

WATenERgy CYCLE

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

WP5 Joint Pilot Actions

Joint Del. 5.2 Ex-Post Water efficiency evaluation



PP3 - Municipal Enterprise for Water Supply and
Sewerage of Kozani

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

PP2 - General Secretariat for Natural Environment and
Water

WP5: Joint Pilot Actions

- Responsible partners:
 - **PP3 - Municipal Enterprise for Water Supply and Sewerage of Kozani**
 - **PP4 - University of Thessaly-Special Account Funds for Research-Department of Civil Engineering**
 - **PP2 - General Secretariat for Natural Environment and Water**
- Partners involved: ALL
- Budget: 885,021.23 €

WP5: Joint Pilot Actions

WP5 includes Joint Pilot Actions

- Evaluation of the pilot case **prior** to the pilot actions. General presentation and description of the pilot case and the pilot action; identification of problems; water and energy audit (Water Balance and Pis); conclusion
- Evaluation of the pilot case **after** the pilot actions. Description of the pilot action implementation; water and energy audit after the implementation of the pilot action; discussion related to the new PIs values; problems encountered during the pilot action implementation; costs estimation; conclusions
- Summary report on the implementation of the pilot action (per partner).

WP5: Joint Pilot Actions

Beneficiary		Pilot action	Equipment	Water Use Efficiency	Energy Efficiency
LP	DEYA Larissas (Greece)	Purchase & Installation of Energy Recovery System (three IE3 High Energy Efficiency Motors 250 KW two Inverters, one Softstarter: & Installation Service) at the Central Pumping Station for Larisa Water Utility	three IE3 High Energy Efficiency Motors 250 KW two Inverters, one Softstarter: & Installation Service		√
PP3	DEYA Kozanis (Greece)	Purchase of Energy Recovery System (ENR) and Automated Meter Reading (AMR) (700 AMR, 2 mobile reading systems, software, 3 ENRs DN150 & 2 ENRs DN200, training) for Kozani Water Utility	700 AMR; 5 small hydroturbines	√ Apparent losses	√
PP5	UKKO (Albania)	Water leak detection car (equipped with facilities), Leak detection equipment flow analysis, aquaphone, analysis securr 300. Water losses measurement database and decision support system. Korça City Zone Pressure no. 3 will represent the UKKO JSC study area that will be our pilot action area	Leak detection car with incorporated Water Leak detection Equipment	√ Real losses	
PP6	WBN (Cyprus)	Purchase of equipment for water pressure management (PRVs) and smart water meters SCADA, PILLAR, software including training of personnel. Monitor operating parameters (pressure, flow, quality parameters). Water Balance calculation	<ul style="list-style-type: none"> · 700 AMR in DMA25 · PRV installation in DMA 15 · Electronic sensors for water quality monitoring · Electronic power generators 	√ · Apparent losses · Real losses	√
PP7	BWA (Bulgaria)	Purchase of leak detection, monitoring and sewerage network inspection equipment. Training purposes	Water leak detection equipment to be used for training & educational purposes	√ Horizontal training	
PP8	Prilep (N. Macedonia)	Purchase of leak detection system and measuring equipment, GIS software for "Water supply and drainage". Water losses measurement database and decision support system	GIS software and leak detection system and measuring equipment	√ Real losses	

WP5: Joint Pilot Actions – Water or Energy Efficiency?

Water use efficiency

PP3-DEYAK

PP5-UKKO

PP6-WBN

PP7-BWA

PP8-JKP ViK Prilep

Energy efficiency

LP/PP1 - DEYAL

PP3 - DEYAK

PP6-WBN

WP5: Joint Pilot Actions – Water Use Efficiency

Real Losses

PP5: Supply of leak detection car and equipment

PP6: PRV in DMA 15

PP6: electronic sensors for monitoring water quality (indirect effects on pipes)

PP7: theoretical and practical education of water leak detection equipment

PP8: GIS software

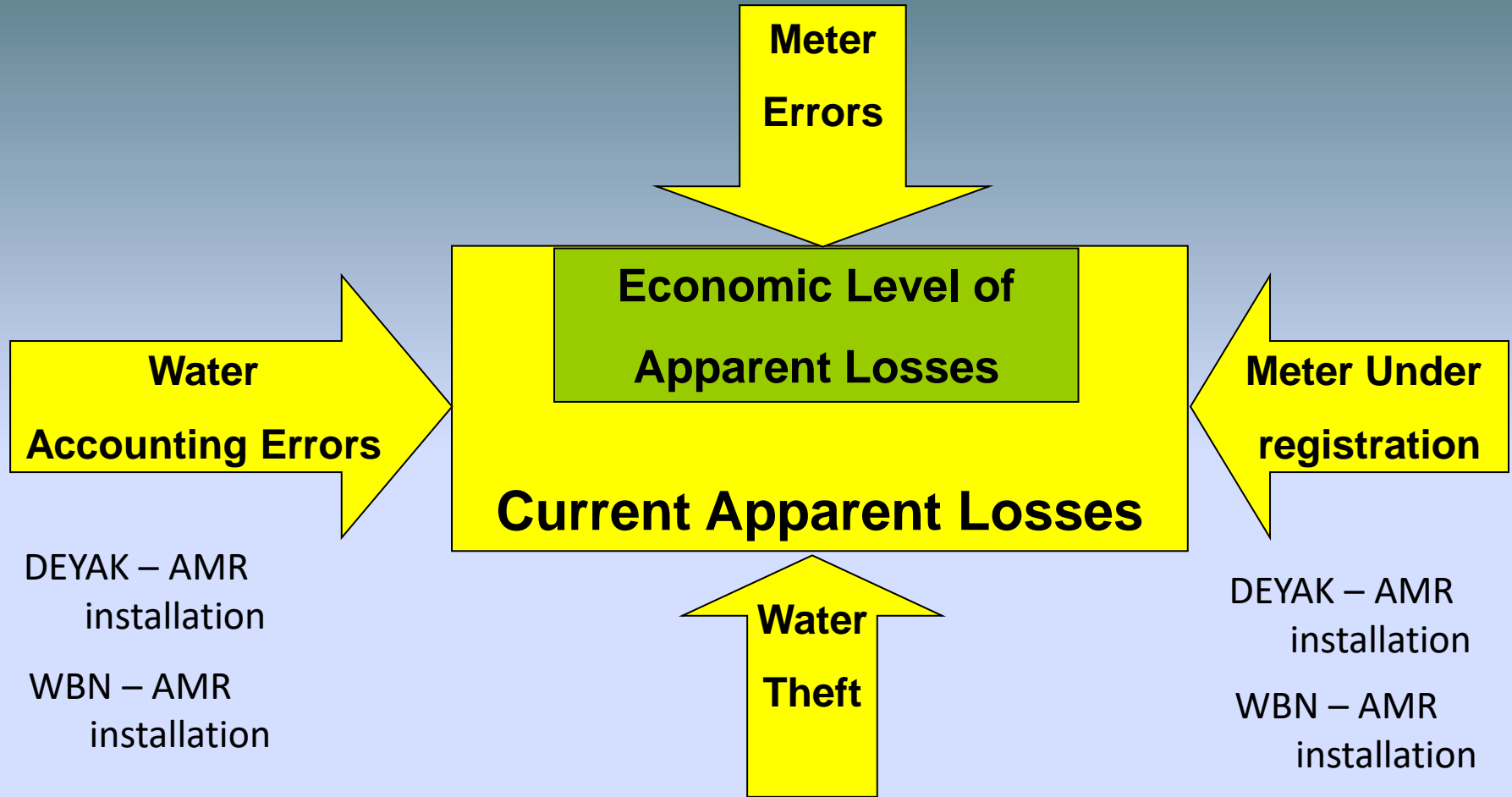
PP8: leak detection equipment

Apparent Losses

PP3: Installation of 700 AMR

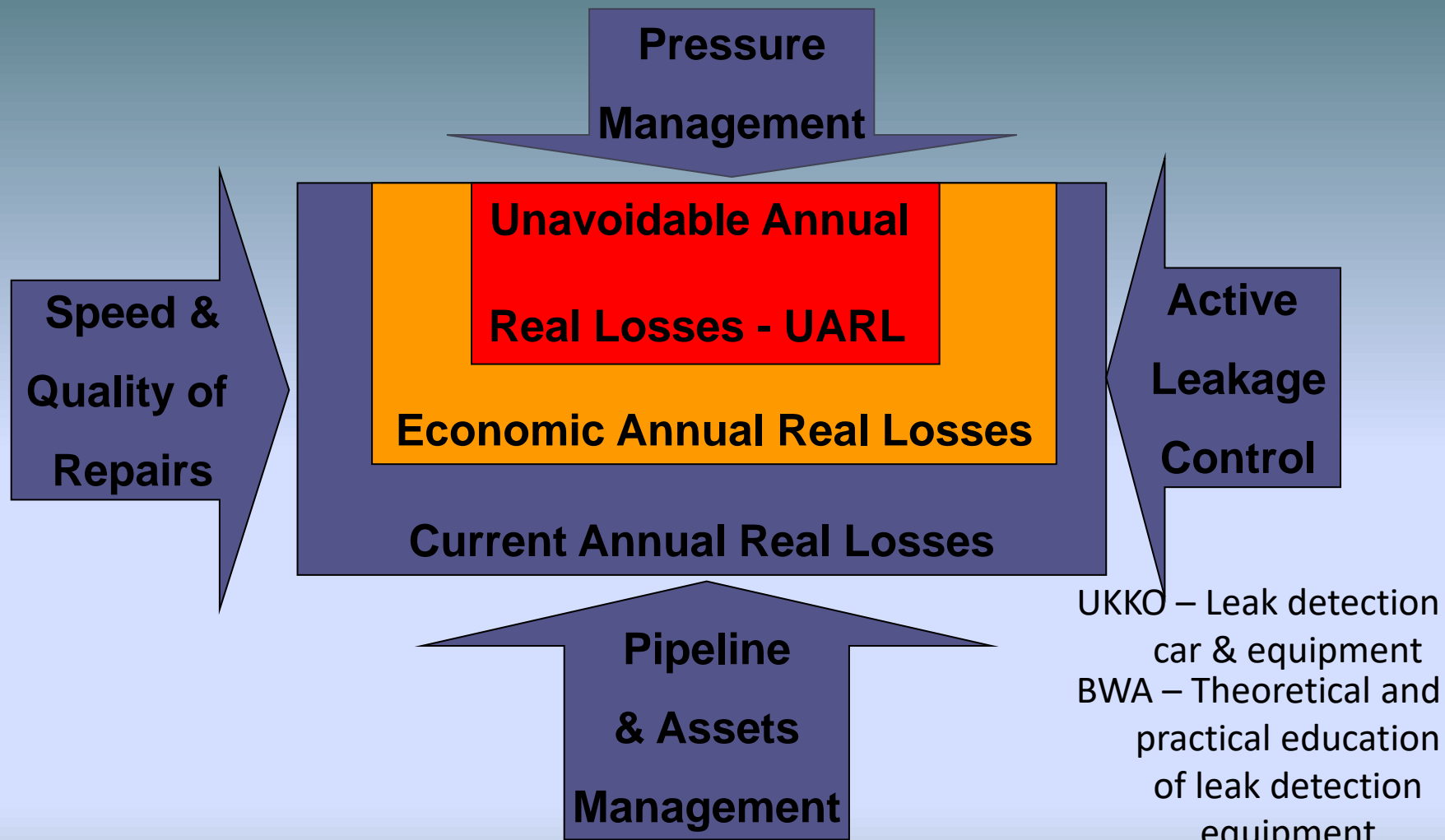
PP6: Installation of 700 AMR

Apparent Losses Reduction



Real Losses Reduction Pillars

WBN – PRV in DMA 15



UKKO – Leak detection car & equipment
BWA – Theoretical and practical education of leak detection equipment
JKP ViK Prilep – Leak detection equipment

WBN – water quality sensors

JKP ViK Prilep – GIS software

Project co-funded by the European Union and National Funds of the participating countries

Initial status – pilot areas characteristics

General Data	Larissa (GR)	Kozani (GR)	Korca (AL)	WBN (CY) – DMA25	WBN (CY) – DMA15	BWA (BG)	Prilep (FYROM)
Total population served	162,591 (2011 census)	3,462	4,150	1,909	22,766	212,877	76,768
Total area covered (Km ²)	335.12	0.433 Km ²	1.2	2.0	8.0	6,400	1,194.44
Total pipes' length (Km)	1,078	9.696	25	21.5	85.0	1,497	247.76
Mean altitude (m)	67	672.9	945	325	135.0	400	550-700
Mean operating pressure (atm)	4.3	4 atm	6-8	1.8	3.3	7	3.5
Age of pipes (per material, diameter)	1930-1970 pipe networks from cast iron; 1970 – today: steel & PVC; 2007 – today: PE	PVC as follows:					
Diameter	Length (m)	Age (years)					
63	7,428	20					
75	165	20					
90	575	20					
200	1,529	20					
Total	9,697		High Density polyethylene; since 2000	MDPE, AC, UPVC 75 - 160mm; 30 year	AC, UPVC 100-160mm; 30 years	Eternit, steel, galvanized steel, ductile iron, PVC and PE; Since 1936	DN700mm; DN600mm; DN500mm; DN400mm; DN300mm; DN315mm; Secondary network LN 200-50 mm;
No. of service connections	37,500	235	965	704	4,469	52,083	19,144
No. of water meters	82,737	1,154	N/A	N/A	N/A	N/A	N/A

Ex-ante & ex-post WB evaluation

	DEYAL		DEYAK		SH.A UKKO		WBN – DMA 25		WBN – DMA 15		JKP ViK Prilep	
	2017	2019	2017	2019	2017	2019	2017	2019	2017	2019	2017	2019
System Input Volume	15.899.359	15.779.607	509.522	509.522	258.258	243.002	1.331.267	1.304.180	174.305	212.390	7.793.289	8.399.875
Authorized Consumption	12.532.914	12.211.089	214.679	237.275	188.612	182.330	852.584	868.766	112.524	124.516	3.395.071	3.953.170
Billed Authorized Consumption	11.599.694	11.283.286	212.553	234.926	188.572	182.290	845.924	868.766	112.524	123.454	3.357.446	3.688.492
Billed Metered Consumption	11.599.694	11.283.286	212.553	234.926	188.572	182.290	845.924	868.766	112.524	123.454	3.357.446	3.688.492
Billed Unmetered Consumption	0	0	0	0	0	0	0	0	0	0	0	0
Unbilled Authorized Consumption	933.220	927.803	2.126	2.349	40	40	6.660	0	0	1.062	37.625	264.678
Unbilled Metered Consumption	933.220	927.803	0	0	35	40	0	0	0	0	36.425	14.678
Unbilled Unmetered Consumption	0	0	2.126	2.349	5	0	6.660	0	0	1.062	1.200	250.000
Revenue Water	11.599.694	11.283.286	212.553	234.926	188.572	182.290	845.924	868.766	112.524	123.454	3.357.446	3.688.492
Water Losses	3.366.445	3.568.518	294.843	272.247	69.646	60.672	478.683	435.414	61.781	87.874	4.398.218	4.446.705
Apparent Losses	1.550.957	1.511.790	26.350	5.095	31.302	50.386	33.290	32.600	4.360	18.560	733.574	59.123
Unauthorized Consumption	158.994	157.796	5.095	5.095	23.949	320	6.660	6.520	870	1.062	700.000	40.588
Meter and Metering Errors	1.391.963	1.353.994	21.255	0	7.353	50.066	26.630	26.080	3.490	17.498	33.574	18.535
Real Losses	1.815.488	2.056.728	268.493	267.152	38.344	10.286	445.393	402.814	57.421	69.314	3.664.644	4.387.582
Non-Revenue Water	4.299.665	4.496.321	296.969	274.596	69.686	60.712	485.343	435.414	61.781	88.936	4.435.843	4.711.383
MCD	3.001.845	3.439.716	-				292.300	336.425	26.334	27.746		
Accounted for NRW	1.297.820	1.056.605	296.969	274.596	69.686	60.712	193.043	98.989	35.447	61.190	4.435.843	

Ex-ante & ex-post WB evaluation

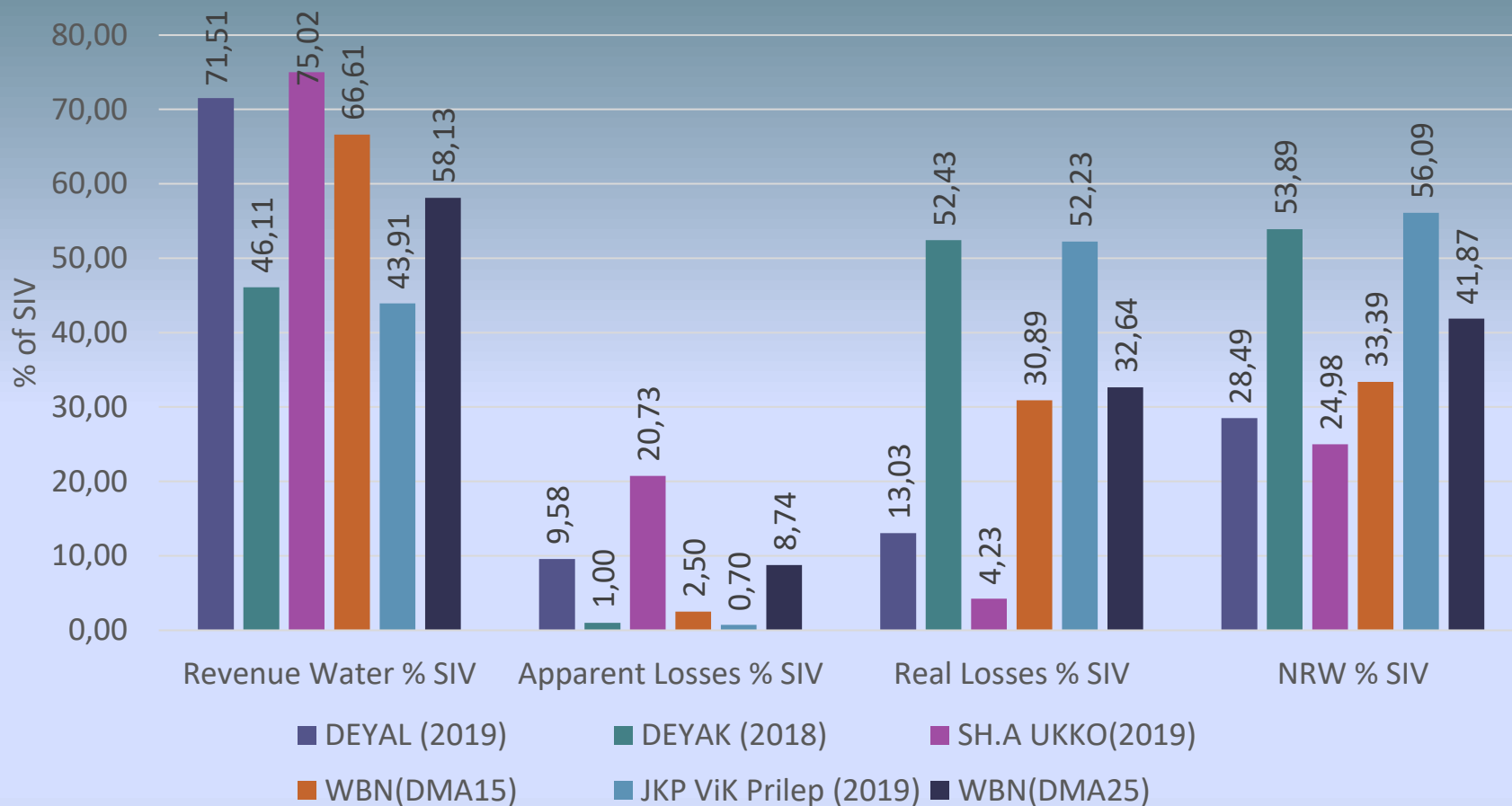
- DEYAL: NRW level in 2017 was 4,299,665m³, representing 27.04% of SIV and in 2019 NRW is 4,496,321m³, representing 28.49% of SIV.
- DEYAK: NRW level in 2017 was 296,969 m³, representing 58.3% of SIV and in 2019 NRW level is 274,596m³ representing 53.89% of SIV.
- Korce UKKO: NRW level in 2017 was 69,686 m³, representing 26.98% of SIV and in 2019 NRW is 60,712 m³, representing 24.98% of SIV.
- WBN DMA 25: the water balance showed that NRW level in 2017 was 61,781 m³ representing 35.44% of SIV, while in 2019 it is 88,936 m³, representing 41.87% of SIV.
- WBN DMA 15: the water balance showed that NRW level in 2017 was 485,343 m³ representing 36.46% of SIV, while in 2019 it is 435,414 m³, representing 33.39% of SIV.
- JPK ViK Prilep: NRW was estimated to be 4,435,843 m³ for 2017, representing 56.92% of the SIV, while in 2019 NRW is 4,711,383 m³, representing 56.09% of the SIV.
- BWA: the water balance could not provide any insights as the pilot action was mainly the training and education of the staff.

Ex-ante & ex-post PIs

Performance Indicators	Units	DEYAL		DEYAK		SH.A UKKO		WBN-DMA 25		WBN-DMA 15		JKP ViK Prilep	
		2017	2019	2017	2019	2017	2019	2017	2019	2017	2019	2017	2019
Inefficiency of use of water resources	%	11.42	13.03	N/A		24.02	4.23	32.94	32.63	33.46	30.89	47.02	52.23
Water losses per connection	m ³ /conn/day	89.77	95.16	1,254.78	1,158	72.17	62.87	87.76	124.82	107.11	97.43	175.56	177.50
Water losses per mains length	m ³ /Km/year	8.56	9.07	83.36	76.97	7.63	6.65	7.87	11.2	15.59	14.18	48.63	51.10
Apparent losses	%	9.75	9.58	5.17	1.00	2.95	20.73	2.50	8.74	2.50	2.50	9.41	0.70
Apparent losses per system input volume	%	9.75	9.58	5.17	1.00	2.95	20.73	2.50	8.74	2.50	2.50	9.41	0.70
Real losses per connection	L/conn/day	132.64	150.26	3,130.55	3,114	176.1	29.20	223.46	269.74	273.05	246.95	400.77	479.83
Real losses per mains length	L/Km/day	4,614	5,227	75,912	75,533	6,797	1,127	7,317	8,832	14,509	13,122	40,523	50,422
Infrastructure Leakage Index (ILI)	-	2.14	2.42	11.6	11.6	16.2	0.3	8.8	10.66	6.26	6.04	10.38	12.51
Unmetered water	%	21.17	22.61	N/A	N/A	26.97	24.97	35.44	41.87	36.46	33.39	56.45	55.91
Non-revenue water by volume	%	27.04	28.49	58.28	53.89	26.98	24.98	35.44	41.87	36.46	33.39	56.92	56.09
Revenue Water as % of SIV	%	72.96	71.51	41.72	46.11	73.02	75.02	64.56	58.13	63.54	66.61	43.08	43.91
Real Losses as % of SIV	%	11.42	13.03	52.70	52.43	24.02	4.23	32.94	32.64	33.46	30.89	47.02	52.23
Real Losses as % of NRW	%	42.22	45.74	90.41	97.29	89.01	16.94	92.94	77.94	91.77	92.51	82.61	93.13
Apparent Losses as % of NRW	%	36.07	9.58	8.87	1.86	10.93	20.73	7.06	20.87	6.86	7.49	16.54	1.25

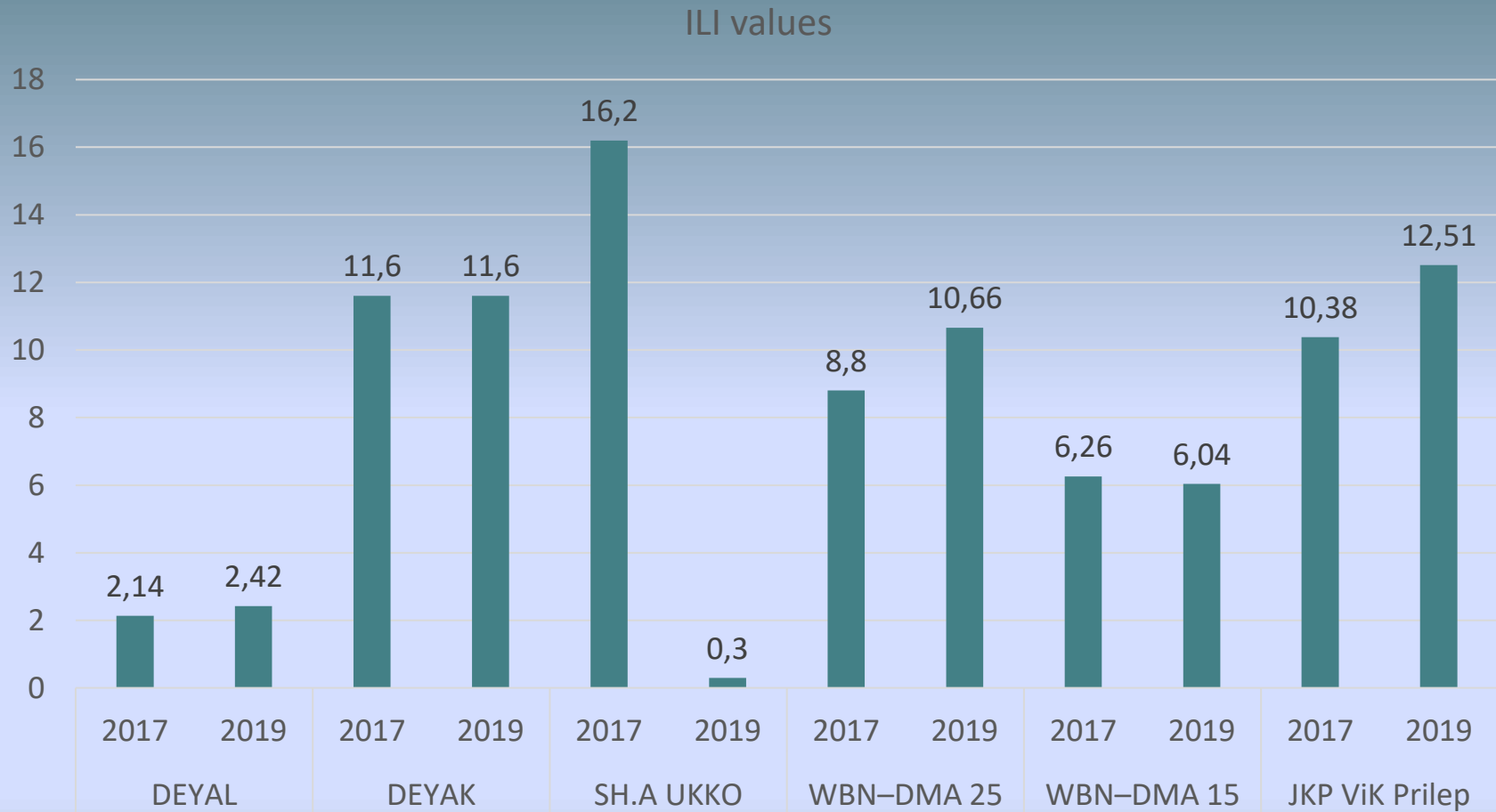
Ex-post – PIs (2019 base year)

Revenue Water, Apparent Losses, Real Losses, NRW



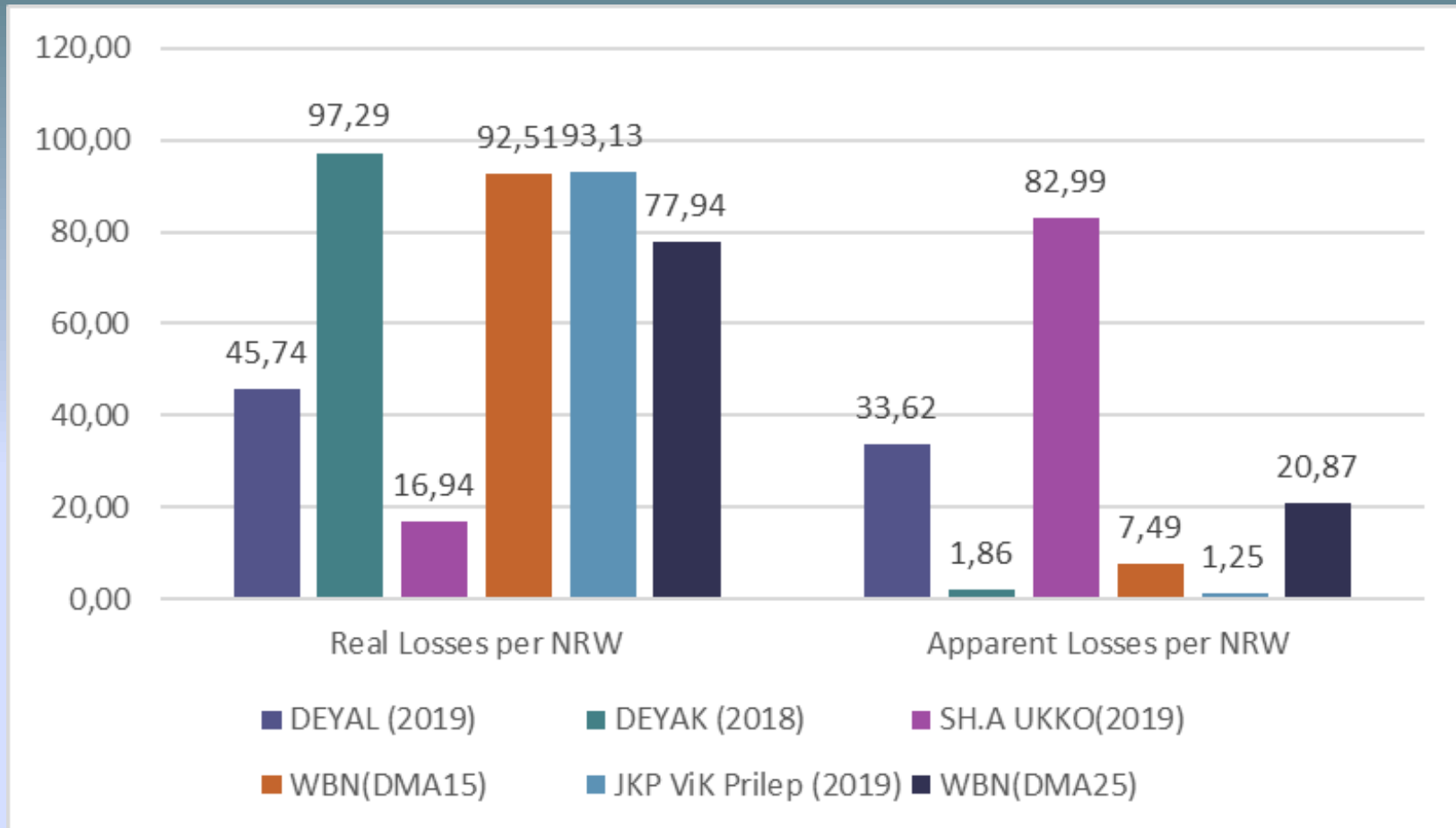
Ex-post – PIs (2019 base year)

ILI



Ex-post – PIs (2019 base year)

Real Losses & Apparent Losses as % of NRW



Ex-post – Results (1/4)

- DEYAL:
 - real losses are the major part of NRW representing 11.50% of SIV or 129.29L/connection/day in 2017 while in 2019 real losses represent 13.03% of SIV or 150.26L/connection/day.
 - Apparent losses represent 9.74% of SIV in 2017 and 9.58% of SIV in 2019.
 - ILLI value for 2017 is 2.14 while for 2019 it is 2.42.
 - DEYAL implemented a pilot action targeting energy recovery, thus the comparison of the water balance and PIs for 2017 and 2019 is not expected to provide any sufficient conclusions regarding the pilot action
- DEYAK:
 - real losses are the major part of NRW representing 52.7% of SIV or 3,130L/connection/day in 2017 while in 2019 real losses are 52.43% of SIV or 3,114L/connection/day.
 - Apparent losses represent 5.17% of SIV in 2017 and 1% of SIV in 2019.
 - ILLI value for 2017 is 11.6, while for 2019 it remains the same.
- Korce UKKO:
 - real losses are the major part of NRW representing 24.12% of SIV or 176.1L/connection/day while in 2019 real losses are 4.23% of SIV or 29.2L/connection/day.
 - Apparent losses represent 2.84% of SIV in 2017 while in 2019 apparent losses are 20.73% of SIV.
 - ILLI value for 2017 is 16.2 while for 2019 it is 0.3.
 - apparent losses were underestimated. The water utility should perform a pilot activity to better estimate water theft and meters under-registration.

Ex ante – Results (2/4)

- WBN – DMA25:
 - real losses are the major part of NRW representing 32.94% of SIV or 223L/connection/day in 2017 while in 2019 real losses are 32.64% of SIV or 269L/connection/day.
 - Apparent losses represent 2.5% of SIV in 2017 and 8.74% in 2019. ILI value for 2017 is 8.8 while in 2019 it is 10.65.
 - estimations for DMA25 are elaborated using the top-down approach for 2017 and the bottom-up one for 2019 → apparent losses and real losses for 2017 are based on assumptions and estimations and cannot be taken as reliable. For 2019, the estimations are reliable. It is important to show the impacts of AMR installation in the case of DMA25.
- WBN – DMA15:
 - real losses are the major part of NRW representing 33.46% of SIV or 273L/connection/day while in 2019 real losses are 30.89% of SIV or 254L/connection/day.
 - Apparent losses represent 2.5% of SIV for both years.
 - ILI value in 2017 is 6.25 while in 2019 is reduced to 6.04

Ex ante – Results (3/4)

- Blagoevgrad (BWA case):
 - real losses represent the major part of NRW, up to 48.45% of SIV or 695.07Lt/connection/day.
 - Apparent losses represent 10.08% of SIV.
 - the pilot action of BWA had a rather training and educational character - during the pilot action BWA trained 6 managers and engineers from the WSS of Blagoevgrad & 20 students were educated regarding leakage detection activities in water distribution networks.
- JKP Vik Prilep:
 - real losses represent the major part of NRW level, up to 47.02% of the SIV or 400.77 L/connection/day in 2017, while in 2019 real losses are 52.23% of SIV or 479.83L/connection/day.
 - Apparent losses account for 9.41% of the SIV in 2017 while in 2019 apparent losses are 0.70% of SIV.
 - ILL value is 10.38 in 2017 while in 2019 it is 12.51.
 - Although real losses are higher in 2019, NRW levels are lower - high real losses are due to inaccurate measurements and assumptions when estimating the WB of 2017.

Ex ante – Results (4/4)

- NRW levels are high for JKP ViK Prilep pilot case (56.09%) followed by DEYAK (53.89%) while Korce has the lowest NRW level (24.98%) in 2019
- Real losses as % of SIV are high for DEYAK (52.43%) followed by JKP ViK Prilep (52.23%) while the lowest values is the one of UKKO (4.23%).
- Real losses as % of NRW are high for DEYAK (97.29%) followed by JKP ViK Prilep (93.13) while the lowest one is from UKKO (16.94%).
- The highest ILI values for 2019 is the one from JKP ViK Prilep (12.51) followed by DEYAK (11.6) and the lowest one is from UKKO (0.3)
- For apparent losses the highest values are the ones from UKKO (20.73% of SIV) followed by DEYAL (9.58) and the lowest one is from JKP ViK Prilep (0.7%).

WP5: Joint Pilot Actions

Real Losses

PP5: Supply of leak detection car and equipment

PP6: PRV in DMA 15

PP6: electronic sensors for monitoring water quality (indirect effects on pipes)

PP7: theoretical and practical education of water leak detection equipment

PP8: GIS software

PP8: leak detection equipment

Apparent Losses

PP3: Installation of 700 AMR

PP6: Installation of 700 AMR

Pilot Actions Results

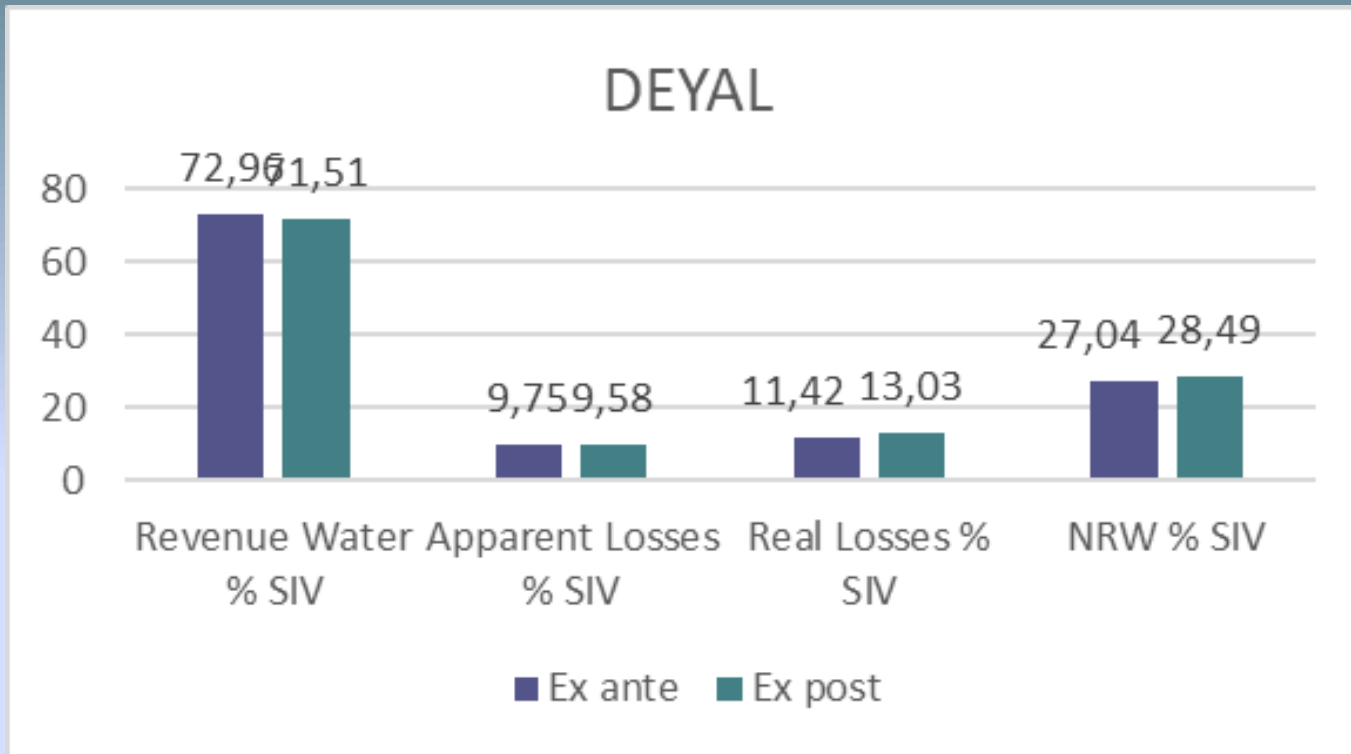
- NRW reduction
- Real losses reduction
- Leak events reduction
- Leaks detection
- Energy cost reduction
- Water production cost reduction
- Apparent losses reduction
- Labour cost reduction
- Recording of water use profiles
- Define areas with high water use
- Maintenance and operation costs minimization
- Continuous supply of information without depending in the maintenance of the power supply
- Underground cadastre
- Improved customer service

Ex-post comparison

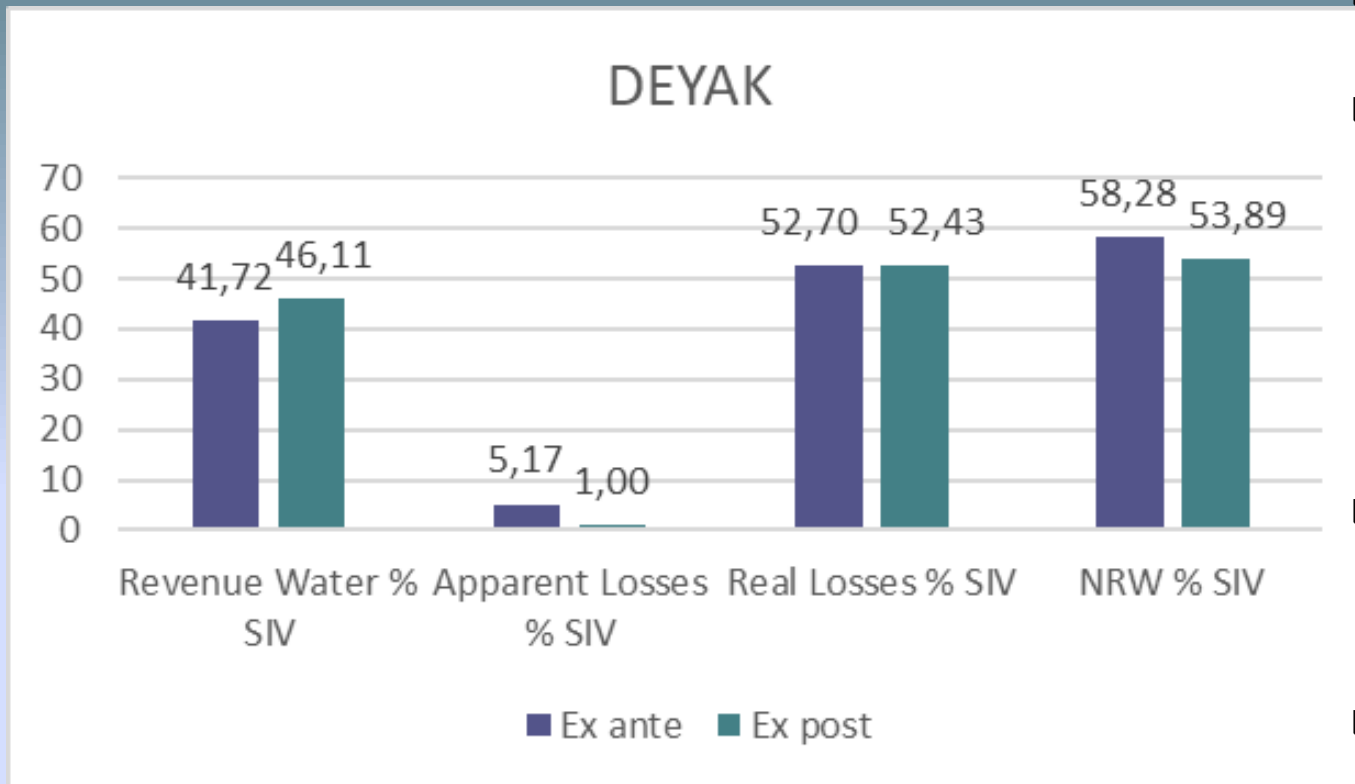
DEYAL pilot case

Pilot Actions Results

- No conclusion drawn as the pilot action is addressed to energy recovery



Ex-post comparison DEYAK pilot case



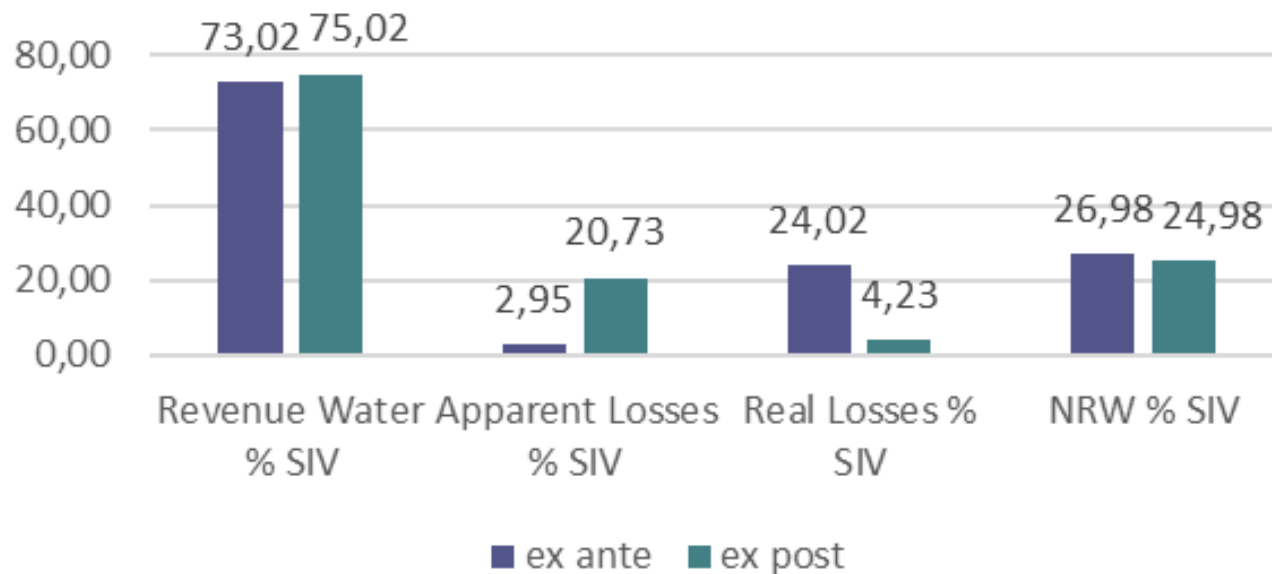
Pilot Actions Results

- ❑ Replacement of 700 water meters with AMRs
- ❑ From the analysis of the 82 AMRs installed in parallel with the existing water meters, it was shown that the deviation in registrations was from - 2.79% to 12.55% depending on the water meter age.
- ❑ Water meters aged 2 years register higher water volumes than the consumed ones (2.79% to 1.34%).
- ❑ Water meters aged 9 years were found to register higher water volumes (2.26%) to under-register (1.88%).
- ❑ Water meters aged more than 15 year under-registered from 12.55% to 15.00%.

Ex-post comparison

UKKO pilot case

SH.A UKKO



Pilot Actions

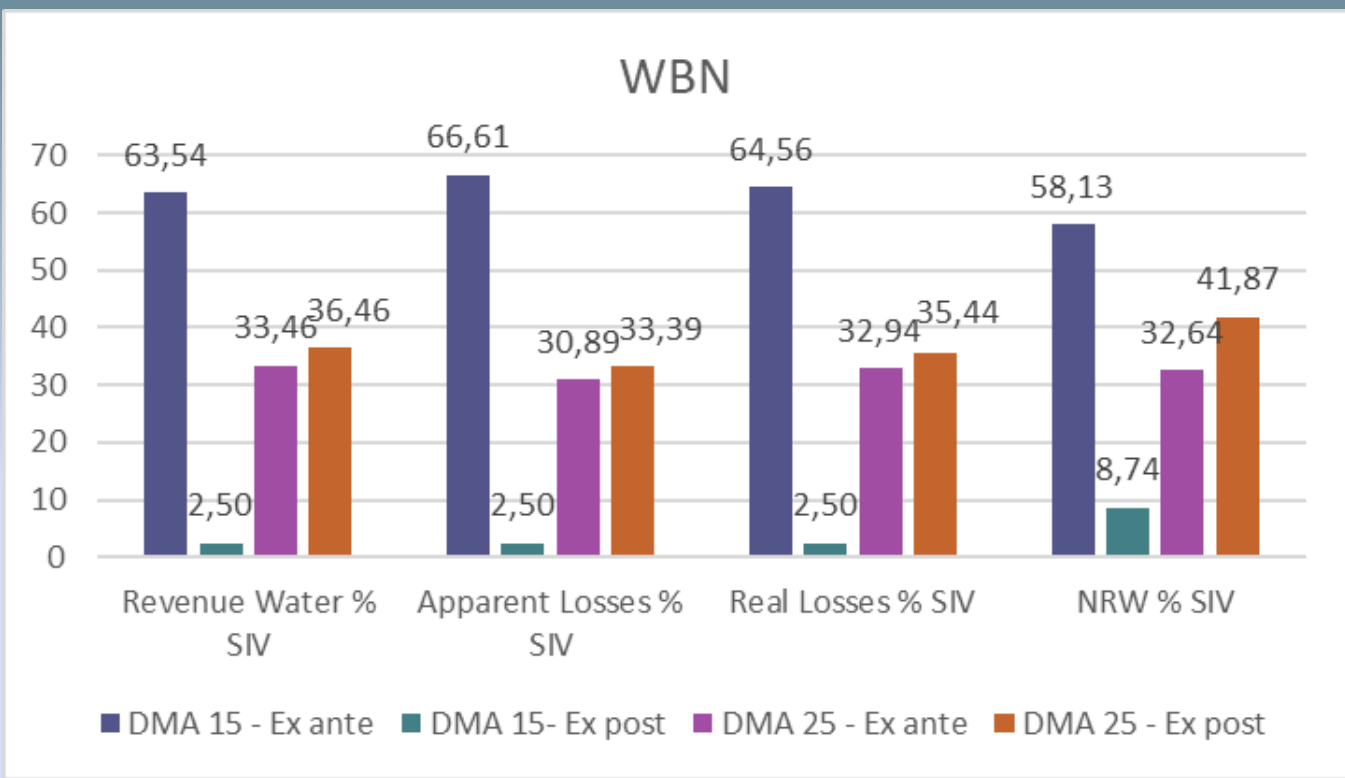
Results

- ❑ there is a significant reduction in real losses but at the same time apparent losses were underestimated.
- ❑ Total water saving in UKKO was 4,866m³ in the 14 months of the pilot action implementation, meaning that the equivalent population that could be supplied with water is 965 people.
- ❑ Additional benefits include the energy savings.

Ex-post comparison

WBN pilot case

Pilot Actions Results

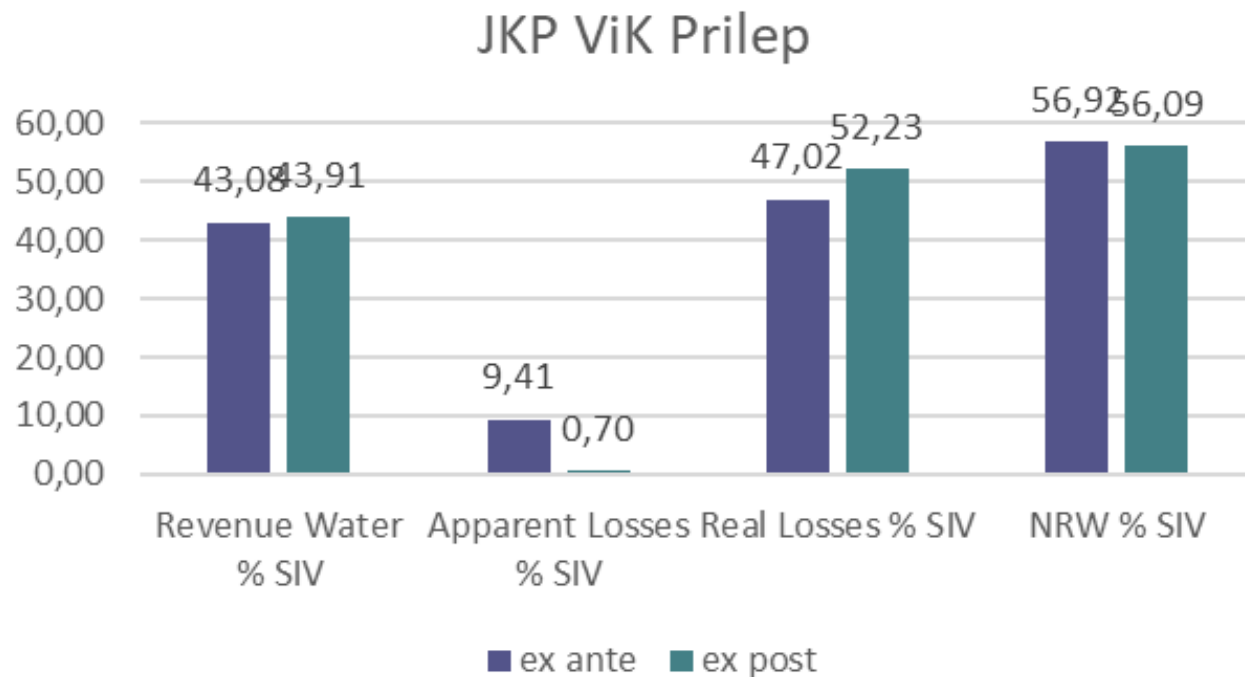


- ❑ In DMA 25 700 AMRs are installed → although the results gathered are not representative, revenue water is increased
- ❑ In DMA 15, a PRV is installed to reduce pressure → real losses are reduced radically (from 64.56% of SIV to 2.5%) and NRW is also reduced

Ex-post comparison

JKP ViK Prilep pilot case

Pilot Actions Results



- hidden leaks are detected by using the equipment, improving at the same time the customer service.
- The time to repair failures is reduced to 30%.
- NRW level is reduced from 56.92% in 2017 to 56.09% in 2019
- The water utility detected 58 leaks out of which 38 leaks on private connections and 20 leaks found in water supply network.

Ex-post comparison

BWA pilot case

Pilot Actions Results

- ❑ the results obtained from the pilot action is increased awareness of local population, as well as the specialists working in WSS Operator of Blagoevgrad that could lead to future improvement of the situation.
- ❑ As non-governmental organization BWA pilot activities were aimed at knowledge and good practices dissemination.
- ❑ There may not be water saving achieved by the current pilot actions, but it is expected that the general activities carried out will help with the improvement of water sector in Bulgaria regarding water usage management, water loss reduction and subsequently on last place to increase the energy efficiency.

WATenERgy CYCLE

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

WP5 Joint Pilot Actions

Joint Del. 5.2 Ex-Post Water efficiency evaluation



PP3 - Municipal Enterprise for Water Supply and Sewerage of
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