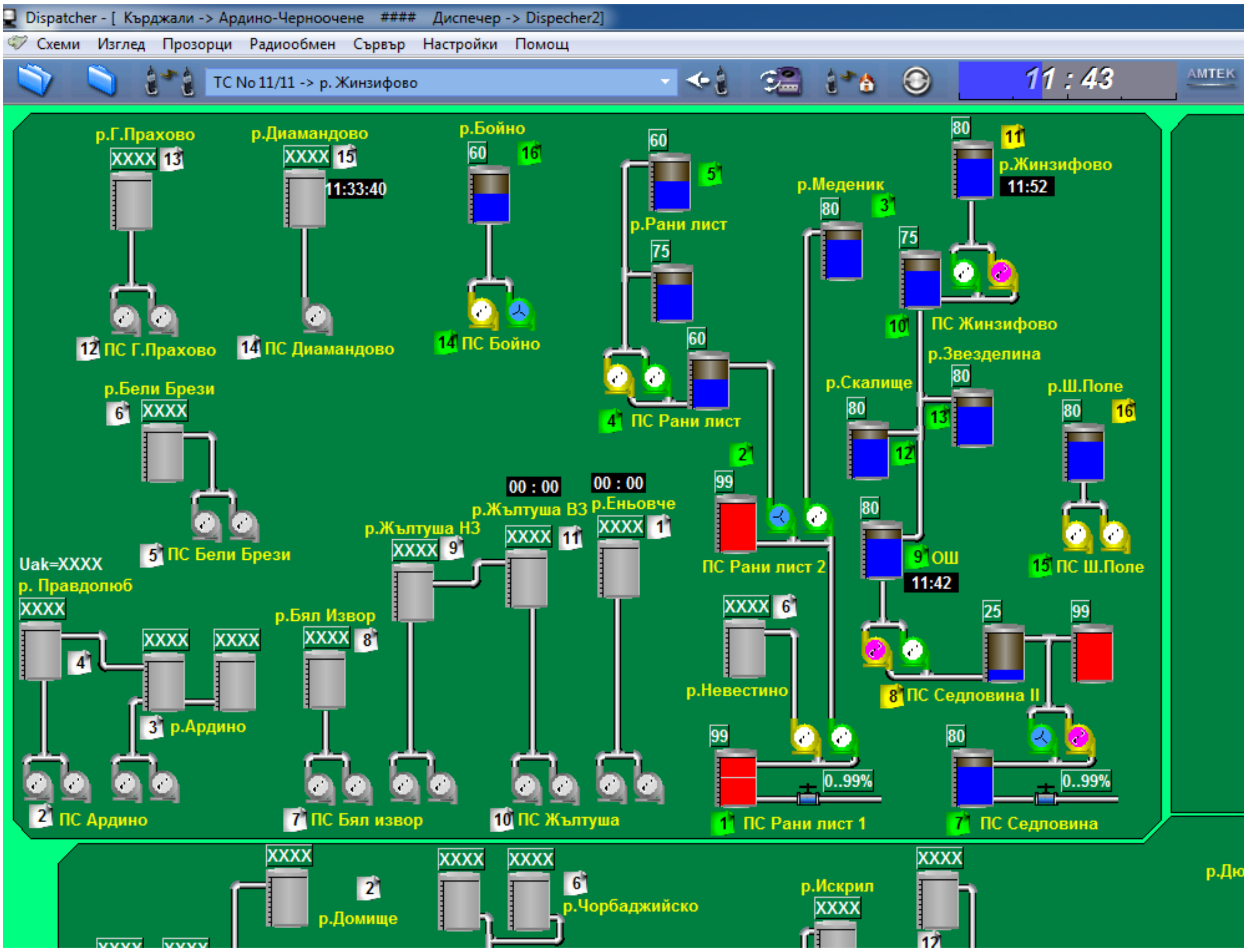
In newly constructed WWTP Kardzhali and Momchilgrad there is a three-stage "SKADA" system, which provides fully automated management, including and remote.

At the Pazardzhik town of Kardzhali was put into operation in 1990. there is a partially built automation. The PIP currently under development envisages a major repairs to the WWTP, including the construction of a three-tier "SCADA" system.

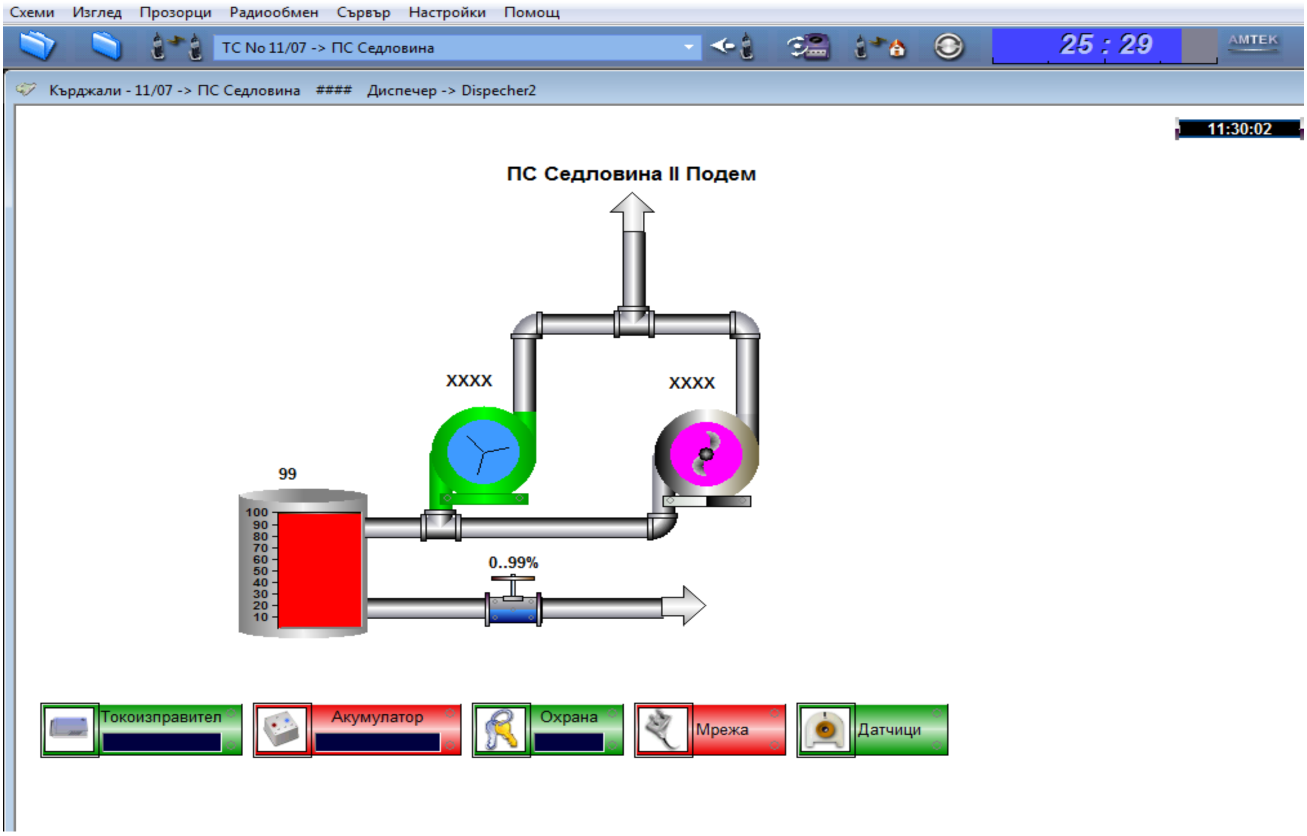
At the entrances of Kardzhali and Momchilgrad, as well as large water mains are installed induction flow meters, which signal constantly in the dispatch stations. The program of the company envisages additionally mounted on such flowmeters in separate zones as well as at the entrances of the larger settlements. They are designed to be mounted on pressure sensors with remote reading.

In order to locate accidents on the main water supply from Borovitsa dam to the town of Kardzhali with a length of 25 km. another 4pcs are provided. pressure sensors with remote reading from dispatcher point. One sensor is currently installed.

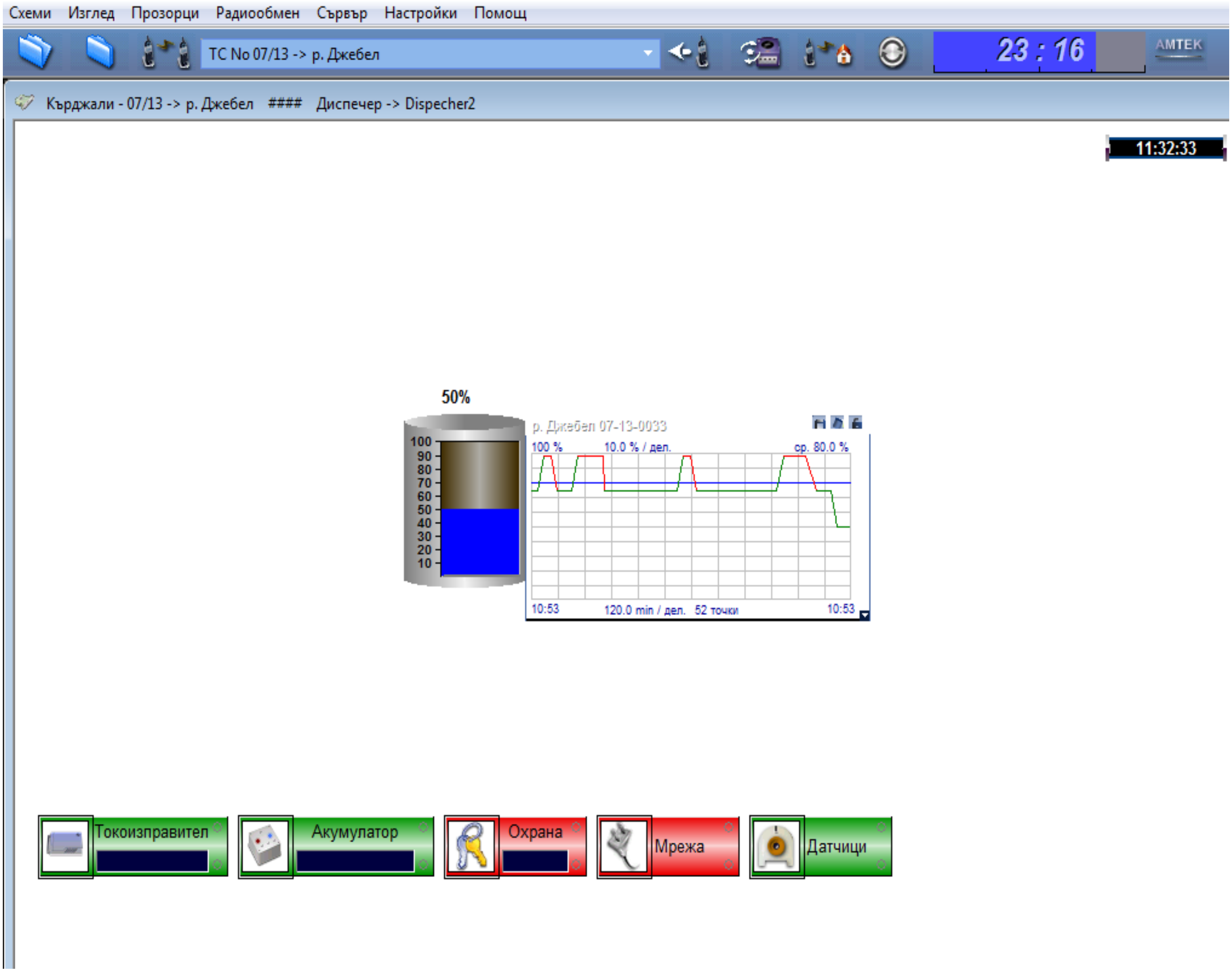
SCADA on-board report for control and management of feed water from the HP and HP



Dispatcher - [Кърджали -> Ардино-Черноочене #### Диспечер -> Dispecher2]
Схеми Изглед Прозорци Радиообмен Сървър Настройки Помощ
TC No 11/11 -> р. Жинзифово
11 : 43
р.Г.Прахово
р.Диамандово
р.Бойно
р.Рани лист
р.Медениk
р.Жинзифово
ПС Г.Прахово
ПС Диамандово
ПС Бойно
ПС Жинзифово
р.Звезделина
р.Скалище
р.Ш.Поле
ПС Рани лист
р.Бели Брези
ПС Бели Брези
р.Жълтуша Н3
р.Жълтуша В3
р.Еньовче
ПС Рани лист 2
ОШ
ПС Ш.Поле
Uak=XXXX
р. Правдолюб
р.Бял Извор
р.Невестино
ПС Седловина II
р.Ардино
ПС Ардино
ПС Бял извор
ПС Жълтуша
ПС Рани лист 1
ПС Седловина
р.Домище
р.Чорбаджийско
р.Искрил



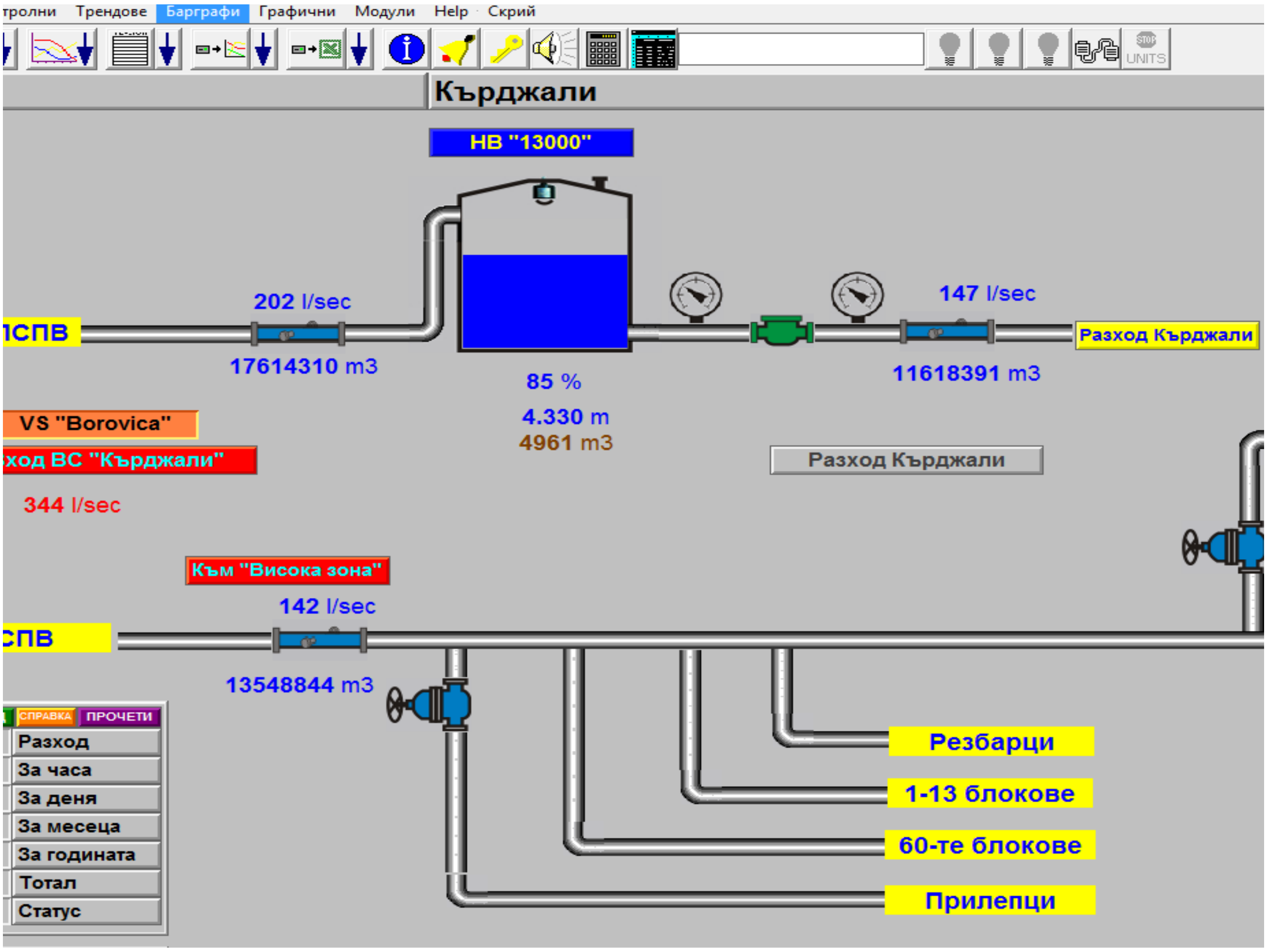
Схеми Изглед Прозорци Радиообмен Сървър Настройки Помощ
ТС No 11/07 -> ПС Седловина
25 : 29
AMTEK
Кърджали - 11/07 -> ПС Седловина #### Диспечер -> Dispecher2
11:30:02
ПС Седловина II Подем
XXXX
XXXX
99
0..99%
Токоизправител
Акумулатор
Охрана
Мрежа
Датчици

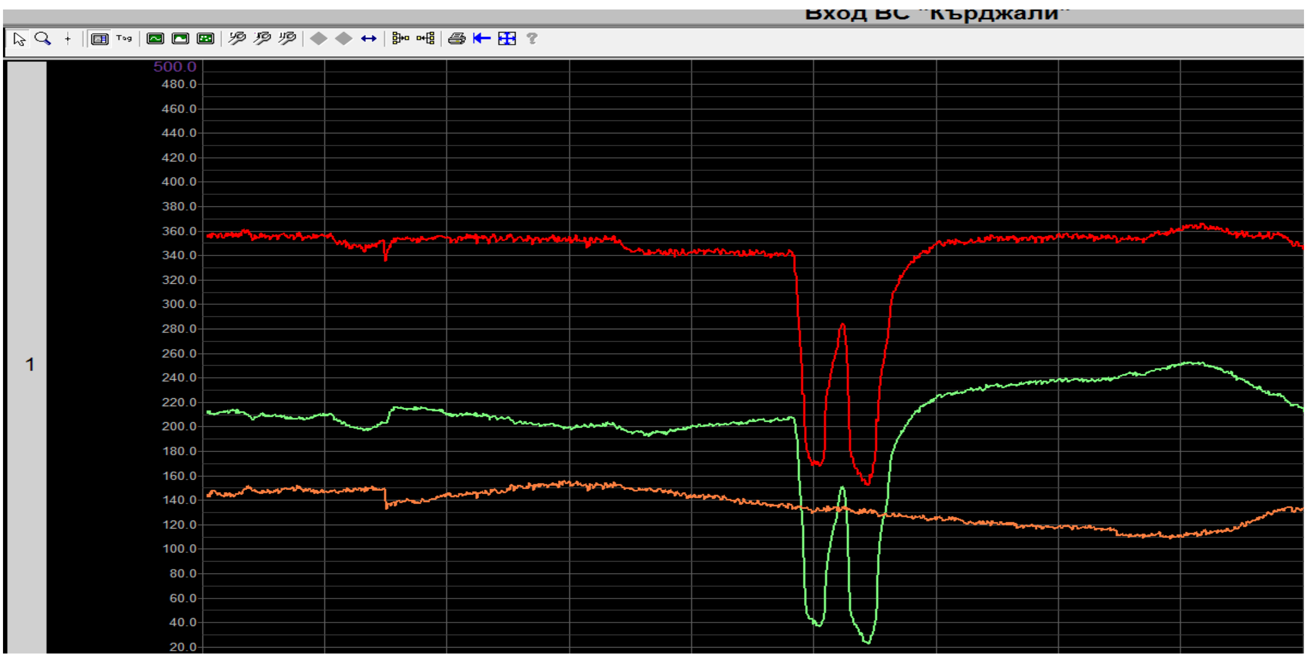


SCADA for HP control and management

Flow meters for monitoring incoming water in Kardjali from the Encez PWN and zone water meters.

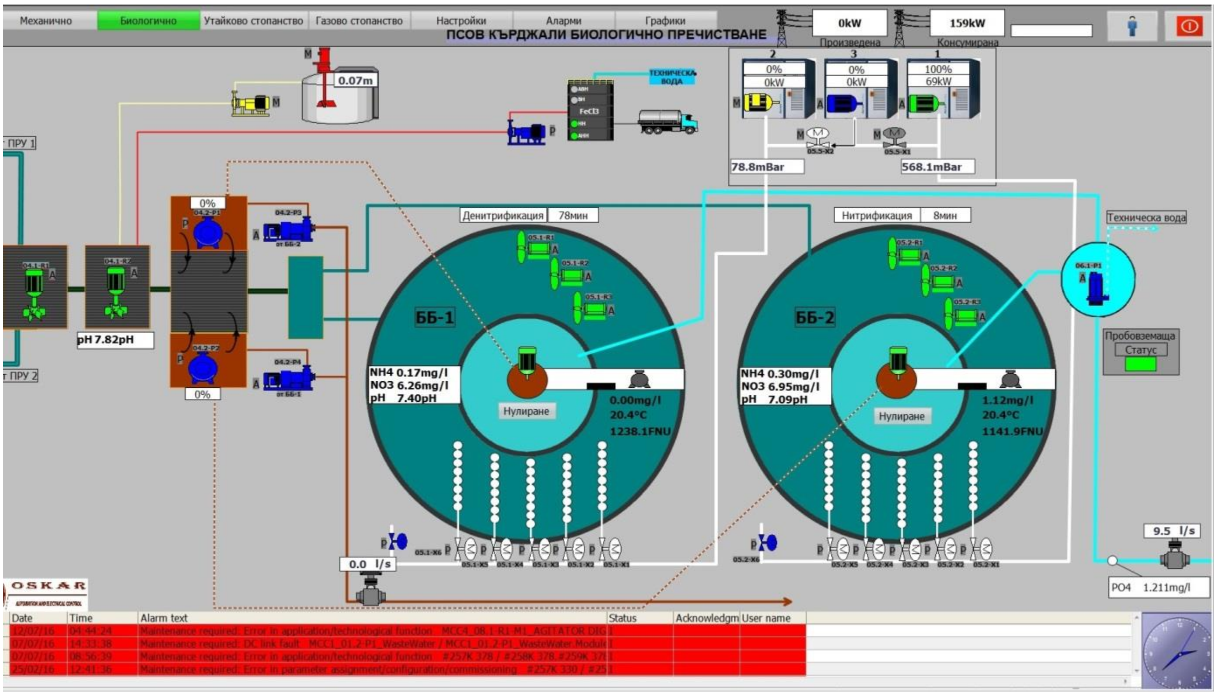
The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".



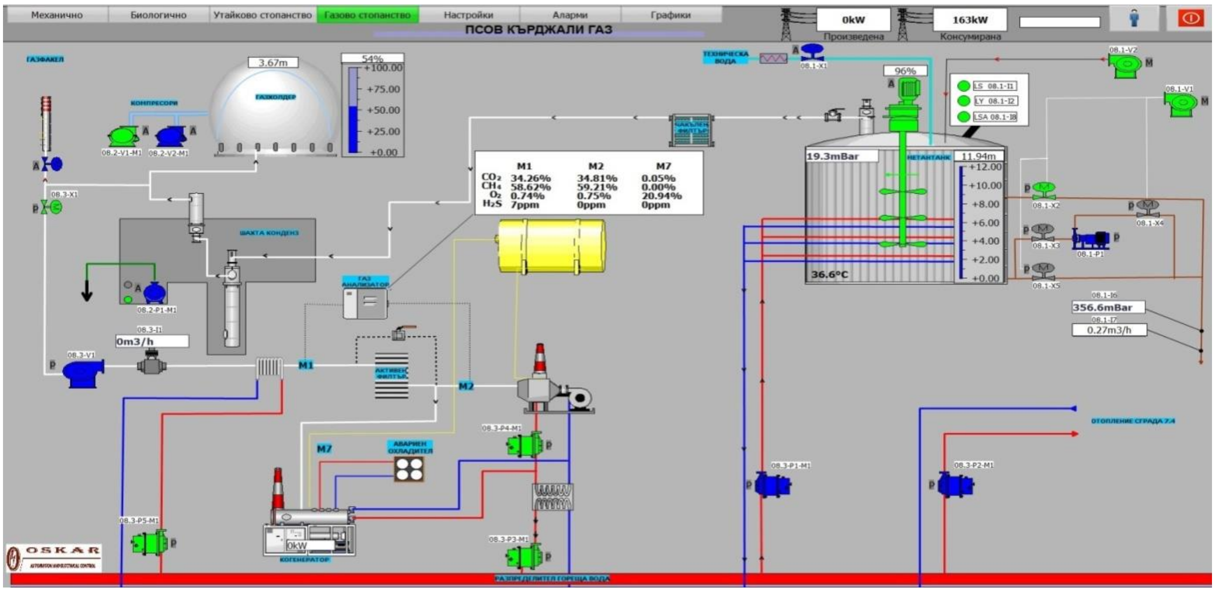


The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

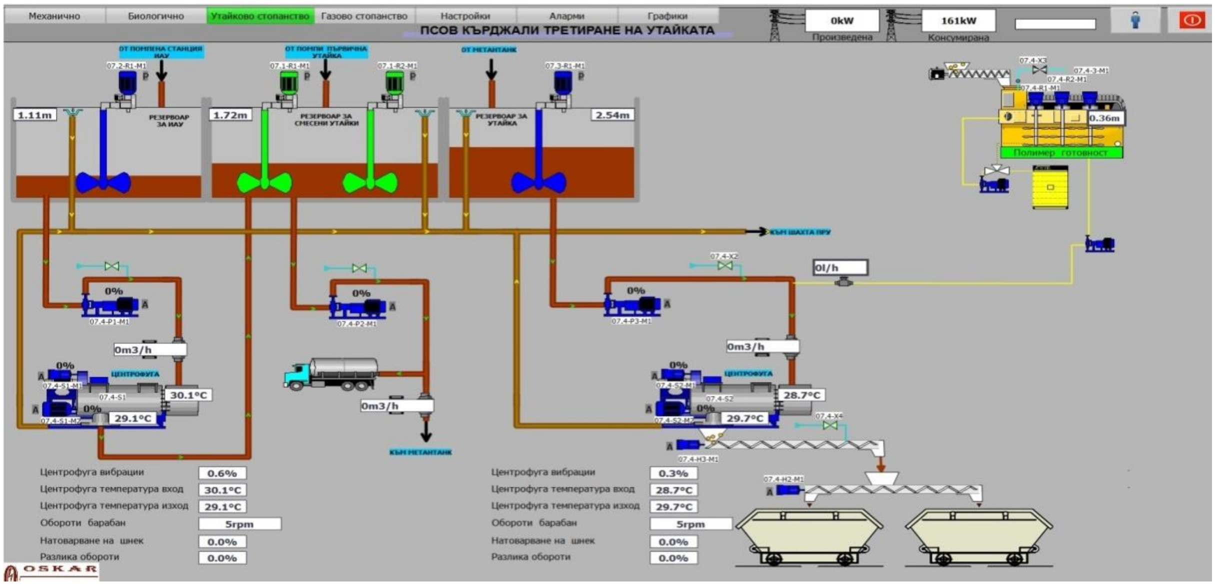
At the inlet and outlet of the WWTP there are installed automatic sampling systems and flowmeters for recording the input and output water. All water and sludge purification processes are automated and controlled by a SCADA (Data Dispatch Control and Data Collection System). The WWTP is capable of being controlled by the PLCs of the programmable logic controllers or manually controlled on each section to ensure continuous operation in case of a SCADA system failure or any device.



SCADA for Biological Steps



SCADA Gas Holding



SCADA Sludge Holding

• Is there a simulation model available for the network? If yes, give more details. No

such as whether it is market software or own model? what is his degree of reliability? whether it is regularly calibrated and validated? Used for decision-making and / or planning? etc. (if any, please provide evidence, such as sketches, diagrams, designs, pictures)

• Is there a policy for support? If yes, give more details. Yes. Monitoring and networking with specialized equipment.

how does maintenance work? Is there a separate support department? etc.

• Identify the main problem (s) facing the water network. - Common accidents

• Identify the root causes of these problems - Pipe and fitting wear

• Actions to improve existing network operation (what, how, how) Replacement of the depreciated water network

• Are there seasonal fluctuations in water consumption? Please provide data

Consumption of water by months in 2017

January February March April May June July August September October November December

191996 205375 204161 207366 220022 222179 256392 265212 273326 249817 211004 187214

• The water balance assessment period used for water

for example per year / semester / four months / three months / two months / month / another (give sufficient reasons for your choice, such as the billing period, availability of data) Quarterly

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3 Assessment of the Water Balance for the Water Supply Network

Water level

Please provide the water balance of the water distribution network (you can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN")

4 Performance indicators

Water level

Please rate the following performance metrics (at least). You can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN"

- NRW by volume (Fi46) (%) =

- NRW per cost (Fi47) (%) =

loss of connection water (Op23) (m3 / link / year) =

Water losses over network length (Op24) (m3 / Km / year) =

Significant losses (Op25) (%) =

- Significant losses for SIV (Op26) (%) =

actual loss of connection (Op27) (lt / connection / day when the system is under pressure) =

- actual network length losses (Op28) (l / km / day when the system is under pressure)

- UARL =

- ILI =

- ALI =

- Others

Appendix A:

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.5.1 Ex ante evaluation report** *Questionnaire*
Project Beneficiary No	**PB5**
Beneficiary Institution	**Municipality of Gotse Delchev**

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

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Name of the organization/institution: Municipality of Gotse Delchev
Beneficiary number: PB5

1 Introduction

Pilot actions will take place in sub DMA called Dunav. Due to specificity of the areas covered mainly from 4-5 floors blocks, DMA has high level of non-revenue water with relatively short main pipeline and small number of service connections.

DMA Level (2018 base year)

- Total population served = 1 650
- Total area covered (Km^2) = 0,20
- Total pipes' length (Km) = 1,140
- Mean altitude (m) = 525
- Mean operating pressure (atm) = 4,5
- Types of pipes (material, diameters, lengths) =

Material	Diameter	Length
Steel (main pipeline)	200 mm	1 141 m
Brass (service connections)	32 mm	539 m

- Age of pipes (per material, diameter) =

Material	Diameter	Age
Steel (main pipeline)	200 mm	>30 years
Brass (service connections)	32 mm	>30 years

- No. of service connections = 49
- Billing Period = monthly
- River Basin where water is taken from = Mesta river basin

Water Audit (for PBs with pilot action referring to water use efficiency)

2 Water Balance assessment for the water distribution network

Please provide the Water Balance of the water distribution network (you can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN") for the period of 2017 and 2018

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<table>
<tr>
<td rowspan="8">System Input Volume
(A3)
213 938
(100%)</td>
<td rowspan="5">Authorized Consumption
(A14=A10+A13)
72 588
(33,93%)</td>
<td rowspan="3">Billed Authorized Consumption
(A10=A8+A9)
72 588
(33,93%)</td>
<td>Billed Metered Consumption
(A8)
72 558</td>
<td rowspan="3">Revenue Water
(A20=A8+A9)
72 558</td>
<td rowspan="2">Water billed and paid for (Free Basic Recover Revenue)
(A24=A8+A9-A23)
72 558
(33,93%)</td>
<td rowspan="2">Revenue Water
(A24=A8+A9-A23)
72 558</td>
</tr>
<tr>
<td rowspan="2">Billed Unmetered Consumption
(A9)
0</td>
</tr>
<tr>
<td>Water billed but NOT PAID for (apparent NRW)
A23
0</td>
<td>Water billed but NOT PAID for (apparent NRW)
A23
0</td>
</tr>
<tr>
<td rowspan="2">Unbilled Authorized Consumption
(A13=A11+A12)
0
(0%)</td>
<td>Unbilled Metered Consumption
(A11)
0</td>
<td rowspan="5">Non Revenue Water (NRW)
(A21=A3-A20)
141 380</td>
<td rowspan="5">Water not being sold (Non-Revenue Water/real NRW)
(A21=A3-A24-A23)
141 380
(66,09%)</td>
<td rowspan="4">Accounted Non Revenue Water
(A26=A3-A24-A23-A25)
141 380</td>
</tr>
<tr>
<td>Unbilled Unmetered Consumption
(A12)
0</td>
</tr>
<tr>
<td rowspan="3">Water Losses
(A15=A3-A14)
141 350
(66,07%)</td>
<td rowspan="2">Apparent Losses
(A18=A16+A17)
33 278
(15,55%)</td>
<td>Unauthorized Consumption
(A16)
8 278
(3,87%)</td>
</tr>
<tr>
<td>Customer Meter Inaccuracies and Data Handling Errors
25 000
(11,69%)</td>
</tr>
<tr>
<td colspan="2">Real Losses
(A19=A15-A18)
124 827
(58,35%)</td>
<td>Water Losses generating revenues (Minimum Charge Difference)
A25
0</td>
</tr>
</table>

Table 1 – Water Balance of the Zone

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

System Input Volume 173,45 l/s 100%	**Authorized Consumption** 65,65 l/s 37,90%	**Billed Authorized Consumption** 53,01 l/s 30,60%	**Billed Metered Consumption** 53,01 l/s 30,60%	**Revenue Water** 53 l/s 30,60%
			Billed Unmetered Consumption 0 l/s 0%	
		Unbilled Authorized Consumption 12,65 l/s 7,30%	**Unbilled Metered Consumption** 12,05 l/s 7,00%	**Non-Revenue Water (NRW)** 120,44 l/s 69,40%
			Unbilled Unmetered Consumption 0,60 l/s 0,30%	
	Water Losses 107,8 62,10%	**Apparent Losses** 3,01 l/s 1,70%	**Unauthorized Consumption** 0,60 l/s 0,30%	
			Customer Meter Inaccuracies and Data Handling Errors 2,41 l/s 1,40%	
		Real Losses 104,79 60,40%		

Table 2 – Water Balance of WSS Gotse Delchev

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

3 Performance Indicators

- NRW by volume (Fi46) (%) = 66,07%
- NRW by cost (Fi47) (%) = 1,5%
- Water Losses per connection (Op23) (m3/connection/year) = 2884,69
- Water Losses per mains length (Op24) (m3/Km/year) = 123 882,59
- Apparent Losses (Op25) (%) = 15,53%
- Apparent Losses per SIV (Op26) (%) = 15,53%
- Real Losses per connection (Op27) (lt/connection/day when system is pressurized) = 6 042,63
- Real Losses per mains length (Op28) (lt/km/day when system is pressurized) = 259 499,33
- UARL = 3 294,59
- ILI = 90
- ALI = 9,17
- Other (related to your pilot action – you can use the WB/PI Calc-UTH tool)

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

Water Quality Evaluation (for PBs with pilot action referring to water quality)

4 Water Quality assessment for the water distribution network

Please provide the major water quality problems faced. Why you have chosen to implement a pilot action for water quality?

5 Performance Indicators

Please estimate the following performance indicators (at least). You can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN"

- Tests carried out (Op40) (%) =
- Aesthetic tests carried out (Op41) (%) =
- Microbiological tests carried out (Op42) (%) =
- Physical-chemical tests carried out (Op43) (%) =
- Radioactivity tests carried out (Op44) (%) =
- Quality of supplied water (QS18) (%) =
- Aesthetic tests compliance (QS19) (%) =
- Microbiological tests compliance (QS20) (%)
- Physical-chemical tests compliance (QS21) (%) =
- Radioactivity tests compliance (QS22) (%) =
- Water quality complaints (QS30) (%) =
- Other (related to your pilot action – you can use the WB/PI Calc-UTH tool)

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

6 Comments

Values of all indicators calculated can be assessed as extremely high. Two major problems can be distinguish:

- **High level of real (physical) water losses** – values of all relevant indicators calculated are much above average for the country. For example average ILI index calculated for Bulgaria by European Commission in *Reference Document – Good Practices on Leakage Management WFD CIS WG PoM* is 13,50 and value for the pilot area is 90. Regarding other two indicators which assess real losses in the area – Real losses per connection and Real losses per mains length their values are extremely high due to high level of real losses distributed at small length of main pipe lines in the area (just 1,14 km) and small number of service connection (just 49) which mainly serve 5-6 floors buildings with apartments. Main reason for the high level of real losses is technical condition of main pipe line providing water for the area. It is steel pipe diameter 200 mm installed in more than 30 years ago. Pipeline is without any kind of corrosion protection due to this many small defects (hidden leakages) have formed along its entire length. In addition on a monthly averagely one burst is repaired by the Water Operator. Practically all soft measures which can be used for water loss reduction including pressure management at the entrance of pilot area are already applied. It seems that the only effective way for reduction of real (physical) water losses is replacement of main pipeline and service connections for the buildings.
- **High level of apparent (commercial) water losses** – except high level of real water losses apparent losses in the pilot area level of apparent losses is also worryingly high. Values of apparent losses and ALI are much higher than average for the Water Utility of Blagoevgrad. There are two main reasons for this – condition of bulk water meters in blocks (installed in basements of buildings and owed by Water Operator) and inability of all domestic water meters due to lack of a system for remote water meters reading.

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Appendix A:

The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

WATER RESCUE

Water resources efficiency and conservative use in drinking water supply systems

WP	**5 Pilot Actions**
Deliverable *Tool*	**5.6.1 Ex ante evaluation report** *Questionnaire*
Project Beneficiary No	**PB6**
Beneficiary Institution	**Municipal Water Supply and Sewerage Company of Thermaikos**

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The Project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A "Greece-Bulgaria 2014-2020".

Name of the organization/institution: Municipal Water Supply and Sewerage Company of Thermaikos
Beneficiary number: PB6

1 Introduction

Please describe your water distribution network, where the pilot action will take place.

Water Utility Level (2017 base year)

- Total population served = 50,264
- Total area covered (Km^2) = 135.5
- Total pipes' length (Km) = 654
- Mean altitude (m) = 55
- Mean operating pressure (atm) = 3
- Types of pipes (material, diameters, lengths) =
- Age of pipes (per material, diameter) = PVC – 33 years old, Asbestos - >55 years old
- No. of service connections = 32,656
- Billing Period =
- River Basin where water is taken from = River Basin of Halkidiki

Water Audit (for PBs with pilot action referring to water use efficiency)

2 Water Balance assessment for the water distribution network

Please provide the Water Balance of the water distribution network (you can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN") for the period of 2017 and 2018

3 Performance Indicators

Please estimate the following performance indicators (at least). You can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN"

- NRW by volume (Fi46) (%) = 28.5
- NRW by cost (Fi47) (%) =
- Water Losses per connection (Op23) (m3/connection/year) =
- Water Losses per mains length (Op24) (m3/Km/year) =
- Apparent Losses (Op25) (%) = 0.71
- Apparent Losses per SIV (Op26) (%) = 0.71
- Real Losses per connection (Op27) (lt/connection/day when system is pressurized) =
- Real Losses per mains length (Op28) (lt/km/day when system is pressurized)
- UARL =
- ILI =
- ALI =
- Other (related to your pilot action – you can use the WB/PI Calc-UTH tool)

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

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Water Quality Evaluation (for PBs with pilot action referring to water quality)

4 Water Quality assessment for the water distribution network

Please provide the major water quality problems faced. Why you have chosen to implement a pilot action for water quality?

5 Performance Indicators

Please estimate the following performance indicators (at least). You can use the xls file named "WB-PI_Calc-UTH_version 2.2_EN"

- Tests carried out (Op40) (%) =
- Aesthetic tests carried out (Op41) (%) =
- Microbiological tests carried out (Op42) (%) =
- Physical-chemical tests carried out (Op43) (%) =
- Radioactivity tests carried out (Op44) (%) =
- Quality of supplied water (QS18) (%) =
- Aesthetic tests compliance (QS19) (%) =
- Microbiological tests compliance (QS20) (%)
- Physical-chemical tests compliance (QS21) (%) =
- Radioactivity tests compliance (QS22) (%) =
- Water quality complaints (QS30) (%) =
- Other (related to your pilot action – you can use the WB/PI Calc-UTH tool)

IMPORTANT NOTICE: It is important to estimate those Performance Indicators that will show the impact of your pilot action

6 Comments

Please provide any comments.

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Appendix A:

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