WATenERgy CYCLE
Urban water full cycle: from its source to its end-users and back to the environment

WP4 Common methodology & tools

Joint Del. 4.2 Water Auditing towards cost effective water use & volume efficiency

Interreg
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WATenERgy CYCLE

PP4 - University of Thessaly-Special Account Funds for Research-Department of Civil Engineering

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WP4: Common methodology & tools

- Responsible partner: PP4 - University of Thessaly-Special Account Funds for Research-Department of Civil Engineering
- Partners involved: ALL
- Budget: 115,507.68 €

WP4.2: Water Auditing towards cost effective water use & volume efficiency

- **Water Audit: to identify Non-Revenue Water (NRW)**
- **Use of Water Balance (IWA Standard International WB and its modifications)**
- **Use of Performance Indicators: 170 IWA PIs**
- **Identify the NRW causes**
- **Design a NRW reduction strategy**
- **Define NRW reduction measures**

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WP4.2: The Water Balance (WB) (1/2)

- The WB is a user friendly water audit tool, widely being used to determine the water losses in an urban water supply system and assess its performance

- It is actually focused on the Non Revenue Water components

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WP4.2: The Water Balance (WB) (2/2)

<table>
<tr><td rowspan="6">System Input Volume
(A3)</td><td rowspan="3">Authorized Consumption
(A14=A10+A13)</td><td rowspan="2">Billed Authorized Consumption
(A10=A8+A9)</td><td>Billed Metered Consumption
(A8)</td><td rowspan="2">Revenue Water
(A20=A8+A9)</td><td>Water billed and paid for (Free Basic Recover Revenue)
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(A13=A11+A12)</td><td>Unbilled Metered Consumption
(A11)</td><td rowspan="4">Non Revenue Water (NRW)
(A21=A3-A20)</td><td rowspan="4">Water not being sold (Non-Revenue Water/real NRW)
(A21=A3-A24-A23)</td><td rowspan="3">Accounted Non Revenue Water
(A26=A3-A24-A23-A25)</td></tr>
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(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 and Data Handling Errors
(A17)</td></tr>
<tr><td colspan="2">Real Losses
(A19=A15-A18)</td><td>Water Losses generating revenues (Minimum Charge Difference)
A25</td></tr>
</table>

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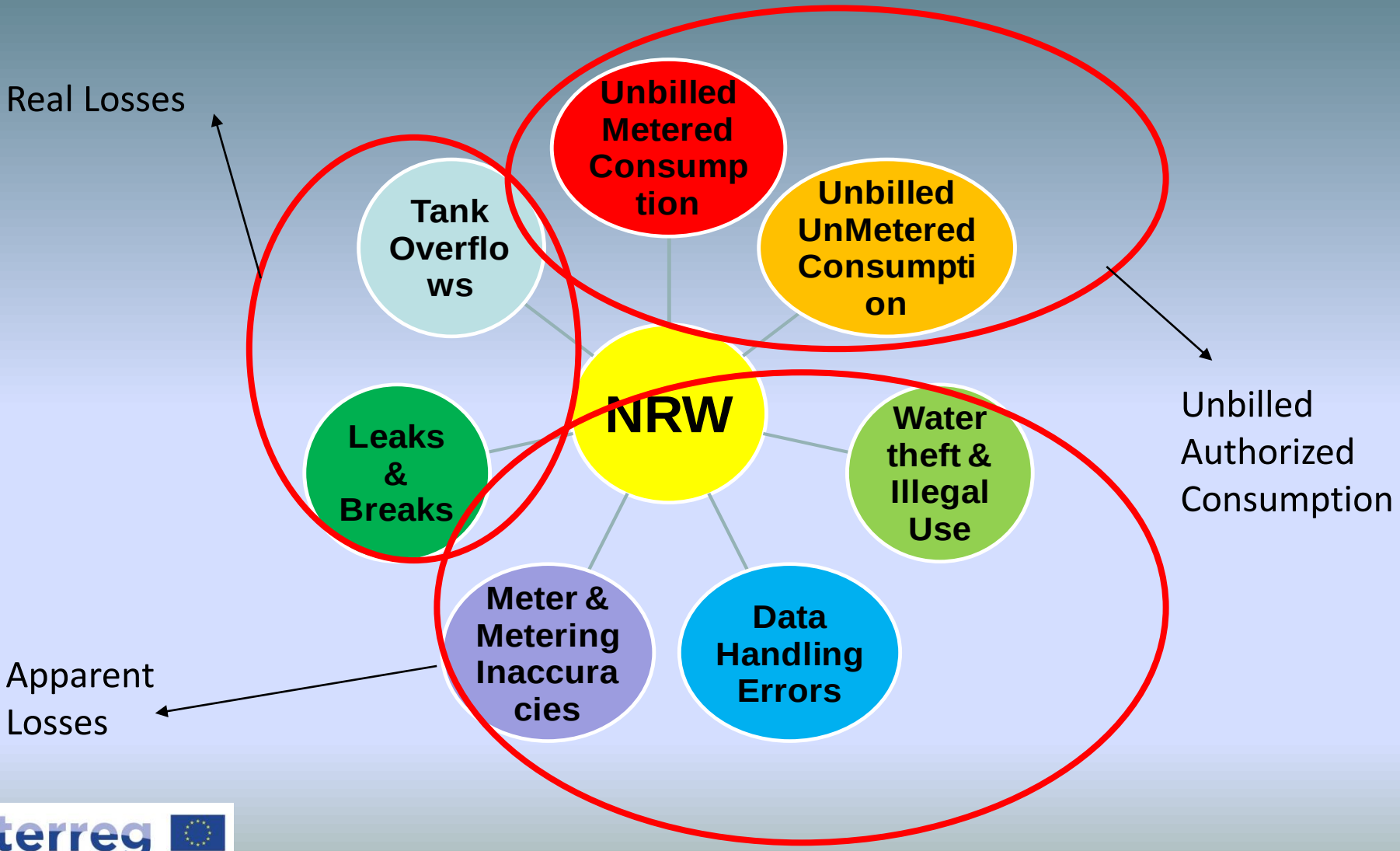
WP4.2: NRW components



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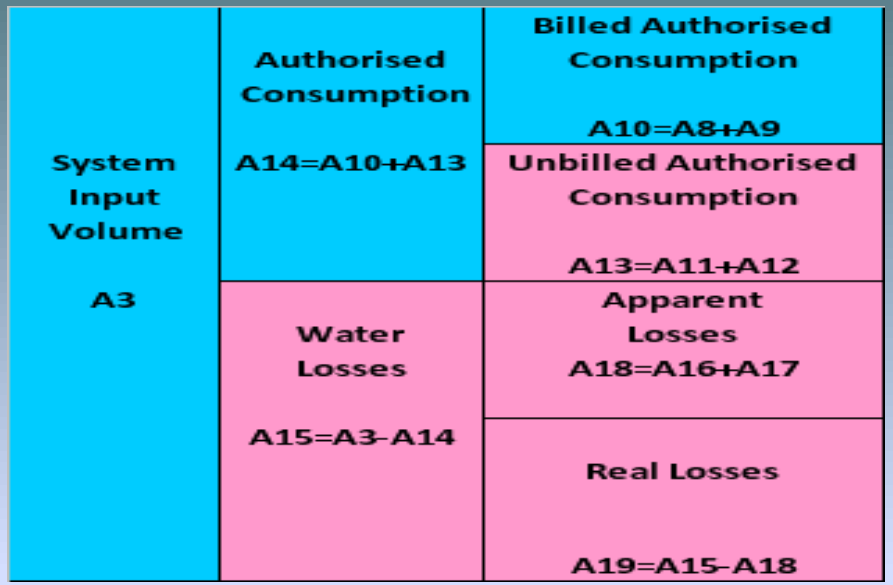
WP4.2: WB analysis (1/6)



- **System Input Volume (SIV)**: The water volume input of the global system during the assessment period (m^3/assessment period). It includes the utility's own sources and imported water from bulk suppliers

- **Authorised Consumption**: The volume of metered and/or non-metered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorised to do so. It includes exported water and leaks and overflows after the point of customer metering

- **Billed Authorised Consumption**: The volume of metered and/or non-metered water taken by registered customers providing revenues to the utility

WP4.2: WB analysis (2/6)

<table>
<tr><td rowspan="2">Billed Authorised Consumption

A10=A8+A9</td><td>Billed Metered Consumption
A8</td><td rowspan="2">Revenue Water

A20=A8+A9</td></tr>
<tr><td>Billed Unmetered Consumption
A9</td></tr>
</table>

- **Billed Metered Consumption**: The volume of metered water taken by registered customers (domestic, commercial, industrial etc.). It includes water exported. It provides revenues to the utility.
- **Billed Unmetered Consumption**: All billed consumption which is calculated based on estimates or norms but is not metered. This might be a very small component in fully metered systems (e.g. billing based on estimates for the period a customer meter is out of order) but can be the key consumption component in systems without universal metering. This component might also include water exported which is unmetered but billed
- **Revenue Water**: Water providing revenues to the utility

WP4.2: WB analysis (3/6)

Unbilled Authorised Consumption A13=A11+A12	Unbilled Metered Consumption A11
	Unbilled Unmetered Consumption A12

- **Unbilled Metered Consumption; Unbilled Unmetered Consumption; Unbilled Authorised Consumption**: Fire fighting and training, flushing of mains and sewers, cleaning of suppliers' storage tanks, filling of water tankers, water taken from hydrants, street cleaning, water of municipal gardens, public fountains, frost protection, building water etc. These may be metered or unmetered according to local practice

WP4.2: WB analysis (4/6)

Apparent Losses A18=A16+A17	Unauthorised Consumption A16
	Customer Meter Inaccuracies and Data Handling Errors A17

- **Unauthorised Consumption**: Misuse of fire hydrants and fire service connections and illegal connections and theft.

- **Customer Meter Inaccuracies and Data Handling Errors**: Random errors due to accounting procedures, misread meters, incorrect estimates for stopped meters, adjustments to original meter readings, improper calculations, computer programming errors and systematic errors due to under-registration or over-registration of customer meters

- **Apparent Losses**: Unauthorised consumption (theft and illegal use) and metering errors

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WP4.2: WB analysis (5/6)

Real Losses A19=A15-A18	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
	Leakage on service connections up to the measurement point

- **Real Losses**: They are actually the water physical losses. They consist of:
  - Leakage on water mains and at the treatment works
  - Leakage on transmission and/or distribution mains
  - Leakage and overflows at transmission and/or distribution storage tanks
  - Leakage on service connections up to the measurement point

WP4.2: WB analysis (6/6)

<table>
<tr><td rowspan="2">Unbilled Authorised Consumption

A13=A11+A12</td><td>Unbilled Metered Consumption
A11</td><td rowspan="8">Non - Revenue Water

A21=A3-A20</td><td rowspan="8">Non - Revenue Water when MCF is deducted

A24=A21-A23</td></tr>
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Difference (MCF)
A23</td></tr>
<tr><td>Leakage and overflows at transmission and/or distribution storage tanks</td></tr>
<tr><td>Leakage on service connections up to the measurement point</td></tr>
</table>

- **Non-Revenue Water (NRW):** NRW is the difference between SIV and billed authorised consumption. It consists of: (a) unbilled authorised consumption; and (b) water losses

- **Minimum Charge Difference (MCD):** Volume of water billed minus volume of water consumed (metered). It is used when the utility uses a flat rate for minimum consumption. It is actually the water being charged but not consumed

The Minimum Charge Difference: the predominant water pricing policy

- There are two types of fixed costs forming the fixed charge included in a water tariff :
  - expenses not related to the amount of water a customer uses (e.g. water meters maintenance, water connection fee etc.). These are the correct and socially just fixed costs that each customer must pay, regardless of its actual water consumption. They all form the so-called “opportunity cost”.
  - expenses related (proportionally) to the amount of water a customer uses (e.g. costs related to pipe breaks rehabilitation etc). These expenses should not be considered as “fixed charge”, although water utilities tend to consider them as such.
- There also other types of water use, e.g. fire fighting free of charge, other public water use free of charge, that should be considered as fixed charge (opportunity cost)
- Other kinds of cost, e.g. related to pipes/tanks flushing water should be considered as of type 2 (as they have to do with the network’s percentage of use index – an non IWA one)
- The utility’s operating (running) costs should be recovered through the water rates (revenues of water consumption), excluding the first type of fixed costs (unless they are also included in the operating costs).

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The Fixed Charge Role (1/4)

Calculating the MCD when the fixed charge is expressed in €:

- the MCD expresses the equivalent water volume (in m^3), that if sold (on net water price, excluding the fixed cost) would have resulted in the same revenues (in €), minus the actual fixed cost (opportunity cost).

CALCULATION

The Total Revenues (R) (€) related to the water being sold (and related water services) within the time period (T) of analysis, are the sum of the revenues (R_{fc}) related to the fixed cost and those (R_{wuc}) related to the water being sold:

$$R = Rfc + Rwuc$$

where: R_{fc} are the revenues related to the fixed cost ;

R_{wuc} are the revenues related to the water being sold

$$R_{fc} = R_{dc} + R_{ndc}$$

where: R_{dc} is the sum of the revenues related to the water consumption;

R_{ndc} is the sum of the revenues NOT related to the water consumption

The Fixed Charge Role (2/4)

- The total water volume entering the system (SIV):

$$Qwst = Qws + Qwns \Rightarrow Qws = Qwst - Qwns$$

where: Q_{wst} is the total water volume entering the system (SIV) in m^3 ;

Q_{ws} is the water volume sold (m^3);

Q_{wns} is the water volume (m^3) not sold for various reasons, e.g. breaks, leaks, water theft, zero charge, etc.

Q_{ws} is the water volume sold – a part of it brings revenues to the water utility while another part does not bring any revenues:

$$Qws = Qwsp + Qwsnp$$

where: $Qwsp$ is the water volume sold (m^3) generating revenues;

$Qwsnp$ is the water volume sold (m^3) not generating revenues to the water utility

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The Fixed Charge Role (3/4)

- The mean apparent/actual unit charge of water use in (€/m^3) is: $Awuc$

$$Awuc = Rwuc / Qwsp$$

- The mean unit rate of revenues (€/m^3) > mean unit charge of water use (€/m^3):

$$A = R / Qwsp$$

- Thus MCD (in m^3) is:

$$MCD = \frac{(R_{fc} - F_c)}{(R_{wuc} / Q_{wsp})}$$

- where: Fc expresses (in €) the actual fixed cost of the water services (opportunity cost)

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The Fixed Charge Role (4/4)

Calculating the MCD when the fixed charge is expressed in m^3

- The MCD represents the water volume that although included in the water bills as water consumption, is not actually being used.
- The water volume that if sold under the mean apparent/actual unit charge of water use A_{wuc} (€/m^3) it would generate revenues equal to the actual Fixed Cost (opportunity cost) should be excluded

CALCULATION

$$MCD = Q_{tot}^{billed} - Q_{tot}^{used} - Q_{opportunity\ cost}$$

Where: Q_{tot}^{billed} is the total billed water use (m^3);

Q_{tot}^{used} is the total the water volume used (m^3);

$Q_{opportunity\ cost}$ is the water use (m^3) representing the opportunity cost (F_c) the consumer has to pay

$$Q_{opportunity\ cost} = Fc / Awuc$$

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The methodology (1/3)

<table>
<tr><td rowspan="8">System Input Volume

A3</td><td rowspan="4">Authorised Consumption

A14=A10+A13</td><td rowspan="2">Billed Authorised Consumption

A10=A8+A9</td><td>Billed Metered Consumption
A8</td><td rowspan="4">Revenue Water

A20=A8+A9</td><td rowspan="2">Revenue Water

A20=A8+A9</td></tr>
<tr><td>Billed Unmetered Consumption
A9</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption

A13=A11+A12</td><td>Unbilled Metered Consumption
A11</td><td rowspan="6">Non - Revenue Water

A21=A3-A20</td></tr>
<tr><td>Unbilled Unmetered Consumption
A12</td><td rowspan="3">Non - Revenue Water when MCF is deducted

A24=A21-A23</td></tr>
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Top – down Approach

- Step 1: Define **SIV** and enter in A3
- Step 2: Define **Billed Metered Consumption** & **Billed Unmetered Consumption** and enter in A8 & A9 respectively. Calculate **Billed Authorised Consumption** (A10=A8+A9) & **Revenue Water** as A20=A8+A9 (actually A10=A20)
- Step 3: Calculate the **NRW** as A21=A3-A20

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The methodology (2/3)

<table>
<tr><td rowspan="6">System Input Volume

A3</td><td rowspan="3">Authorised Consumption

A14=A10+A13</td><td rowspan="2">Billed Authorised Consumption

A10=A8+A9</td><td>Billed Metered Consumption
A8</td><td rowspan="2">Revenue Water

A20=A8+A9</td><td rowspan="2">Revenue Water

A20=A8+A9</td></tr>
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A9</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption

A13=A11+A12</td><td>Unbilled Metered Consumption
A11</td><td rowspan="5">Non - Revenue Water

A21=A3-A20</td><td rowspan="4">Non - Revenue Water when MCF is deducted

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</table>

- Step 4: Define **Unbilled Metered** and **Unmetered Consumption** and enter in A11 and A12 respectively. Calculate **Unbilled Authorised Consumption** as A13=A11+A12
- Step 5: Calculate **Authorised Consumption** as A14=A10+A13
- Step 6: Calculate **Water Losses** as A15=A3-A14

The methodology (3/3)

<table>
<tr><td rowspan="9">System Input Volume

A3</td><td rowspan="4">Authorised Consumption

A14=A10+A13</td><td rowspan="2">Billed Authorised Consumption

A10=A8+A9</td><td>Billed Metered Consumption
A8</td><td rowspan="2">Revenue Water

A20=A8+A9</td><td rowspan="2">Revenue Water

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A13=A11+A12</td><td>Unbilled Metered Consumption
A11</td><td rowspan="7">Non - Revenue Water

A21=A3-A20</td><td rowspan="5">Non - Revenue Water when MCF is deducted

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</table>

- Step 7: Assess components of **Unauthorised Consumption** and **Metering Inaccuracies** and enter in A16 and A17 respectively. Calculate **Apparent Losses** as A18=A16+A17
- Step 8: Calculate **Real Losses** as A19=A15-A18
- Step 9: Assess components of **Real Losses**
- Step 10: Define **MCF** and enter in A23. Calculate **NRW when MCD is deducted** as A24=A21-A23

Tips & Tricks (1/3)

- **Billed Metered Consumption**: the period used in the calculation should be consistent with the auditing period
- **Billed Unmetered Consumption:** Define the household customers without meters and implement a pilot project during a small period. For commercial customers the pilot project should be more precise
- **Unbilled Unmetered Consumption:** It 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 authorised consumption should be less than 1% of SIV

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Tips & Tricks (2/3)

- **Unauthorised Consumption**: In the UK an acceptable estimate is 0.25% of SIV, while in Australia is 0.1% of SIV.
- **Customer Meter Inaccuracies:** In the UK the household meters under register 3.3% of the household consumption and 4.7% of the non household consumption. In Australia the household meters under register 2% of the household consumption and 2% of the non household consumption.
- **Apparent Losses**: IWA considers that they can range from 0 to 10% of SIV for direct pressure systems, while they are more for systems with customer storage tanks

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Tips & Tricks (3/3)

- **Real Losses**: they can be assessed using techniques such as:
  - Component analysis: background leakage at joints and fittings, reported leaks and bursts and unreported leaks and bursts
  - Analysis of night flows: Minimum Night Flow (MNF)

- **Minimum Charge Difference:** difference between the actual metered consumption level and the billed one.

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Water Balance: Bottom-up approach

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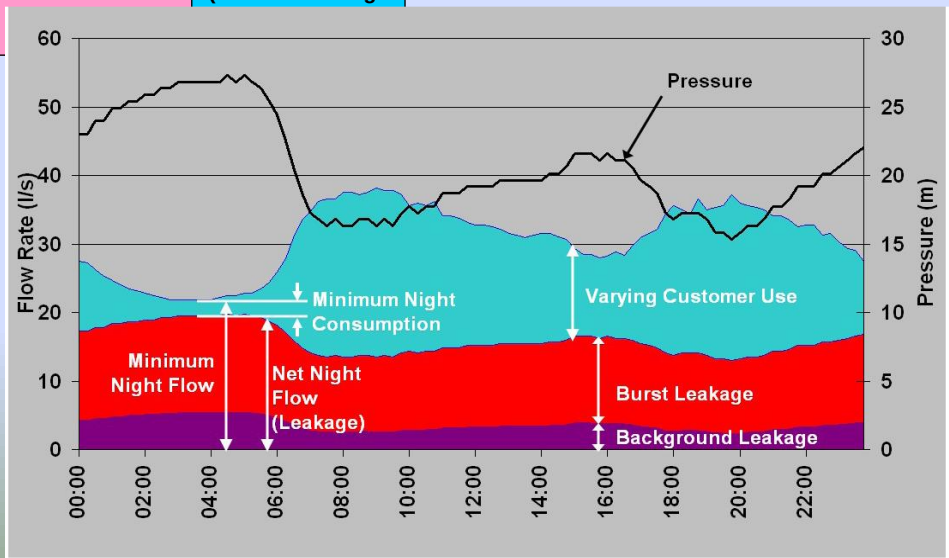

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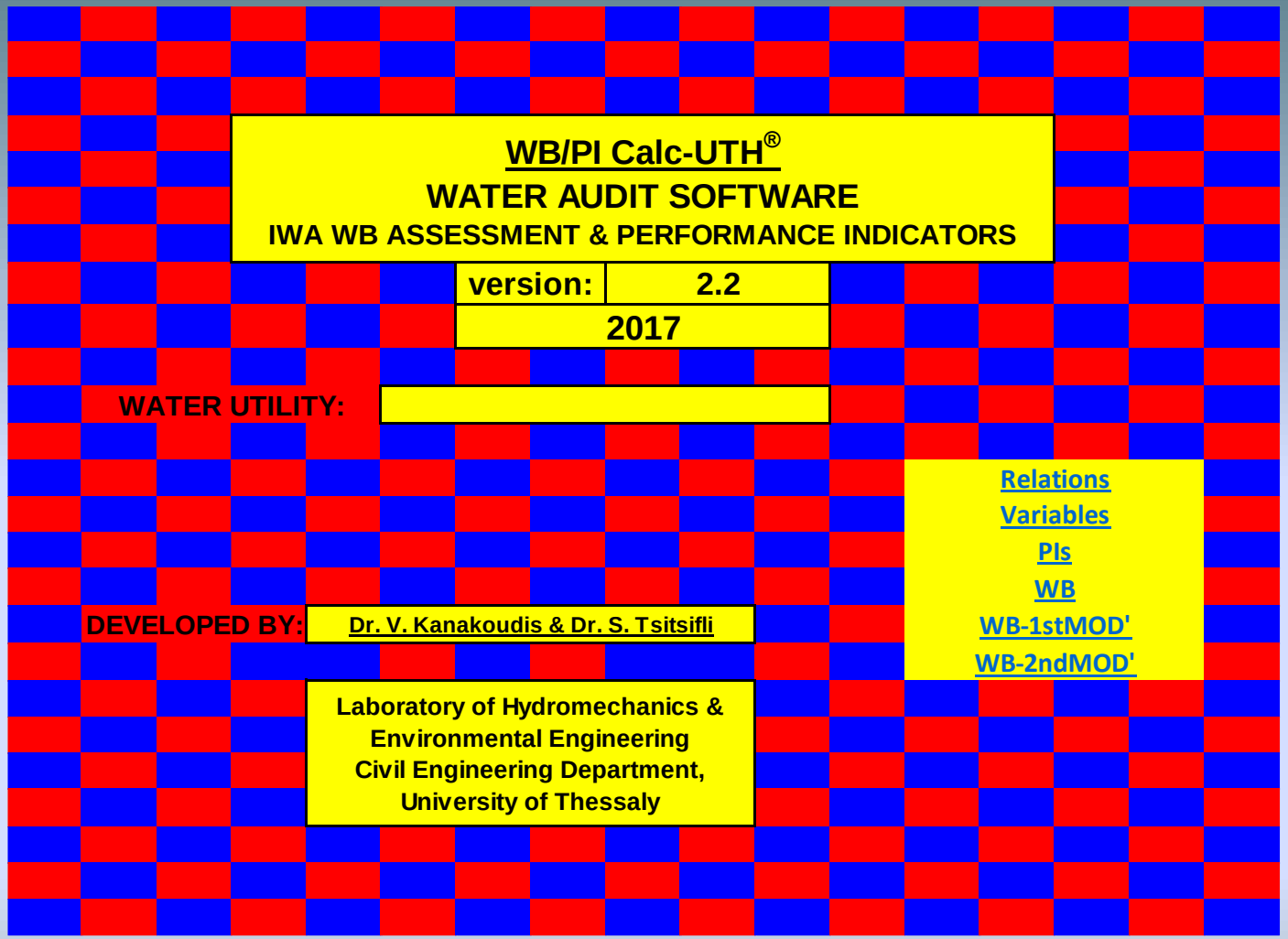
Water Audit Software - WB/PI Calc-UTH



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Performance Indicators (1/2)

- A system to evaluate the water supply system performance
- 170 IWA PIs based on 232 variables
- More variables suggested

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Performance Indicators (2/2)

Name	Group	Subgroups	Number
WR	Water Resources		4
Pe	Personnel	Total Personnel	2
		Personnel per main function	7
		Technical services personnel per activity	6
		Personnel qualification	3
		Pesronnel training	3
		Personnel health and safety	4
		Overtime work	1
Ph	Physical	Treatment	1
		Storage	2
		Pumping	2
		Treatment	2
		Transmission and distribution	2
		Meters	4
		Automation and control	2
QS	Quality of service	Service coverage	5
		Public taps and standpipes	4
		Pressure and continuity of supply	8
		Quality of supplied water	5
		Service connection and meter installation and repair	3
		Customer complaints	9

Name	Group	Subgroups	Number
Op	Operational	Inspection and maintenance of physical assets	6
		Instrumentation calibration	5
		Electrical & signal transmission equipment inpection	3
		Vehicle availability	1
		Mains, valves and service connection rehabilitation	3
		Inspection & maintenance of physical assets	2
		Pumps rehabilitation	2
		Operational Water Losses	7
		Failure	6
		Water metering	4
		Water quality monitoring	5
Fi	Economic & Financial	Revenues	3
		Costs	3
		Composition of running costs per type of costs	5
		Composition of running costs per main function of the water undertaking	5
		Composition of running costs per technical	6
		Composition of capital costs	2
		Investment	3
		Average water charges	2
		Efficiency	9
		Leverage	2
		Liquidity	1
		Profitability	4
		Economic water losses	2

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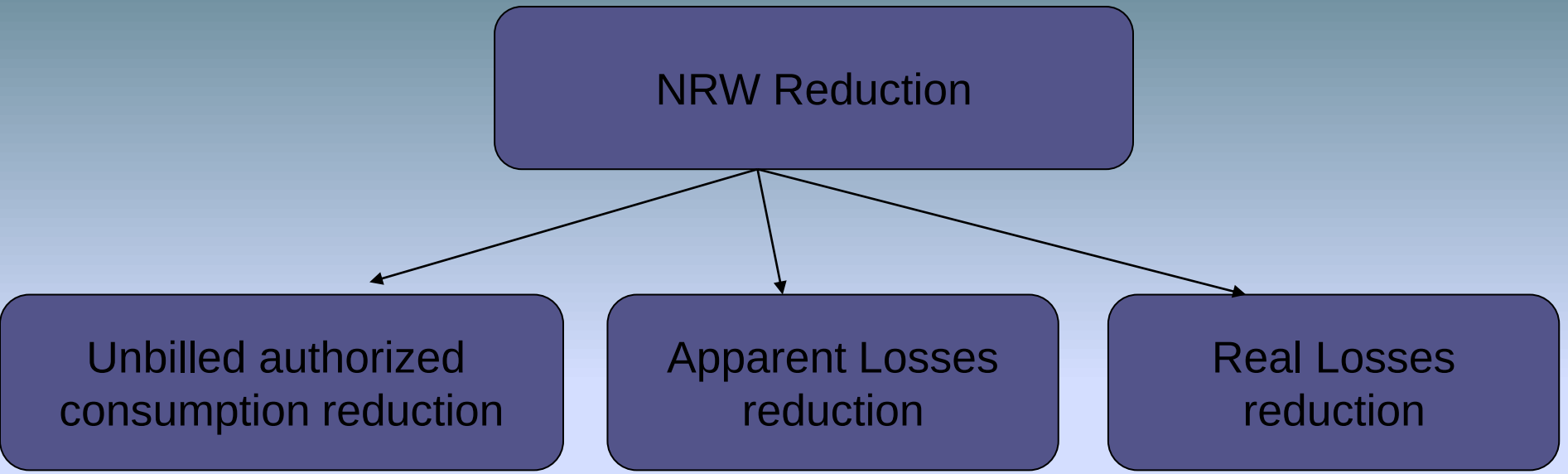
NRW reduction



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NRW reduction Action Plan

Unbilled Authorized Consumption	Up to 1%	Considered within acceptable limits
	1-5%	Introduce new tariffs
	5% and above	Review overall billing policy
Apparent Losses	Up to 2%	Considered within acceptable limits
	2-5%	Reduce unauthorized consumption, meter reading and accounting errors
	5% and above	Review metering accuracy / policy
Real Losses	Up to 5%	Considered acceptable, may be uneconomic to reduce
	5-10%	Reduce visual leakages and overflows at storages and fix visual network leaks
	10% and above	Improve active leakage control, effective maintenance, pressure management

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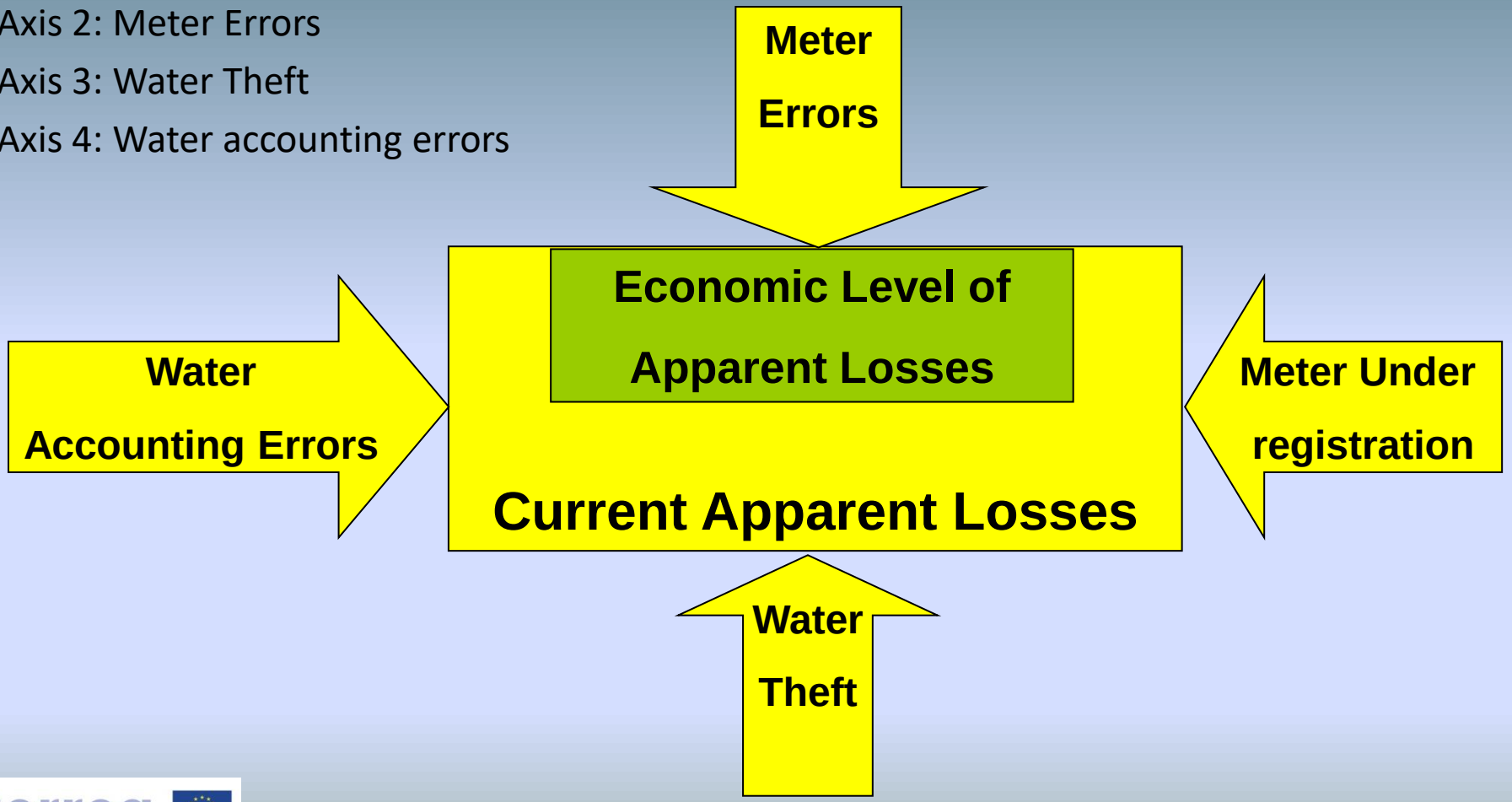
Apparent Losses Reduction (1/3)

- Axis 1: Meter under registration
- Axis 2: Meter Errors
- Axis 3: Water Theft
- Axis 4: Water accounting errors



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Apparent Losses Reduction (2/3)

- Axis 1: Meter under registration
  - **Action**: Implement a pilot project to define the water meters under registration levels
    - **Measure:** replace stopped water meters
    - **Measure**: install UFR to catch low flow rates
  - **Action**: Monitor water consumption pattern and explore meters presenting sudden changes
    - **Measure**: impose high fines when water theft is found
  - **Action**: define water meters optimum replacement time
    - **Measure**: replace water meters aged over the optimum replacement age
  - **Action**: Deal with the roof tanks problem
    - **Measure**: abolition of roof tanks where possible
    - **Measure**: install UFR

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Apparent Losses Reduction (3/3)

- Axis 2: Meter Errors
  - **Action**: Implement a pilot project to define water errors levels
    - **Measure**: training program to people recording water meters
    - **Measure**: provide them with technological tools (e.g. tablets, etc.)
    - **Measure**: install AMR
- Axis 3: Water Theft
  - **Action**: Implement pilot projects to see where water theft takes place
    - **Measure**: Impose high fines to avert people of stealing water
    - **Measure**: information programs to the consumers
- Axis 4: Water accounting errors
  - **Action**: define water accounting errors levels
    - **Measure:** training programs to the employees handling water accounting
    - **Measure**: Install AMR system (cost benefit analysis)

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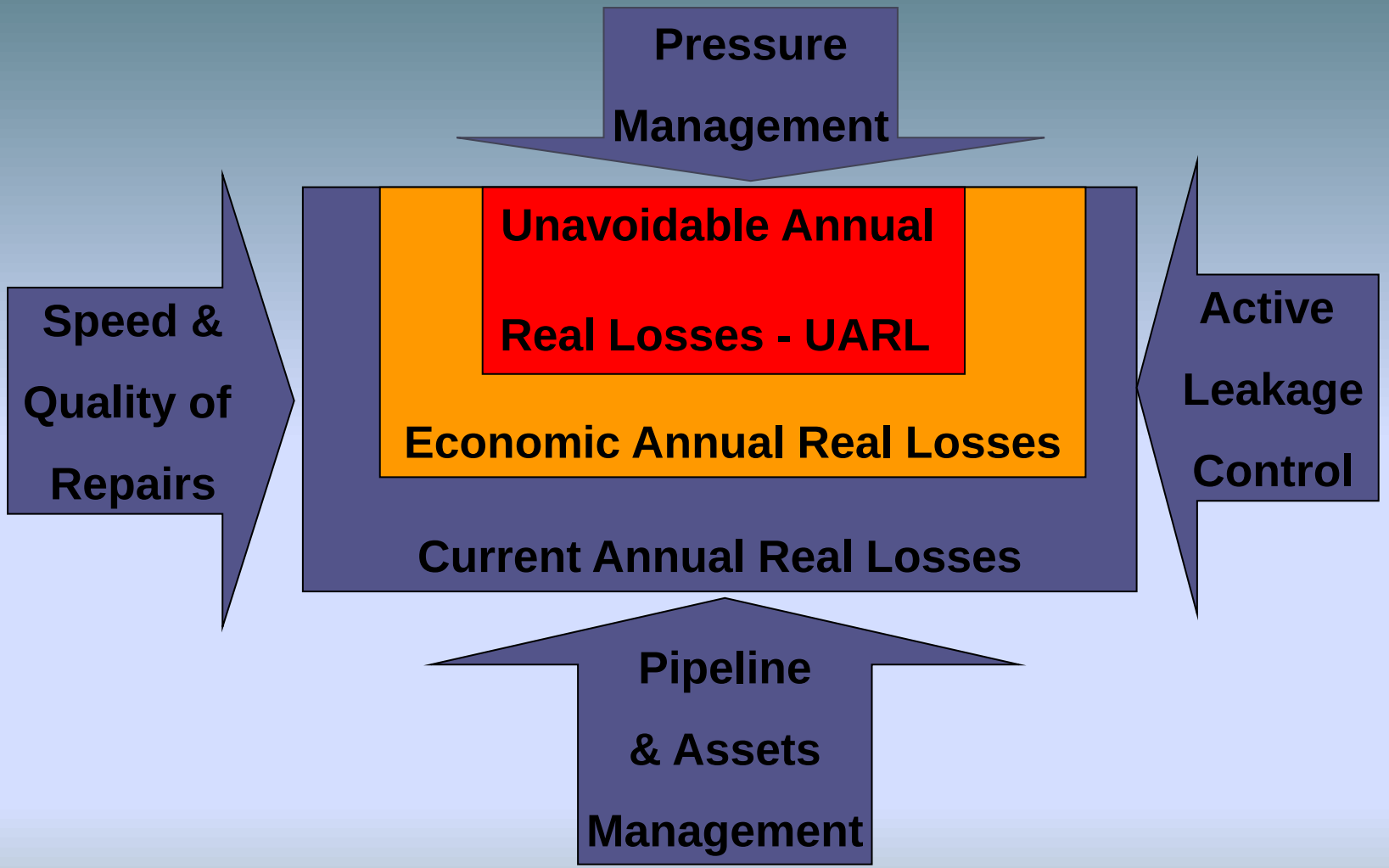
Real Losses Reduction Pillars



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Real Losses Reduction (1/4)

- Axis 1: Pressure Management
  - **Action**: Investigate the formation of pressure zones
    - **Measure:** pressure zones formation
    - **Measure**: install PRVs (pressure reduction valves)
  - **Action**: Investigate the formation of DMAs
    - **Measure**: DMAs formation
    - **Measure:** install PRVs
  - **Action**: Monitor pressure in the head of the zones
    - **Measure**: install PRVs

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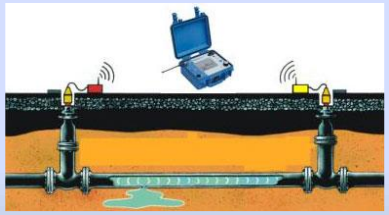
Real Losses Reduction (2/4)

- Axis 2: Active Leakage Control
  - **Action**: Investigate areas with high leakage rates and locate leakage problems
    - **Measure**: install permanent acoustic loggers
    - **Measure**: create teams detecting leaks with vehicles fully equipped
    - **Measure**: staff training in detecting and localizing leaks
  - **Action**: Leaks localizing, locating and pinpointing
    - **Measure**: noise loggers, leak noise correlators, ground microphones, sounding sticks procurement
    - **Measure**: leaks locating software procurement



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Real Losses Reduction (3/4)

- Axis 3: Pipeline and assets management
  - **Action**: Investigate and record pipes age
    - **Measure**: record and validate pipes network in SCADA
    - **Measure**: record pipes material, diameters and age
  - **Action**: Determine the pipes optimum replacement time
    - **Measure**: Calculate the pipes optimum replacement time using the right formulas
    - **Measure**: pipes replacement
  - **Action**: Determine the spatial and time frequency of pipe failure incidents
    - **Measure**: Use the right models and record the pipes failures, their causes and the measures taken
    - **Measure**: Pipes replacement
    - **Measure**: pipes rehabilitation
  - **Action**: Implement proactive and preventive maintenance
    - **Measure**: Implement maintenance programs

Real Losses Reduction (4/4)

- Axis 4: Speed and quality of repairs
  - **Action**: Determine the time to repair a failure incident
    - **Measure:** training employees
    - **Measure**: Use fully equipped teams
    - **Measure**: Use emergency units

Physical Losses Assessment Matrix

ILI=CARL / UARL

Physical Loss Assessment Matrix

Technical Performance Category		ILI	Litres / connection / day (when the system is pressurised) at an average pressure of:				
			10 m	20 m	30 m	40 m	50 m
Developed Country Situation	A	1 - 2		< 50	< 75	< 100	< 125
	B	2 - 4		50-100	75-150	100-200	125-250
	C	4 - 8		100-200	150-300	200-400	250-500
	D	> 8		> 200	> 300	> 400	> 500
Developing Country Situation	A	1 - 4	< 50	< 100	< 150	< 200	< 250
	B	4 - 8	50-100	100-200	150-300	200-400	250-500
	C	8 - 16	100-200	200-400	300-600	400-800	500-1000
	D	> 16	> 200	> 400	> 600	> 800	> 1000

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Physical Losses Assessment Matrix Explanations

- **A**: Further loss reduction may be uneconomic unless there are shortages. Careful analysis needed to identify cost effective improvement.
- **B**: Potential for marked improvements. Consider pressure management. Better active control practices and better network maintenance.
- **C**: Poor leakage record. Tolerable only if water is plentiful and cheap. Even then, analyze level and nature of leakage and intensify leakage reduction efforts.
- **D**: Horrendously inefficient use of resources. Leakage reduction programs imperative and high priority.

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Volume & Cost Analysis

Volume		Cost		
		High	Medium	Low
	High	Leakage on mains (RL) Leakage on service connections (RL)	Unauthorized Consumption (AL)	Unbilled metered consumption (U)
	Medium	Customer Meter Replacement (AL)	Customer metering inaccuracies and data handling errors (AL)	Pressure management (RL)
	Low	Reservoir Leakage (RL)	Unbilled unmetered consumption (U)	Reservoir overflows (RL)

RL= Real Losses; AL = Apparent Losses; U = Unbilled Authorized Consumption

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Best & Worst practices – PP1 & PP3

	LP DEYAL			PP3 DEYAK	
Case	Pressure reduction	Pipes replacement	Awareness activities	PRV installation in a pilot DMA	Underground chambers replacement
Reduction of Real Losses	YES	YES		YES	YES
Reduction of Apparent Losses			YES		
Description	6 PRVS were installed since 2000	About 100 Km of pipes replaced in 2017-2018	Awareness activities in schools	DEYAK installed ia PRV for the PM application in a selected pilot DMA. The isolation valves were checked and a "Zero Pressure Test" took place.	158 chambers were replaced with all the other equipment (fittings etc.).
Expected Results	Real Losses reduction; reduction of leaks	Real Losses reduction; reduction of leaks	Reduction of leaks awareness time (people react when they see a leak)	A SIV reduction of 15% was expected	Real losses reduction
Actual Results (e.g. reduction of pressure, more accurate water metering, etc.)	Pressure reduction	Leaks reduction	Leaks awareness time reduction; consumption reduction	Mean operating pressure reduced from 5.77 to 3.72 atm; water volume metered through water meters reduced 5%	Reduction of SIV by approximately 8%; Slight increase in pressure because many background leaks were repaired
Duration	2000 – today	2017-today	Continuously	1 month in 2014	1 year
Water volume saving (m^3 per time period)	1,200,000m^3 of SIV in 17 years	The results will be available within 2018	Leaks awareness time reduction; consumption reduction	350,000 m^3/year	
Total cost (€)				~50,000 €	~350,000 €
Other benefits	Better control of the network operation	Better water quality	Conservative users		

Best & Worst practices – PP5, PP6 & PP7

	PP5 SH.A UKKO	PP6 WBN	PP7 BWA		
Case	Water meters replacement	WBN DMA - Leakage control activity	Water loss reduction in DMA Golak, Razlog town	Water loss reduction in water supply system of Strumsko district	Water losses management in Dryanovo and Tryvna
Reduction of Real Losses		YES	YES	YES	YES
Reduction of Apparent Losses	YES			YES	
Description	Water meters replacement with digital ones	Installation of a PRV, locate un-reported leaks	zoning the water network of the populated area "Golak" into DMA & pressure management	Pressure management; water meters replacement	Constant monitoring of the network and acting DMA through CheckCalcs software.
Expected Results	Reduce of meters errors	The NRW is 25% or 15.000 m^3/day Year 2018	Decrease of input water in the water supply system and non-revenue water	Decrease of input water in the water supply system and NRW	Acquiring better managing and exploitation experience of all staff connected to the maintenance of the network of both towns. Water loss reduction
Actual Results (e.g. reduction of pressure, more accurate water metering, etc.)	Reduction of total losses from 28-30% to 22-25%; reduction of metering errors from 5% to 1%	Reduction of pressure to 30 m, locate un-reported leaks 5935	Almost double reduction of input water. Data from 1.09.2016 – 1673,4 m^3/day input water and on 1.09.2017 – 876,3 m^3/day	Water losses were reduced by 38% and malfunctions by 55%; average increase in registered water consumption	Dryanovo: The input water quantity was reduced by 44,2% or 2,26 times. Water loss reduction is 3,88 times. Tryavna: The input water quantity was reduced by 77,8% or 1,29 times. Water loss reduction is 1,46 times.
Duration	2013-2014	2012-18	1 year	1 year	3 years
Water volume saving (m^3 per time period)	-	Reduced water losses in DMA by 1.300 m^3/day	797.1m^3/day SIV	38% reduction in real losses	500,000 m^3 in 3 years
Total cost (€)		Unit cost of PRV instalment 4.600€, Total cost of leak detection project 169,000 in €per year	About 27,500€	About 30,000€	About 41,000€
Other benefits		Potential water supply of a population of 11,000 persons			

Best & Worst practices – PP7 & PP8

	PP7 BWA	PP8 ViK Prilep	
Case	Improvement & development of infrastructure in Veliko city	Replacement of 2,500 water meters	Confrontation of illegal water use
Reduction of Real Losses	YES	NO	NO
Reduction of Apparent Losses	YES	YES	YES
Description	Construction and reconstruction of water supply and sewerage networks in Veliko Tarnovo city.	Replacement of 2,500 water meters where old water meters existed and in consumers without water meter.	A team for the detection of illegal connections was formed; a procedure was developed for connecting and disconnecting of users and connections.
Expected Results	Improvement of potable water quality; Water loss reduction in water supply networks; Improvement of water supply and sanitation services.	Installing water meters should made better performance, efficiency, accurate water measuring, reduction of water losses, accurate metering and billing.	Reduce illegal water use
Actual Results (e.g. reduction of pressure, more accurate water metering, etc.)	Improved quality of potable water; Increased volume of water supply with 50%; Water loss reduction with 20%; Improvement of exploitation reliability up to 100%	More than 8,000m^3 were recorded in water meters (in 2007) resulting in income increase.	The teams for illegal connections in the period of one year controlled a total of 2,016 buildings.
Duration	2 years	2006 - 2007	April 2008 to March 2009 January 2011 to December 2011
Water volume saving (m^3 per time period)	1,818,662 m^3 within 3 years	Water volume metered in June 2006: 246.554 m^3 ; water volume metered in June 2007: 254.756 m^3; water volume saved 8.101 m^3. Which means losses are reduced and (approximately 3, 3%)	22,200 m^3 monthly of water has been saved in 2008-2009 In the period of 2011 a total water quantity of 7,105 m^3 monthly has been saved
Total cost (€)	22,338,777.84€		
Other benefits			Staffed and trained special team which will be mobile and will exclusively work on detection, processing and disconnection of illegal connections. Written procedures accepted and adopted by the Managing Board, the Mayor and the communal inspectorate.

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Urban water full cycle: from its source to its end-users and back to the environment

WP4 Common methodology & tools

Joint Del. 4.2 Water Auditing towards cost effective water use & volume efficiency

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PP4 - University of Thessaly-Special Account Funds for Research-Department of Civil Engineering

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