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Xylem makes case for wastewater climate-friendly investment

Water technology company Xylem has released a report identifying a huge potential to cut greenhouse gas emissions associated with electricity use in wastewater treatment by applying currently available equipment in investments that are either cost-neutral or bring overall cost savings.

The report, based on a study by Vivid Economics, looked at the USA, Europe and China and investigated the application of 18 distinct electricity-related emissions abatement opportunities in wastewater management. According to the study, nearly half of the electricity-related emissions in wastewater management can be abated at a negative or neutral cost.

The study found that almost half of the electricity-related emissions could be abated with existing technologies, and that for 95% of this abatement the savings from energy efficiency would exceed the spending on the abatement measures. A smaller proportion of emissions could be tackled in the USA on this basis compared to Europe, because of lower electricity costs in the USA. China offers the greatest potential because of the opportunity to install complete new systems. The report claims that nearly 100% of the abatement opportunities examined would be at zero or negative cost, and it put the total abatement potential there at nearly 13 million metric tons of carbon dioxide equivalents annually.

Extrapolating the findings of the study globally, the report suggests that the potential global volume of negative cost abatement is nearly 44 million metric tons of carbon dioxide equivalents a year.

The report argues that the primary barriers to adoption are awareness of the opportunity and willingness to adopt existing solutions that have a higher initial capital cost and a lower ongoing operating cost. 'What's missing is the enabling framework to incentivize investment and accelerate widespread adoption of these advanced, sustainable solutions,' says Patrick Decker, President and CEO of Xylem in the foreword to the report.

The opportunities assessed in the study covered use of high efficiency pumping, variable speed pumping, variable speed blowers, high efficiency mixing, optimised control systems, and improved biogas production in wastewater transport, secondary treatment, and / or sludge treatment, use of efficient air scour blowers and filter system controls in tertiary treatment, as well as optimised new plant for secondary, tertiary, and aerobic and anaerobic sludge treatment.

According to the report, more than $25 billion in net savings can be generated with the adoption of high efficiency wastewater technologies in China alone. With the addition of the United States and Europe, the savings become greater than $40 billion, it claims.

Xylem says that two levers identified in the report would accelerate adoption of such highly efficient wastewater technologies: new financing models that incentivize investments in low-carbon technologies, which would assist with the initial higher capital costs that often come with these advanced technologies; and increasing the energy efficiency standards of wastewater equipment, which would ensure broader adoption.

> ***'What's missing is the enabling framework to incentivize investment and accelerate widespread adoption of these advanced, sustainable solutions.'***
> **Patrick Decker, President and CEO, Xylem**

The report concludes: 'Now is the time for the industry and all stakeholders in the climate change agenda to work together to overcome these barriers to adopting high efficiency wastewater treatment technologies, which will result in greater productivity of wastewater operations, and a meaningful step forward in tackling climate change.'

Xylem's Decker added: 'Infrastructure investments today can have positive environmental and economic consequences for decades. Importantly, the pragmatic solutions identified in this report pay for themselves and, in many cases, unlock new capital that can be invested in additional infrastructure improvements. As we address the effects of a growing global population and its accompanying strain on natural resources, the public and private sectors must come together to identify and implement new ways to realize the full potential of a low-carbon economy.'

To download the report, Powering the wastewater renaissance: energy efficiency and emissions reduction in wastewater treatment, visit: http://poweringwastewater.xyleminc.com/ ●

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Singapore PUB awards desal and ceramic contracts

Singapore's water agency PUB has selected HSL Constructor Pte Ltd as the contractor for the construction of the country's third desalination plant. The plant, sited at Tuas and to be owned and operated by PUB, is expected to commence operations in 2017 and will add another 30 million gallons (136,000m³) of water per day (MGD) to Singapore's water supply.

The open tender attracted bids from eight companies. At a tender price of S$217 million ($154 million), HSL Constructor Pte Ltd offered the most competitive price for the design and construction of the plant, according to PUB.

Currently, Singapore has two desalination plants, the 30MGD SingSpring desalination plant, and the 70MGD Tuaspring Desalination Plant. PUB has also awarded a consultancy services tender for a fourth desalination plant, which will be built at Marina East.

Desalinated water currently meets 25% of Singapore's water demand. With water demand expected to increase, PUB says that it intends to increase desalinated water capacity in order to continue to meet 25% of future water demand in 2060.

PUB also recently announced that its Choa Chu Kang Water Works is becoming the first in the country to use ceramic membranes thanks to upgrading works taking place in the latter part of the year.

PUB is collaborating with PWN Technologies to use its CeraMac system, with membranes supplied by Japan's Metawater. The new CeraMac plant at CCKWW is due to be operational in 2018 and will have a daily capacity 40 MGD, making it one of the largest ceramic membrane plants for drinking water treatment in the world. ●

New French public-private model

Suez and the French town of Dole have announced that they have entered into a new type of public-private model as part of the provision of water and sanitation services for the town.

France's first two semi-public companies with a single purpose have been created, one each for water and wastewater, alongside the award of Euro67 million contracts to Suez for the delivery of water and sanitation services.

The two companies - Doléa Eau and Doléa Assainissement – are known as 'SemOps', based on the French Société d'Economie Mixte à Opération Unique. These start their activity on 1 January 2016 with the purpose serving the 25,000 residents of Dole with water and sanitation services respectively.

The town owns 49% of the capital of the companies, Suez 51%, while the Board is chaired by the town's mayor and the company CEO is a Suez employee. Both parties each have three members on the SemOp board.

Not only are SemOp undertakings created for a specific purpose, they are also fixed term – 13 years in the case of Dole. According to Suez, these new arrangements open the way for a new mode of shared management combining a local authority and a private operator, selected through a tender procedure. The set-up means the local authority is involved in each decision concerning the SemOp and has an equal vote with the operator on the actions to implement. ●

Inauguration of energy-efficient desal

An energy-efficient pilot desalination plant to be powerd by renewable energy has been opened in Abu Dhabi, following the award of a contract to Suez by the Masdar Institute of Science and Technology in the middle of last year.

The project based in Ghantoot, 90 kilometres northwest of Abu Dhabi, covers the design, engineering, procurement, construction, commissioning, operation, maintenance and evaluation of the pilot plant over a period of 18 months.

Suez has reported that it had successfully passed water production and water quality tests, in terms of performance and compliance with Masdar's requirements. The plant reaches the potable water production of 100m³ per day with an electrical energy consumption of less than 3.6 kWh/m³, which Suez says means it therefore offers greater energy-efficiency than the current state-of-the-art desalination systems.

For the project, Suez has brought together some of its most advanced and innovative technological desalination partners to achieve the sustainability objectives, including Dow Water and Process Solutions, with its advanced and innovative ultrafiltration and reverse osmosis membrane technologies, Adionics, with its innovative liquid/liquid deionisation technology.

In parallel, together with the Masdar Institute of Science and Technology and ENGIE's Laborelec, Suez is conducting studies on seawater desalination using solar power, in order to develop seawater desalination plants fully powered by renewable energy. The main final target is to apply those renewable energy technologies on large scale desalination plant.

'Suez is proud to play an active role in the Masdar Seawater Desalination Programme and to contribute to Masdar's ambitious initiatives for renewable energy,' said Jean-Louis Chaussade, CEO of Suez. 'Within this project, Suez's objective is to identify new desalination technologies that will address sustainable access to water, both in the arid region and throughout the world. By doing so, Suez demonstrates its commitment to identify and develop global solutions for the sustainable management of resources, a key issue, especially in the region.' ●

Practical application of Acoustic Propagation Velocity Measurement (APVM) for condition assessment of drinking water mains

The drinking water networks in the Netherlands are, with an estimated average age of 45 years, relatively young. However, as the networks age over the coming decades, water companies will face increasing demands for investment in pipeline replacement. To know which mains should be replaced when, information is required about the residual life of these mains. To know this, the current condition has to be assessed. Several methods are available for condition assessment and recently the Acoustic Propagation Velocity Measurement (APVM) method was introduced in the Netherlands. R. Beuken, K. Laven, P. Horst, R. Diemel and G. Mesman describe the theory behind the APVM method, field tests conducted in the Netherlands, and the results of a validation exercise on an asbestos cement main. The field tests showed that the method is applicable to drinking water networks in the Netherlands. The validation exercise found that the APVM method provides results similar to other assessment methods requiring insertion of systems into the main or samples to be removed from the main. It was also found that a prerequisite for trustworthy results is the availability of reliable data on the properties of the mains, in particular the initial wall thickness and the Young's modulus of the pipe material.

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The total length of the drinking water distribution network in the Netherlands is approximately 117,000km. The total replacement value is estimated at €20,000 to 30,000 million ($21,232 to $31,848 million). The Netherlands has a high standard of supply of drinking water. Water is supplied without free chlorine, water loss levels are estimated at 5% (Geudens, 2012) and the average burst rate is estimated at 0.053 bursts/km/year (Vreeburg et al., 2013). The distribution network has a wide variety of pipe materials and ages, including some pipelines near or beyond the end of their design lives. If the water companies desire to maintain the condition of the network and these standards of supply, a considerable length of mains must be replaced in the coming decades. A key question many of these water companies are facing is: which mains should be replaced when?

The National Research Council of Canada developed and patented the Acoustic Propagation Velocity Measurement (APVM) method as part of a long-term research program into the propagation of sound waves in water pipelines (Hunaidi, 2006). Offered under the name ePulse™ by the company Echologics, the APVM method claims to measure the condition of metallic or asbestos cement water mains, averaged over test intervals of approximately 100 meters. The measurements are conducted from street level while the network remains in normal operation. The fact that minimal enabling works are required allows the testing to occur at low cost compared to pipeline inspection methods requiring internal access or the extraction of samples. The APVM method was introduced recently in the Netherlands. Within the Joined Research Program that KWR Watercycle Research Institute (KWR) conducts for the water companies in the Netherlands, the practical application of the APVM method was investigated with an aim of evaluating its accuracy and total costs, as well as the decision-making power of the information provided.

Condition assessment with APVM: theory

The APVM method involves measuring the behaviour of sound in a pipeline, and using this together with the material properties and geometry

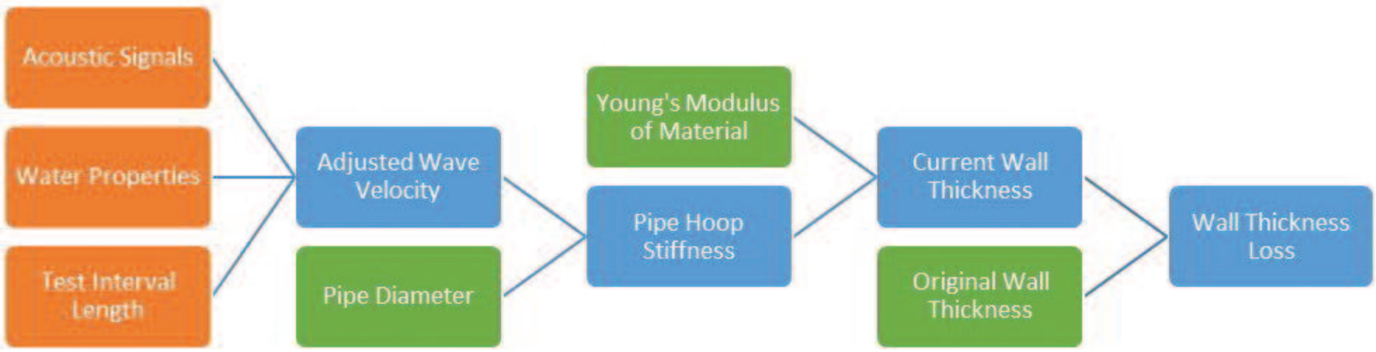


Figure 1
The sequence of inputs (green), measurement (orange) and computations (blue), from left to right

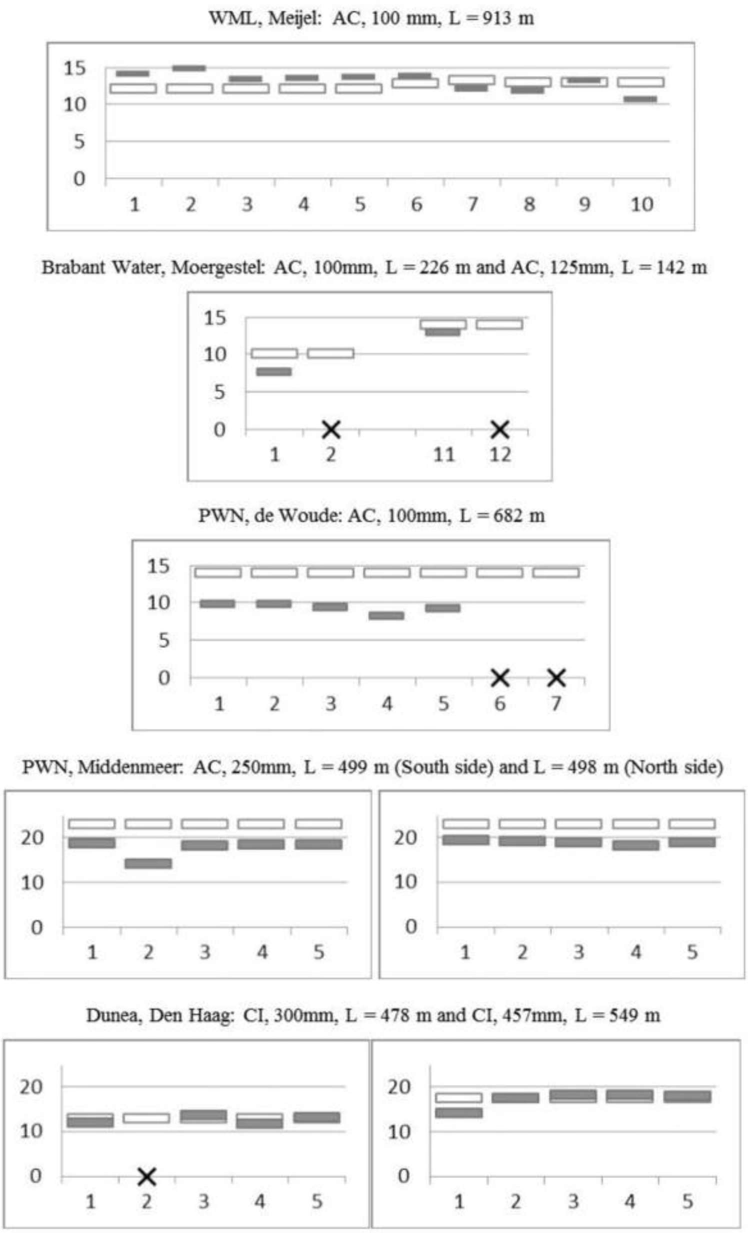


Figure 2
Results of 41 measurements with APVM. The x-axis shows the test interval number, with each test interval representing approximately 100m of pipe length. The y-axis represents wall thickness, with the original nominal wall thickness indicated with hollow boxes and the APVM measured wall thickness indicated with filled boxes. The X's indicate that no valid measurement was obtained

of the pipeline to calculate the current average wall thickness. The measurements are taken without inserting sensors into the pipeline or excavating the pipeline for direct physical testing of the pipe wall.

Measurements are taken of the average wall thickness over test intervals, with each comprising a 50m to 200m length of continuous main. Acoustic sensors are attached to the outside of the main at either end of the test interval. Once the sensors are attached, sound is introduced into the main from a point outside the test interval, and it is measured by the acoustic sensors.

The sound waves used for the APVM method travel through the water, however their propagation velocity is affected by the pipe wall. In an open body of water, sound propagates away from its source in spherical pressure waves, which propagate at approximately 1450m/s. When sound is introduced into a pipeline, the propagation becomes more complex as interaction with the pipe wall occurs. The pipe wall reflects the sound waves back into the water, and also vibrates in several different ways (axially, radially, and longitudinally).

One particular type of vibration known as the water hammer mode allows assessment of the pipe wall. This is the water-borne pressure wave, which causes the pipe to expand and contract symmetrically in the hoop direction. The sound volumes used by the APVM method correspond to pressure variations of less than 0.001 Bar, so this movement of the pipe wall occurs at a microscopic level. At one particular frequency of sound, the natural vibration rate (the ring frequency) of the pipe will match the frequency of the sound in the water, resulting in a combined vibration mode that loses very little energy as it propagates down the main. The speed at which this particular frequency propagates through the water body is controlled by the hoop stiffness of the pipe. The hoop stiffness is defined as the ratio of force (as applied to the pipe wall by water pressure) to displacement (expansion or contraction in the hoop direction). A very stiff pipe will resist this flexing, causing the sound waves inside the pipe to propagate close to the speed of sound in an open body of water. A less stiff pipe will flex more easily, slowing down the speed at which these sound waves propagate.

In certain pipe materials (asbestos cement, cast iron, ductile iron, and steel) there is a known and consistent relationship between the pipe's hoop stiffness and the wall thickness. By measuring the hoop stiffness using the APVM method, the wall thickness can thus be calculated. Laboratory testing during the development of the APVM method showed that the hoop stiffness of a degraded main is controlled primarily by the wall thickness at the thinnest point around the circumference of the main (Hunaidi, 2006). The intuitive basis for this is that the circumference will expand primarily at the weakest (thinnest) point. Thus the results of testing with the APVM method will reflect the thickness at the thinnest point around the circumference of the main. The thinnest point around the circumference is also the likely failure point of the main, making these results appropriate for estimation of future main break rates.

The basic acoustic mechanism behind the APVM method was developed jointly by the National Research Council of Canada and Echologics Engineering (Hunaidi, 2006). Initial field tests of the method were conducted between 2005 and 2008. During these tests, several additional parameters were discovered to be factors in the equation* relating the velocity of sound in the mains to the wall thickness. Primary among these parameters was the Young's Modulus of elasticity of the pipe material itself. While standard values of the Young's Modulus were available for common pipe materials such as cast iron, ductile iron, steel, and asbestos cement, there proved to be substantial variation between pipes of the same material. While standard accepted values of the Young's Modulus were available for most pipeline materials, testing samples of the pipe material using the method specified by ASTM C2015 yielded different values. It was found that the Young's Modulus of samples of cast iron from water mains could be reliably predicted by its installation date. Samples of asbestos cement taken from water mains were found to have a Young's Modulus that varied from the design specifications,

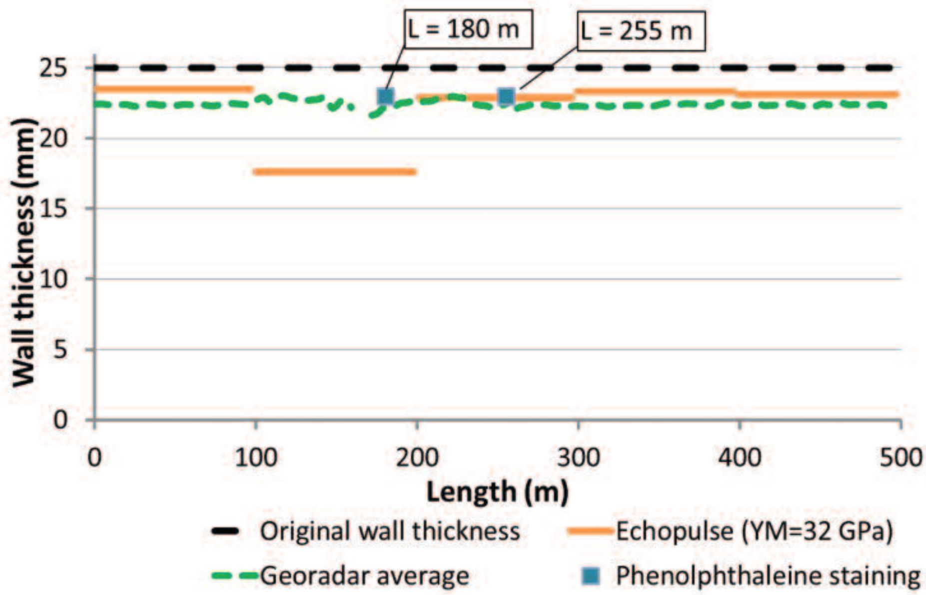


Figure 3
Results of measurements of the effective wall thickness in Middenmeer, South side. The x-axis shows the distance in meters from the starting point of the testing. The y-axis shows the original wall thickness and the measurements obtained by the three test methods indicated

although the values obtained from these field tests were fairly consistent throughout all samples taken from North America.

The current wall thickness measurement provided by APVM represents only the portion of the pipe wall that contributes strength to the pipe and allows it to resist flexing under internal pressure. This is referred to as the ‘effective wall thickness’. For asbestos cement pipes, this represents the portion of the pipe wall unaffected by calcium leaching and still providing structural strength. For cast and ductile iron pipes, this represents the portion of the pipe wall unaffected by corrosion. The results tend to match up best with the thinnest point around the circumference of the pipe, averaged over the test interval.

It should be noted that the APVM method provides only the average wall thickness over each test interval. The method cannot locate individual defects within the test areas. It is therefore usable as a decision-making tool for selecting and prioritizing mains for replacement or rehabilitation, and as a pre-screening tool to select mains for further investigation, but cannot be used to identify the locations of individual corrosion pits for repair. The method does, however, involve a leak detection test during the field measurements, so through-wall defects that are losing water are detected.

Condition assessment with APVM: measurements

One feature of APVM testing is the non-disruptive nature of the field measurements. The method examines the propagation of sound in the main, which can be both induced and measured from the outside. Acoustic sensors (accelerometers, hydrophones, or geophones) are placed at two access points along the pipeline, generally about 100m apart, but with distances between 50m and 200m technically feasible.

When possible, existing fittings such as valves or fire hydrants are used for connection points, with sensors placed in contact with the outside of the fittings. Where no existing fittings are available, small excavations can be made to reach the top of the main to allow testing. While vacuum excavated holes of 100mm to 300mm diameter have most often been used, a new technique has recently been developed which allows even smaller holes (25 to 50mm diameter) to be used. A core is first drilled out of the roadway or concrete (if required), and then a water drill is used to bore a hole to the top of the main. A steel rod is then pushed down to the top of the main and used to conduct sound from the main to the surface. Sensors are placed on the top of the steel rods. This new approach has substantially reduced the cost associated with preparing access points for APVM testing where no fittings are available.

Sound is introduced into the main from a third access point outside the test interval. This can be done by flowing water out of a fire hydrant or by gently tapping on the fitting. The sound is measured as it passes by each sensor location, and a comparison of the signals is made. The sequence of measurement and computation is as shown in Figure 1. There are a number of inputs required to perform the calculation of the wall thickness. Acoustic signals, water properties, and pipe length are all measured in the field during testing. The pipe diameter and the wave velocity (adjusted for the water properties) must be known in order to complete the pipe hoop stiffness calculation. The pipe's hoop stiffness and the Young's Modulus of the material are used to calculate the current wall thickness of the pipe. Calibration factors obtained empirically from previous tests are applied at this stage to account for bell-and-spigot joints and the presence of internal linings. This calculated current wall thickness is given as an average value over each test interval. This can, in turn, be compared to the original wall thickness (either as indicated in pipe catalogues or from direct measurements if available) to compute the percentage of loss of wall thickness. Results of testing are a table comparing original wall thickness to current wall thickness, and showing the percentage of loss.

Field trials with APVM in the Netherlands

In 2012 several water companies in the Netherlands performed field tests of the APVM method. The results from five asbestos cement mains and two cast iron mains are presented in Figure 2. Based on these tests the following observations are made:

- Water companies consider the measurements with the APVM method as easy to execute. Good results were obtained when sound was induced in the pipe by tapping on the pipe with a rod.
- Of the measurements attempted, 88% were successful in obtaining a wall thickness measurement. In Figure 2, in five cases no value for the measured wall thickness was obtained (this is indicated with an X). These appeared to be caused by a PVC repair pipe several metres long.
- In 12 of 41 cases (seven at asbestos cement mains and five at cast iron mains) the calculated wall thickness was greater than the nominal original wall thickness. Several explanations are possible:
    - Variations of the Young's Modulus of the material. For asbestos cement it is plausible that the material used in pipe manufacture was not perfectly homogeneous, and that as long as all pipes exceeded the design requirement a certain amount of variation was accepted. The Young's modulus as published in the catalogue (Eternit, 1980) is 25GPa. Echologics has conducted several lab tests to measure the Young's modulus of older asbestos cement mains and obtained results of approximately 38GPa. Two recently tested asbestos cement mains from the Netherlands resulted in a Young' s Modulus of 32GPa.
    - Variations in the original wall thickness. The wall thickness specified in the catalogue is a

minimum required value. In practice the wall thickness can be higher and pipe size tolerances to 2mm are common.
  - Random measurement error. The accuracy of APVM testing is advertised as +/- 10%, so a result of 5% above the original nominal wall thickness on a pipe that is in close to pristine condition is within the margin of error.
  - Incorrect parameters used in the calculation. In the case of the first dataset illustrated in Figure 2, excavation of the main in 2014 revealed that the original wall thickness was in fact 15mm, not the 12mm indicated in the records. The current wall thicknesses reported APVM measurements were in fact less than the original wall thickness on these seven measurements.
- A daily productivity rate of approximately one kilometre of main was achieved.

Validation of APVM at PWN

To test the reliability of the APVM measurements a validation was carried out by PWN. At the Middenmeer - South side location (see Figure 2), additional measurements were performed in December 2012. In-line radar inspection was carried out by MJ Oomen Radartechnologie, and two phenolphthalein tests were performed by PWN. For more information on radar inspection, see Slaats et al. (2004) and Smolders et al. (2009). The results are shown in Figure 3.

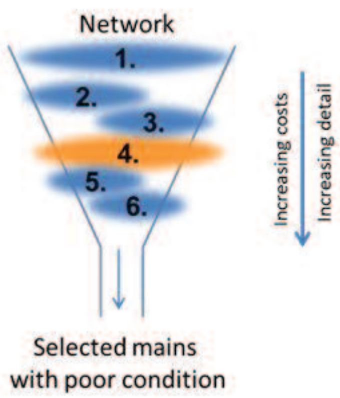
According to the catalogue, the original nominal wall thickness of the main was 23mm. Samples of the pipe wall were extracted for phenolphthalein tests at two locations. The full wall thickness was measured at these sites to be 24.9mm at location 1 (length = 180m) and 25.4mm at location 2 (length = 255m). Based on these measurements, it is assumed that the actual original wall thickness was 25mm.

- Four of the five APVM wall thickness measurements yielded values from 22.9 to 23.5mm (the orange lines). The second measurement has an aberrant result of 17.6mm. Based on the lab tests mentioned previously, a Young's modulus of 32GPa was applied for the calculation of the effective wall thickness.
- The in-line georadar measurement requires access to the main's interior. For this purpose, at the centre (length = 260m) a pipe was taken out. A successful inspection was done between 260 and 500m. Measuring towards the other side resulted in problems, as the main seemed to be too narrow (length = 165m). This turned out to be a non-registered PVC repair pipe, which also explains the aberrant result of 17.6mm with APVM. In order to be able to measure the entire main, a second access point was created at the beginning of the line (length = 0m). The measurement with radar consists of three longitudinal measurements (clock position: 10, 12 and 2) every 20mm. In Figure 3, the average value of the three measurements is displayed (the green dashed line). The measurements show an effective wall thickness ranging from 20.8mm to 23.5mm. The average wall thickness equals 22.4mm.
- Both phenolphthalein tests indicate an effective wall thickness of 23mm.
- Apart from the part with the non-registered PVC repair pipe, the results from measurements with APVM show comparable values for the effective wall thickness with radar and phenolphthalein.

A second but less extensive validation of APVM has been performed at the Brabant Water water company. This validation also showed that the APVM measurements matched the results of phenolphthalein dye testing to within the claimed +/- 10% margin of error for APVM measurements. For more information, see Beuken et al. (2014).

Figure 4
Different methods for condition assessment of mains

Type of assessment:	
Qualitative	1. Expert judgment
Coarse	2. Failure registration
	3. Exit assessment
Intermediate	4. APVM
Detailed	5. Destructive testing
	6. In-line inspection



Business case for the application of the APVM method

Application of condition assessment is cost-effective if the financial benefits from improved decision-making based on the information provided exceed the costs of the inspections. In Appendix 1 an example of a business case is given. The current costs of application of APVM are approximately €15/m ($16/m). It is expected that after further commercialisation in Europe, this price will decrease to approximately €8/m ($8.5/m). Based on the expected price of €8/m and the example presented in Appendix 1, the application of APVM is cost-effective.

APVM related to other methods for condition assessment

To assess the condition of drinking water mains a number of methods are available. For an extensive overview of condition assessment techniques, see Liu et al. (2012). The listing below shows the methods that have been employed to date by water companies in the Netherlands:

- Expert judgment, based on local experiences of fitters and engineers. Important considerations are the objectivity of the provided information and documentation. The information is typically general and non-specific for the network as a whole and often biased on some, mostly the most problematic, mains. Total costs are typically below €1/m ($1.06/m).
- Analysis of mains failures. Eight water companies in the Netherlands provide data to the national burst registration database (USTORE). Information is obtained on which mains materials, diameters, vintages and soil types have the most negative impact on the performance of supply. For more information, see Kwakkel et al. (2013) and Vreeburg et al, (2013). Total costs are typically below €1/m ($1.06/m).
- APVM as discussed here, providing a general indication of the condition of metal and asbestos cement mains. Total costs are in the order of €10/m ($10.6/m).
- In-line inspection, providing a detailed picture of the condition of the main. Several techniques are available for the inspection of metal and asbestos cement mains larger than 200mm. Total costs are on the order of €50/m ($53.1/m). Other relevant aspects are the interruption of supply and the possible impact on the water quality.
- Destructive testing, providing a reliable result, however only of a limited part of the main (that is, the sample). These tests are referred to as

destructive since pipe material is removed. For this purpose, the most common tests in the Netherlands are for PVC (microscopic analyses, gelation and resistance towards slow crack growth), for asbestos cement (phenolphthalein) and cast iron (sandblasting to remove corrosion and testing of tensile strength). Proactive destructive testing costs in the order of €1000/test ($1061/test). Destructive inspection is also applied on pipe material, especially on asbestos cement and cast iron, which becomes available at repair or replacement. These assessments, in the Netherlands referred to as exit assessments, are a lower cost source of information on the condition of specific mains.

- Figure 4 illustrates a concept for using these different methods together to make replacement decisions. The categories of methods for condition assessment are ordered by increasing costs and detail of assessment. A first definition of cohorts of pipe is made based on pipe information systems and the combined experience of experts. Next, a coarse assessment of the expected condition of pipe from each cohort can be made based on the burst frequency (through tracking burst events) and the deterioration (by tracking the observed condition of any pipe extracted from the ground, known as exit assessments). A further assessment of the decreased wall thickness of asbestos cement and cast iron mains is possible with APVM. In many cases this will be sufficient to underpin replacement decisions. If more specific information is required, for example for trunk mains or mains in high risk areas, a more detailed assessment can be performed applying (preferably) in-line inspection or if no other solution is viable by applying destructive testing.

Conclusion

If water companies want to maintain the actual performance of a continuity of supply of drinking water, they will face increasing investments in the coming decades. More, and more detailed, information about the condition of mains is a requirement for answering the question: which mains should be replaced when? Research at KWR conducted for water companies in the Netherlands has shown that the recently introduced APVM method is a good complement to existing methods for condition assessment. Field tests show that the method is applicable to water mains, and a validation indicates that the measurements are accurate to within +/- 10% for asbestos cement mains. A prerequisite for reliable results is the availability of reliable data on the properties of the mains (especially on the original wall thickness and the Young's modulus) and on the presence of repair pipes. Field tests have shown that the actual original wall thickness of asbestos cement mains is often greater than indicated in the GIS and pipe design documents. Deployment of the APVM method seems cost effective, especially if further market introduction results in reduced costs of inspection. ●

Appendix 1 - Business Case: inspection of a 100mm asbestos cement main

Assumptions :

- Replacement costs in urban area: € 150/m ($159.2/m)
- If the inspection has a positive result (good condition), postponement of replacement for 20 years
- Inspection costs: € 8/m ($8.5/m)
- Estimated inspection results (to be checked afterwards):
  - Positive: probability of 45% of a positive inspection result and a main in good condition.
  - False positive: probability of 5% of a positive inspection result and a main in bad condition.
  - False negative: probability of 5% of a negative inspection result and a main in good condition.
  - Negative: probability of 45% of a negative inspection result and a main in bad condition.

Applying a net interest of 3%, the discounted costs of replacement in 20 years are €83/m ($88.1/m). In case of a false positive result it is assumed that the main will be replaced in10 years, with discounted costs of € 112/m ($119/m), although an additional penalty of € 50/m ($53/m) is given.

Business case inspection APVM, costs are discounted.
Please note that 41 is calculated as: 45% * (8 + 0 + 83)

Inspection	Condition	Probability	Costs of inspection	Costs current replacement	Costs future replacement	Result
Positive	Good	45%	€ 8/m		€ 83/m	€41/m
Positive	Bad	5%	€ 8/m		€ 162/m	€ 9/m
Negative	Good	5%	€ 8/m	€ 150/m		€ 8/m
Negative	Bad	45%	€ 8/m	€ 150/m		€ 71/m
		100%				€ 129/m

In this example the total calculated costs equal €129/m. This is lower than the current cost of replacement (€150/m). In this example, performing inspection with APVM is cost-effective.

It is noted that the values applied in these assumptions should be checked by evaluating inspection results in the field. In this calculation the financial effect of avoided bursts due to the installation of new mains is not taken into account. In general in the Netherlands these costs are very low.

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Footnote

* As this relationship is regarded by Echologics as a trade secret, it cannot be published.

Commercial water losses in Bulgaria – reasons, impact, and ways to improve the situation

Bulgaria faces major challenges in identifying and rectifying issues with commercial water losses. Ivaylo Kastchiev looks at the key factors contributing to the country's significant water loss issues.

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According to the International Water Association (IWA) 'best practice' standard water balance (Lambert, 2003), the system input volume includes authorised consumption (billed and unbilled consumption) and water losses (apparent and real losses). Apparent losses include unauthorised consumption and customer metering inaccuracies.

A practical approach towards apparent water loss control was suggested by IWA (Rizzo et al., 2004), suggesting that the four drivers to manage apparent losses include unauthorised consumption, meter accuracy errors, data transfer errors between meter and billing system, and data analysis between archived data and data used for billing/water balance. The methodology is presented in Figure 1.

More detailed information about apparent (commercial) losses was presented by Farley & Trow (2003), who stated that these losses include water that is consumed but not paid for by the user due to inaccurate recording. Commercial losses are not visible, which leads to the fact that many utilities overlook them and concentrate on leaks and reservoir overflows. Commercial losses can amount to a larger volume of water than physical losses and often have a greater value, since reducing commercial losses increases revenue, whereas physical losses reduce production costs. According to that article, commercial losses can be broken down into the following four fundamental elements:

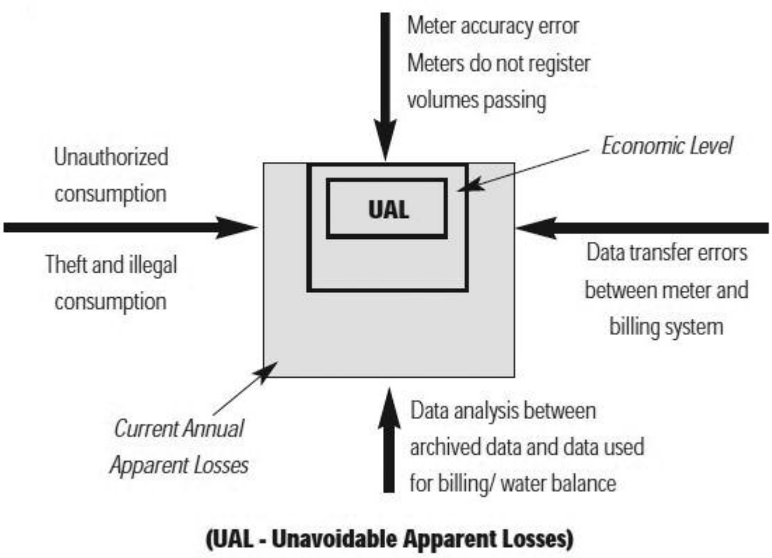

Figure 1
IWA apparent losses management

Inaccurate meters usually tend to under-register water consumption, leading to reduced sales and therefore reduced revenue. The focus should be placed on installing meters in accordance with the manufacturer's specifications; monitoring poor water quality that leads to sediments being deposited in the internal parts of meters; monitoring intermittent water supplies, which lead to air registration and damage to meter components; sizing meters properly, focusing on maximum and minimum flows; conducting customer surveys to understand the nature of each customer's water demand; using the appropriate class and type of meter, depending on the cases and types of customers; maintaining and replacing meters properly, and addressing meter tampering by using high quality meters, conducting customer surveys and comparing expected and actual water use.

Unauthorized consumption including finding and reducing illegal connections, establishing customer awareness programs; tackling meter bypassing by undertaking customer surveys and leakage step tests; preventing illegal use of fire hydrants through appropriate flow measurements at DMA meters; actively checking the customer billing system by conducting complete customer surveys within each DMA; and avoiding corrupt meter readers by rotating them to different routes on a regular basis.

Meter reading errors due to negligence, aging meters or corruption during meter reading and customer billing. Systems and procedures should be established, including greater supervision of meter readers, implementation of rotating reading routes, and frequent spot checks.

Data handling and accounting errors due to the complex process of meter reading and billing, including much paperwork, generating the potential for a number of mistakes that can occur at different stages of the process. The utility should focus on creating a robust billing database, training meter readers, and the introduction of electronic meter-reading devices.

Size and effect

Analyzing IBNET data for big utilities in several countries reveals the aggregated data shown in Table 1.

The results show that it is difficult to find any correlation between the level of non-revenue water (NRW) in percentage terms and the level of metering. In countries with a low level of metering we can see a low level of non-revenue water, but the opposite is also true. At the moment there isn't reliable information to calculate metering indicators in Bulgaria. The levels of reported NRW for 2009-2013 show that it is staying above 61%,

Assessing the size of commercial and real losses inside NRW is difficult. In the IWA standard water balance (Lambert, 2003), apparent losses were calculated of less than 2% from system input, and 12% from NRW (13% total losses). Some information is presented in Table 2 (Yepes & Dianderas, 1996) showing that apparent losses vary between 52% - 65% from total losses.

More recent information has been provided from Nairobi, Kenya (Agence France and Development, 2012), where total losses of 41% have been calculated for 2012, almost half of which (48%) are due to commercial losses.

According to the current Bulgarian legislation, if there is insufficient information and observations for the volume of commercial losses, they are assumed to be no more than 10% from water input. With an average NRW of 60% across the country (61.4% for 2013), and if it is assumed that commercial losses are 10% from system input, then their share of NRW would be 16.7% (10/60). We can see from the information above that these assumptions are quite underestimated.

The largest utility in the country estimated a level of commercial losses of 26.6% from the total losses for the base year of the business plan for 2009-2013 (Sofiyska Voda, 2008).

Currently the water sector in Bulgaria lacks implementation of best

Table 1 - Aggregated large utility data based on IBNET information.

Country	Year	6.1 - Non Revenue Water (%)	7.1 - Metering level (%) Aggregated data	8.1 - Water sold that is metered (%)
England and Wales	2003	16.65%	27.82%	40.12%
Australia	2013	7.13%	100.00%	100.00%
Czech Republic	2013	15.50%	99.29%	99.47%
Poland	2010	18.14%	99.52%	99.50%
Hungary	2007	27.41%	99.59%	99.91%
Romania	2010	44.16%	92.95%	95.71%
Serbia	2012	30.23%	87.39%	87.21%
Macedonia, FYR	2008	62.72%	93.04%	94.31%
Armenia	2010	81.14%	81.94%	83.65%

international practices for water network management (Evins et al., 1989), including the establishment of rules and criteria for decision taking (prioritization); the establishment of district metering areas (DMAs); the determination of DMAs for survey due to problems with water quality compliance, hydraulic or structural issues; determination of a strategic rehabilitation plan based on top priority DMAs.

Only a few utilities have undertaken activities to establish DMAs, permanently measure flow and pressure at zone inlets, create electronic data records and embark on analysis. Thus the operators cannot calculate the potential levels of real and commercial losses, prioritize areas and apply corrective measures.

Information for actual customer consumption is also not available. Comparing billed volumes against official population data can't answer this question – usually meters are manually read over certain periods (of between one and three months), the information for actual population in villages/properties is incorrect, and additionally the level of commercial losses is not included. Data for billed volumes in 2013 provide an average value of 118 l/p/d (a maximum of 222, and a minimum of 58).

An actual consumption survey in compliance with best international practices – including a survey of each building's internal network and residents; replacement of meter connections if needed, installation of data loggers and recording of volume data – has only been done in Sofia city in 2003-2005. Data from 2005 gave the following results (Sofiyska Voda, 2005):

- An average consumption in residential buildings supplied with a central heating system of 186 lpd, and in buildings with a local heating system of 133 lpd;
- An average consumption in family houses during summer that varied between 188-234 lpd (depending on consumption for irrigation), and in winter between 107-110 lpd.

By having this information, we can try to calculate the actual consumption volumes in order to assess the level of commercial losses, but this data is very old and we need to take into account the potential effect of price increases over the years.

Water has very low price elasticity, so a really significant price increase is required to achieve an actual impact on consumption (Inman & Jeffrey, 2006); it is calculated between -0.1 to -0.25, so a 10% price increase would lead to a 1% to 2.5% consumption reduction (Herrington, 2006). According to the regulator`s data, the overall price increase for water during 2007 to 2015 has been 38%, which can't be considered a significant increase. The billed volumes in the whole sector didn't show a constant trend in any direction during 2009 to 2013. Only in the last two years have most of the utilities reported decreasing billed volumes, due mostly to population reduction and very rainy summers.

So if we use aggregated values from real consumption data from 2005 to estimate the actual level of commercial losses in Bulgaria, based on 2013 data for the overall population of 7246 million people (73% of whom live in cities), and total billed volumes of 350M.m^3 (38.6% of system input), actual consumption is calculated to be 422M.m^3, or a difference of 72M.m^3 from the billed volumes.

Assuming that we still have commercial losses (10% from a system input of 908M.m^3) due to lack of proper metering, thefts and data losses inside the utilities, then the total consumption plus commercial losses would be 513M.m^3 (or 56% from system input).

Having actual billed volumes of 350M.m^3 means that the commercial losses should be 163M.m^3 or 18% from system input, and 32% from total losses. The water sector has reported total revenues from regulated services of around BGN600 million ($327.4 million) in 2013. The level of calculated commercial losses would result in lost revenues of BGN275 million ($150.1

Table 1 - Example apparent losses (Yepes & Dianderas, 1996)

General data			Total losses		Apparent losses share inside
State / City	Year	Real	Apparent	Total	Total losses
Singapore	1989	4	7	11	63.64% (7/11)
Spain, Barcelona	1988	11	12	23	52.17% (12/23)
Colombia, Bogota	1991	14	26	40	65% (26/40)
Costa Rica, San Jose	1990	21	25	46	54.35% (21/25)

million) (46%), based on averaged prices for different regulated services, and assuming 100% debt collection.

Even though such an estimation is very general, its results are in compliance with the sources shown above, and it supports the conclusion that commercial losses have significant potential for size, and therefore for optimization. This is crucial in the context of decreasing population (and therefore consumption), and the increased need for investment in future. So in the next section a quick overview is made of the factors generating commercial losses, and the potential to response from utilities.

Factors generating commercial losses

Inaccurate metering

Old and damaged meters: according to current Bulgarian legislation, all revenue meters with Q3 (Qn) less than or equal to $15m^3/h$ should be tested every five years, and those with more than $15m^3/h$ every two years. These requirements are not implemented, as utilities report annually between 7 to 8% tested meters from the total stock. This results not only in less accurate metering, but also hampers debt collection when customers appeal bills in court.

In addition, the water network in Bulgaria suffers from high rates of bursts (1.06 busts/km/year for 2013, compared with levels of 0.2-0.5 for more developed countries) leading to an increased amount of repair works, with water shut-offs impacting negatively on the meters.

Meters not properly sized: according to a household water consumption survey carried out in Spain and South Africa in 2006, apartment blocks had an average consumption of 500l/h, and houses with gardens an average consumption of 1200 l/h. Based on that survey, a weighted error for a meter of (-9.4%) has been calculated, based on different types of meter error percentages for different flow rates (l/h), and in accordance with the percentage household usage for the different flow rates (Arregui et al., 2006).

Currently the lack of information that Bulgarian utilities have about actual water consumption leads to the installation and/or replacement of meters that don't correspond with the customer consumption characteristics.

Example of a connection to bypass a meter.

The usual practice is to replace the existing meter with the same type and diameter, leading to under or oversizing.

In order to solve these issues, utilities need to establish a proper meter database and prioritize the need for surveying, testing and/or replacing meters, starting with the biggest consumers. It is very important to conduct consumption profile surveys for all big customers in order to understand their individual profiles, and of average types of buildings, for general consumption profiles, and to establish norms and standards for meter sizing. Different types of meters can be used for certain groups of customers – types B, C, even D, combined meters, separate connections for normal and fire uses, installation of unmeasured flow reducers, etcetera. Meter downsizing should be done after careful investigation, with respect to network pressure, the condition of internal building networks and other issues.

Meters not properly situated: the length of the house connection inside private properties in Bulgaria is restricted to 2 or 5m from the property boundary line (depending on whether the revenue meter is located outside in a shaft, or inside the building).

Often meters are located much further inside the property, which increases the length of the connection and the chance of hidden bypass connections before the meter. Water utilities, however, find it difficult to understand what the proper meter position should be on site, as often the property fence doesn't agree with the boundary line.

Often the meter shaft is not properly constructed, which hampers meter installation and replacement. Meter shafts are the customer's responsibility, but the legislation doesn't provide effective ways for how to proceed if the customer is not cooperative.

This issue should be addressed by the utilities with the establishment of GIS systems and proper site surveys, but the problem can be solved with legislative changes and actual support from local municipalities.

Access to meter readers: customers should allow meter readers into their property at least once a year. Meters should be read at different intervals depending on the type of customer – usually every month or every three months. Often customers don't allow access for longer periods, and the utilities find it difficult to impact and solve the problem. Water bills should be generated every month, and when the meter is not actually read, the bill is based on estimated quantities. Improving the quality of billing

Example of a connection to bypass a meter.

systems, providing options for meter readings during weekends and better customer service by the utilities can solve this problem.

Common consumption in blocks of flats: in Bulgaria each individual apartment is a separate customer, the opposite to most European countries, where the whole building is a single customer. The utility is supposed to read individual meters in order to distribute the consumption that passed through the revenue meter. If there is a difference between the revenue meter and the sum of all individual consumptions, it is distributed across all customers in the building according to their individual consumption.

The volume of this difference depends on many factors – including internal leaks, unmetered consumers, the difference between the quality of the revenue and individual meters, apartments being billed on base consumption, apartments that do not allow access and are billed on calculated volumes, and other problems. This additional consumption generates objections among the customers – according to the regulator, 25% of all customer complaints for 2014 were about this issue. In many cases, water utilities simply don't install revenue meters to avoid this source of customer complaints.

Meter reading errors

These mistakes occur as both ordinary mistakes during work, related to dirty meter glass, poor visibility and other issues, as well as intentional recording of lower or readings or not reading meters in certain properties. Regardless of whether these mistakes are intentional or not, the negative results impact on the whole utility, as sometimes when the mistakes are exposed, it is too late to undertake certain activities.

Utilities need to increase control over meter readers' work through more check-ups, random inspections, customer surveys and so on. Rotation of meter readers should be planned carefully however, especially when no adequate information is available in the corporate databases, and specific knowledge will be lost. One good solution would be the introduction of mobile devices for meter readers, as it provides a number of control options – specific software, camera photos, GPS tracking and many others.

A number of issues need to be solved in order to introduce remote metering systems as a permanent solution in Bulgaria – not only because it requires heavy capex funds to cover all customers, but also due to technical problems – different types of meters, some of them without a pulse option, flooded meter shafts, problems in signal coverage, with repeaters and concentrators required, among others.

Data handling and accounting errors

These mistakes cover the overall process from meter readers to debt collection, including loss of data for meter reading and meter parameters (including number, seal, and other information) between meter readers and the billing system, correction of billed volumes after customer objections, bills that are sent to the wrong address, and so on.

The size of such mistakes depends on the level of data automation and integration (which is generally low); the level of internal control – including process description, standards and procedures (again very low, allowing mistakes and hampering any optimization efforts); use of manual work and paper forms for meter readings; use of old billing systems with low capacity for data integration, control options and others; and lack of analysis and comparison between read and billed volumes.

In some cases utilities are intentionally not billing certain consumptions, which may be objected to in court, and will be difficult to collect due to the need of paying VAT tax to state budget. The regulator has already suggested to the state to introduce VAT cash accountancy for water utilities (VAT is paid not when issuing the bill, but when the bill is paid by the customer), but it is not likely to be accepted.

Unauthorized consumption

Unregistered consumers: usually such properties are in the process of connection to the network, or are sited in gipsy ghettos. Nevertheless, the lack of a GIS system or differing information between billing and GIS systems (when they exist) allows the possibility for regular properties to use water for a long time without a customer account.

Properties with illegal (bypass) connections: practice in Bulgaria shows that most of the properties in villages and small cities usually have such connections, most of them constructed a long time ago (these networks were usually constructed by the population themselves during the Communist regime). Such connections are difficult to locate, neighbors don't like to report them, and the solution is network replacement, and/or installation of meters outside the properties (which obviously requires increased levels of investment).

These issues could be addressed by the utilities through introducing DMAs, integration between SCADA /telemetry and billing system data, regular water balance analysis and on-site inspections. Such consumption will be visible after most of the inaccurate metering issues and data errors are solved. The only permanent solution to water theft, however, is water-mains replacement, combined with installing meter shafts outside properties based on top-priority areas.

Debt collection

Commercial losses don't end with correct metering, reading and billing of the customers, as bills need to be collected from the utilities. The regulator's report from 2014 showed that the average debt collection ratio of the utilities is 84%. The prescribed period for periodic payments is three years, and water utilities cannot collect older debt in court. The utilities have very big issues with debt collection, due to a lack of focus, strategy and program; a lack of integrated process and controls, adequate systems and experts; a lack of use of external resources, outsourcing and other issues.

All of these can be improved by increasing their capacity and efficiency, introducing proper systems and routines or using external specialist companies. Nevertheless, the existing court system in Bulgaria is relatively slow and not so effective, and additionally is blocking this process.

Conclusions

Several key activities need to be implemented by the Bulgarian utilities in order to properly address the commercial water loss problem:

- A full and updated database of

customers, meters and consumption
- A program for meter investigation, installation and replacement, based on clear priorities and site surveys
- A program for customer surveys, including updating of information on properties, connections, meters, consumption and others
- A program for full surveys of urban areas/DMAs – comparison of actual field results with the information in the databases, based on top priority DMAs
- Strict control of the meter reading process, including digital devices, remote meter readings for priority customers, and other actions
- Constant analysis of the read and billed volumes, together with DMA volumes
- Strict control and monitoring of debt

In most of the cases, commercial losses arise with the support of the utility – both from unintended activities (low levels of control and coordination), and intentional activities (construction of illegal connections, improper meter readings, bill corrections and others). Commercial losses are also related to a number of factors outside the utility – social policies, politics, law enforcement and the court system – and if no effective support is provided to the utilities, then the results can't be optimal.

It is obvious that fighting commercial losses is not as easy as some people think. The utility needs to achieve internal integration and coordination between different types of departments – operations, customer service, finance and others; and to overcome internal resistance, lack of process description and proper software and databases.

What is usually seen is that the utility is focusing only on certain areas, and is not controlling the overall process. Thus a long-term systematic approach should be introduced, covering all related aspects of the process, because the decreasing population is leading to reduced billed volumes and cash flow for the utilities.●

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ASSET MANAGEMENT POLICY

Do we have an adequate asset management policy for water supply and sanitation companies?

International experience suggests that all public companies providing public services have to establish asset management policies. This becomes more important for capital-intensive industries such as water and sewerage companies. The goal of asset management policy is to meet a required level of service in the most cost-effective way through the creation, acquisition, operation and maintenance, renewal and disposal of assets to provide for present and future customers and communities. A better service, in conjunction with a better asset, is a key indication of successful asset management. Avni Dervishi and Dr Arben Bakllamaja provide some thoughts on why water utilities need to have an asset management policy and the key steps in using this to make operational and implementable policy .

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Water companies are capital intensive, and therefore their assets have an important weight in the success of their business. Managing capital-intensive businesses is a challenge for water utilities' management, which involves a high scale of investment in infrastructure assets that should result in improved service delivery with greater efficiency.

It is important for the water regulator, who is in charge of setting standards for investment programmes and asset sales from the licensees in the water supply and sewage sector, to monitor and assist the water service providers to match investments with the service required and with cost efficiency. Equally important is the role of the regulator in ensuring that water

Skanderbeg Square in Tirana (Credit: milosk50 / Shutterstock.com)

companies are managing their assets properly in conjunction with the tariffs they charge to customers.

The central government organisation needs to develop an inherent asset management policy to provide principles and guidance for properly managing water and sewerage companies' assets in conjunction with the quality of service provision and efficiency of their operations. The guidelines of the Ministry of Finance on the Management of assets of public sector organizations stipulates the responsibilities of public organizations to ensure effective management of their assets, and places a key role on the Strategic Management Team to minimise risk and improve the structure of the assets. Equally important is the role of the National Accounting Council, which has established national accounting standards that include the valuation and depreciation methods for assets as an important element of asset management.

This article aims to provide a framework for an asset management policy, the approaches for developing and adopting such a policy, steps on how the policy objectives will be achieved, and the responsibilities for managing policy implementation.

A framework for an adequate sector asset management policy

Policies at the sector level are the responsibility of the central government organisations. In Albania, the Directorate of Water and Sewerage and Solid Waste Policies of the Ministry of Transport and Infrastructure (MIT) is in charge of designing the asset management policy of the water and sanitation sector. The Ministry of Finance is also responsible for setting the standard for accounting, depreciation methods and norms, and so on.

The goal of the water sector's asset management policy is to meet the required level of service standard in the most cost effective way through the creation, acquisition, operation and maintenance, renewal and disposal of assets to provide for present and future customers/communities. A better service, in conjunction with a better asset, is a key indication of successful asset management from the public companies that provide water and sanitation services.

This policy specifies the objectives of asset management in the water sector, such as full operational cost recovery, 24-hour supply, 100% coverage, safe drinking water, and affordable tariffs. The policy should address:

- Ownership of assets
- Key roles and responsibilities (maintenance, replacement, renewal, rehabilitation, disposal)
- Main categories of the assets for accounting purposes
- Depreciation methods for assets
- How the different assets categories are depreciated
- How assets are valued
- How often assets need to be revalued (based on condition)
- Financing of infrastructure

Key roles for managing the asset management policy

The sector asset management policy should identify key roles for implementation of the policy.

International experience indicates three levels of roles and responsibilities:

- The Council's role as owners of the assets for approving, amending or cancelling the operational policy at city level
- The executive management's role in the public utility is integrating the policy into the business plan and ensuring its inherent alignment with other parts of the company's business plan
- The role of the staff of the utility is to properly implement the policy.

The guidelines of the Ministry of Finance on the *Management of assets of public sector organizations* stipulates the responsibilities of the public organisations to ensure effective management of their assets, and places a key role of the strategic management team to minimise the risk and improve the structure of the assets, but not for the policy of asset management.

These guidelines define three levels of responsibilities for asset management:

- The authority of the public

organisation, that is, governing bodies for approving specific rules and procedures for safeguarding, protection and decommission of assets
- The responsibilities of authorised employees for preparing and monitoring the systems for safeguarding and protection of the assets and documentation
- The responsibilities of other managerial levels and employees, for safeguarding and protecting the assets and documentation against losses, theft, misuse and unauthorised use.

How does the asset management policy go through implementation?

International experience suggests that to achieve its objectives, the asset management policy objectives should be incorporated in the management strategy, which should be followed by an asset management plan and action plan.

The policy should define the role of the Water Regulatory Authority (WRA), such as collaborating with other central organisations to develop sector investment programmes aiming to link investments with the service required and with cost efficiency.

It should also monitor the implementation of the asset management strategy and plans, and their on-going review by water service providers, and monitor water companies on management of their assets in connection with the tariffs they charge to customers

After an asset management policy is adopted, it should be followed by the development of an asset management strategy. The asset management strategy should examine and document the status of asset management in the organisation, and identify a future vision and the key objectives for the organisation

After an asset management strategy has been adopted, an asset management plan needs to be prepared. The Asset Management Plan (AMP) should be based on current inventories and condition (acquired or derived), projected performance and remaining service life and consequences of losses (such as vulnerability assessments, emergency management, and critical infrastructure assessments).

The AMP should also consider levels of service, demand forecasts, asset portfolios, and asset management activities (including operations, maintenance, renewal/replacement, and disposals). Additionally, the AMP should include long-term financial forecasts and consider alternative scenarios and risks. It is recommended that the public be consulted during the development of the plans as well, based on international experience, and in order to fulfil its role mentioned above, an asset management plan should be consulted on as well with the regulator.

Once asset management plans have been developed, the organisation's action plan should be adjusted for the asset management to be implemented effectively. The action plan includes data collection, rehabilitation priorities, deterioration forecasts, resourcing requirements to reflect greater maintenance, and monitoring performance indicators.

The approaches to developing the sector asset management policy

According to international experience, there are various approaches to developing and adopting an asset management policy:
- Identify the key issues of asset management, then explore, develop and evaluate alternative policies that can be used to better address the asset management issues, and achieve acceptable or desired solutions
- Develop an asset management policy to adapt and use the example-specific corporate asset management policy
- Include asset management principles (or portions of policy principles or guidelines) into other corporate policies, such as budget or financial plans, and so on; that is, do not have a standalone asset management policy

It is suggested that in the context of the water sector in Albania, a better approach for the central government organisations is to design and adopt an asset management policy that should address the main issues and problems of asset management that many utilities are facing.

Some of the key issues in Albania's water sector that need to be looked at closely and analysed to come up with a good policy are given below:
- Low quality and poorly constructed infrastructure
- A disproportionate share of the investment in the sector has gone to water supply investment, thus leaving behind the need for sewerage and wastewater treatment plant investment.
- Network rehabilitation and renewal has been relatively deferred for lack of funding sources. Deferred asset renewal and maintenance in the water sector inevitably has an impact on the utility's service and will necessitate even larger and more expensive capital programmes in future
- New capital investments are not properly recorded in company books which affects the depreciation costs in the financial statement and the tariff estimates
- Network assessment is often neglected because these assets are buried underground. A utility may have thousands of kilometres of buried pipes that were installed over decades. Many companies have no records of the pipes' age, material, and condition. Moreover, the importance of any specific pipe or a sset on overall service performance is only vaguely assumed
- Lack of maps and of proper equipment makes it difficult to guide the rehabilitation of their vast pipeline networks and other assets, which results in rapid deterioration of the leakage in the system and service quality
- Asset classification is not properly done - this provides the basis for implementing the valuation methods necessary for their efficient use
- The depreciation method does not follow international standards, that is, based on the grouping of assets, which is necessary for planning timely funds for rehabilitation and renewal and or replacement of those assets that have achieved their economic lifespan
- Lack of an adequate register of company assets affects the proper registration of these assets in the fixed asset database on behalf of the owners, which is necessary for asset transfers, sales and insurance.
- Lack of a detailed fixed asset register affects calculation of the depreciation charge, which inhibits identification of the separate components and their useful lives
- The practice of accounting and financial reporting of many companies when conducting sector asset management varies
- Valuation of assets is carried out in compliance with the accounting law of the country. However, the practice of companies in re-evaluating old assets that are still operating needs to be seen in light of international experience, in order to properly adjust the depreciation charge. The life-cycle approach is central to accounting for the total cost of an asset throughout its life

Operationalising the asset management policy by LGUs through the asset management strategy and plans

According to international experience, local government bodies and public companies that own utilities operationalise asset management policies designed by central government that address aspects of asset management (that is, acquisition, operation and maintenance, renewal and disposal of assets) in the context of the business operations of the company. This is manifested in the asset management strategy and plans, where clear operational tasks for asset management are well articulated, and well aligned with the business plan.

Figure 1 Asset management policy through implementation

Adopt an asset management policy	→	Develop an asset management strategy	→	Develop an asset management plan	→	Develop an asset management action plan
MIT develops an asset management policy with the objective that the assets meet performance levels, are used to deliver the desired service in the long term and are managed for present and future users		Based on the asset management policy from MIT, the LGUs/UKs develop their asset management strategy		Based on the respective LGU/UK asset management strategy is developed, UKs need to develop asset management plans.		The asset management plans need concrete action plans to implement the asset management plan.

Following this, the starting point for the local government units is to make an assessment of the main issues identified in the asset management plan in their specific context that should aim to:

- Ensure accurate recording of asset information, and of asset movements
- Exercise strict physical control over all assets (security, safekeeping)
- Comply with the insurance policy to adequately insure all assets
- Comply with Accounting Law requirements for asset evaluation and recording, depreciation, and residual value of assets
- Properly maintain and repair infra structure assets at defined levels
- Monitor standards and service levels to ensure that they meet community expectations and the goals and objectives as per the company business plan
- Develop and maintain asset inventories of all their infrastructures
- Establish infrastructure replacement strategies through the use of full life cycle costing principles
- Plan financially for the appropriate level of maintenance of assets to deliver service levels and extend the useful life of assets
- Plan for and provide stable long term funding to replace and/or renew and/or decommission infrastructure assets
- Incorporate the asset management plan in the company business plan

The prepared plan and its realisation should be delivered to the regulator with the tariff application to ensure that water companies are properly managing their assets in line with the efficiency of their operations and the tariffs they charge to customers

Conclusions

There are many positive benefits to asset management strategy and action plans. Water companies that fully embrace asset management principles may achieve many or all of these benefits just by starting asset management. The benefits include, but are not limited to, the following:

- Better operational decisions
- Greater ability to plan and pay for future repairs and replacements
- Increased knowledge of the location of assets
- Increased knowledge of what assets are critical to the company and which ones are not
- More efficient operation
- Better communication with customers
- A tariff based on good operational information about the true costs required for asset maintenance
- Increased acceptability of the tariff submission from the regulator and the community
- Identification of capital improvement projects that meet the true needs of the company and are, therefore, more attractive to potential donors

Water companies may have to rely on less government funding in future, and eventually less external donor support for capital projects. This will require an increasing reliance on tariffs raised from the communities that the companies serve. Asset management planning is a way to demonstrate to the regulator and the community that the assets are properly managed and that the tariff charged will cover the cost of maintaining those assets and provides a solid justification for the tariff.

From the other side, by analysing the business plan and the tariff submission to the regulator associated with an asset management plan, the regulator can ensure that, notwithstanding affordability issues, a tariff is set that reflects the true cost of maintaining the asset base to provide the required levels of service in the most cost-effective manner, in a transparent and accountable way.

Furthermore, as noted above, having an Asset Management Plan (AMP) – the output of the asset management process – can provide the justification that donors and other financial institutions ask for when they consider investing in a water company. Investor's always ask: 'Why are you requesting investment in this pipe replacement and not that one?' Having an AMP answers this question exactly. Having asset management systems in place allows assets that are poorly performing, in poor condition and critical to water companies' operations to be identified. Therefore, this process links directly to the ability of the water companies to justify and receive adequate financial support from potential investors. ●

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Cost-benefit analysis of systematic reduction of water losses in Croatia

The process of reducing water losses is gaining ground in Croatia, but is still not at a satisfactory level. In Croatia there are water supply systems where water losses have been reduced to a satisfactory level and are maintained as such, but there are also distributors who still need to make great efforts to achieve a satisfactory level of losses. Municipal service companies in Croatia have become aware that dealing with the issue of water losses is essential for efficient management of the water supply system. In line with that, a programme has been launched for systematic reduction of water losses together with the preparation of a feasibility study for many water supply zones in Croatia. Martina Tadic and Karlo Kolovrat look at the programme's integral cost-benefit analysis.

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Water losses in a water supply system have been a topical issue in Croatia over the last several years, since it is well known that a water management system is not sustainable in the long run if the issue of water losses is not addressed, and that losses need to be promptly reduced to an acceptable level.

The need to reduce losses stems from national strategic documents. According to the Water Management Strategy (Official Gazette 91/08), the price of water shall not contain uneconomical utility activities such as heavy water losses in the system, with the Strategy requiring that the water losses be reduced to an acceptable level of 15 to 20%, following the example of European countries.

The reduction of water losses is one of the objectives defined by the Operational Programme Competitiveness and Cohesion (OPCC) 2014 to 2020. The issue of water losses is also addressed within studies used as the basis for applying for EU co-financing. A feasibility study needs to present in what way and to what extent the problem of losses in a particular water supply system will be addressed, which can only be done through systematic analysis of the water supply system and cost-effective project implementation. In addition, another incentive to address the issue of water losses is the significant financial savings for the utility company managing the water supply system.

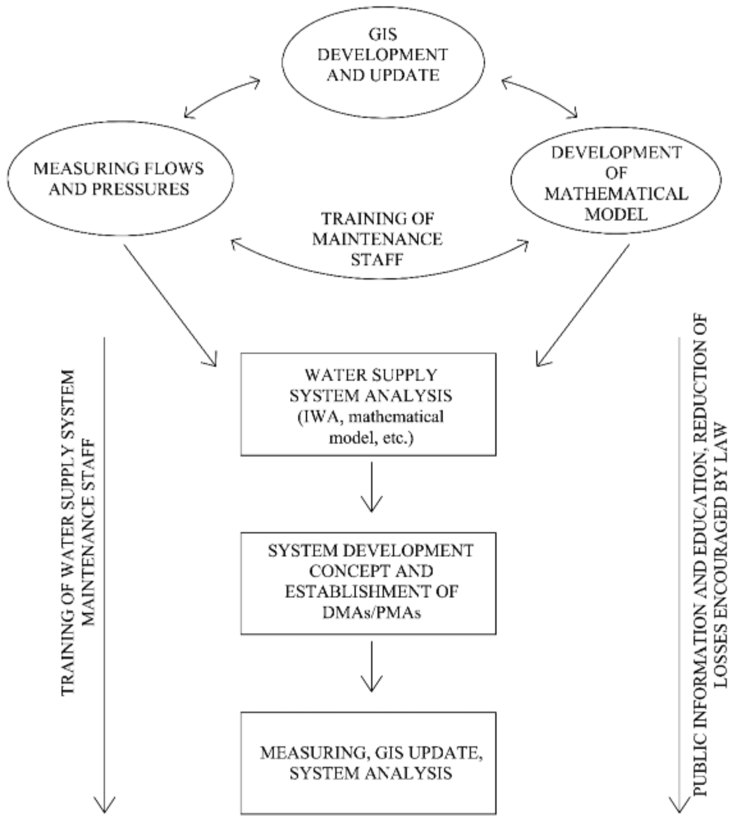

Figure 1 Concept of systematic reduction of losses

Water losses in Croatia

Water losses in water supply systems in Croatia are a big problem, but they are still officially presented as a difference or a share between abstracted and billed water. Many distributors are aware that such way of presenting the water losses doesn't give a real picture of the status of the system, and they unofficially use the indicators from the methodology used by the International Water Association (IWA). Table 1 presents the official data obtained from an Audit Report titled Economically justified differences in public water supply tariffs for the year 2012 across Croatian counties. It is estimated that on average around 50% of abstracted water volume is lost, which exceeds the criteria applied in contemporary practice by several orders of magnitude. This is the consequence of poor legislation (the basis for calculating the water use fee is the volume of water consumed, due to which the consumption charging system doesn't encourage rational water consumption); the old age of the system; distributors not knowing their systems (lost design documents; non-existent design documents; unknown locations of connections and valves, etc; inadequate system maintenance; material of poor quality; and non-registered water consumption.

Active efforts are under way in Croatia to eliminate all of the causes mentioned above, for which one of the indicators is the initiation of a programme for the systematic reduction of water losses in many distribution areas. The loss reduction programme, with a cost-benefit analysis (CBA), will provide the most detailed analysis of water supply systems ever prepared in Croatia. From a technical point of view, all the elements in the water supply system will be pinpointed, the water supply system will be analysed in the best possible way (depending on the quality of inputs available to the utility company), and problems in the water supply system will be defined.

The programme will identify the real status of water losses in the system, which will then serve as a starting point for their reduction. The analysis of losses in the water supply system using the IWA methodology and mathematical models will propose several solutions to monitor and reduce water losses. The most suitable and optimum solution will be selected based on the results of the CBA.

An advantage of this approach is the fact that, in addition to a technical component, it also includes a financial and economic component, facilitating the selection of the most suitable solution for the reduction of water losses. The CBA provides insight into the cost-effectiveness of a project, since in addition to analysing alternative options, an option 'without the project' needs to be analysed as well. Using such an approach one can prove whether the selected option is cost-effective, what the benefits of implementing the project are, and how project implementation will affect the utility company's operations and water tariff.

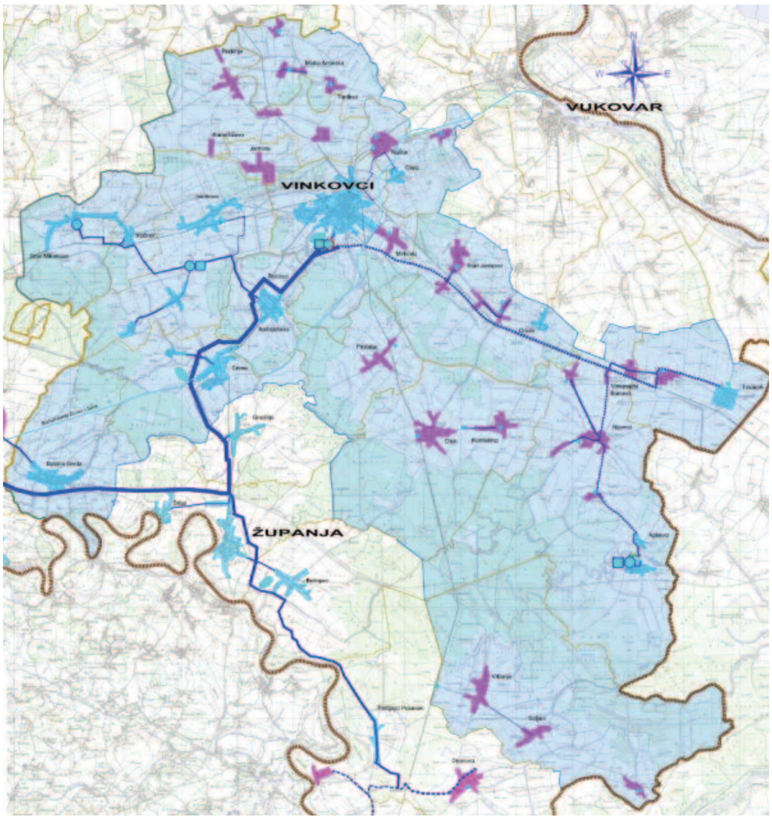

Figure 2
Distribution area of Vinkovacki vodovod i kanalizacija doo

Based on this analysis utility companies can apply for co-financing from the Cohesion Fund.

Programme for systematic reduction of water losses

The programme for systematic reduction of water losses covers a comprehensive analysis of the water supply system. The comprehensive analysis of the water supply system aimed at reducing water losses includes the following:

- Implementation of GIS (advanced management of all data and information)
- Analysis of flow and pressure measurement obtained from the SCADA system
- Additional flow and pressure mea surement with an analysis of preliminary District Metered Areas (DMAs)/Pressure Management Areas (PMAs)
- Mathematical modelling of the water supply system
- Calibration of the mathematical model of the current status of the water supply system based on SCADA measurements and additional measurements
- Analysis of the current system status
- Planning and establishing DMAs/PMAs in accordance with planning documents
- Cost-benefit analysis for the foreseen

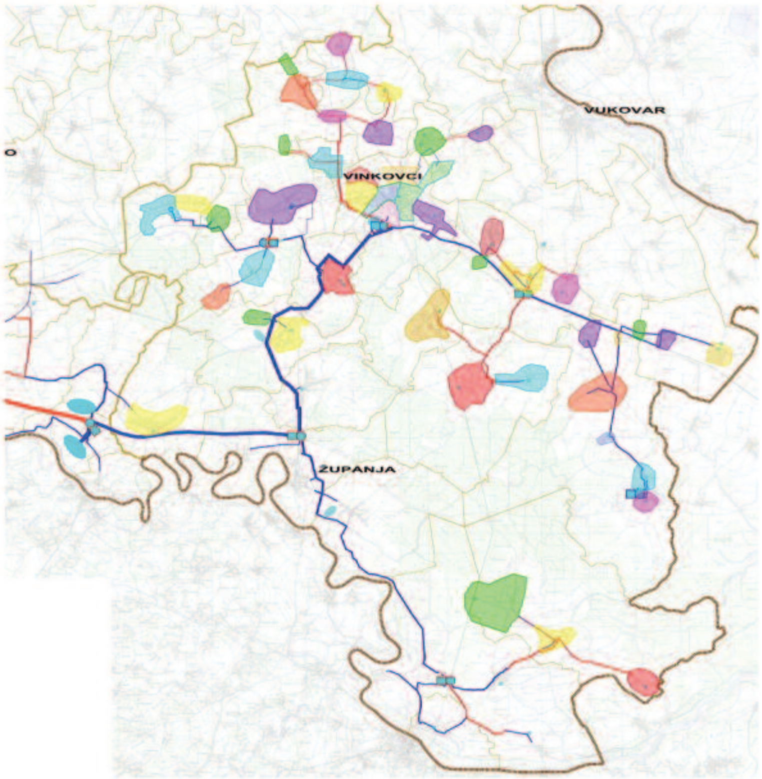

Figure 3
Existing division of water supply system Vinkovci into DMAs/PMAs

system zoning and the system development concept
- Mathematical modelling of the planned development of the water supply system with the established DMAs/PMAs
- Design and development of measuring and measuring/control points
- Training the staff of the utility companies and establishing a permanent team to be exclusively in charge of addressing the issue of water losses in the water supply system

The purpose of this programme is to raise the awareness of the staff in the utility companies of the importance of addressing the initial losses, so that the water losses reduction programme doesn't end after the comprehensive analysis of the water supply system and the establishment of DMAs/PMAs, and that it is necessary that active work on the system continues.

A trained maintenance team will continue to monitor pressures and flows in the DMAs/PMAs, measuring the flows and pressures using mobile equipment as planned, analysing the status in the system according to IWA methodology, and taking every measure necessary to reduce water losses and keep them at a satisfactory level. It is important to realise that systematic reduction of losses is not a project that ends on a specific date, that is, with the programme analysing the water losses, but that it is a process that lasts as long as the system itself (Fig 1).

The programme for systematic reduction of losses must not depend only on the efforts of experts in the water supply system. Consumers also play an important role in the water supply system. It is necessary to raise the awareness of all consumers about the sustainability of the water management system, indicate their role in the water supply system, and encourage them to get involved in the fight against system water losses. An active loss reduction policy will be presented through the media and other sources of public information. Consumers need to become aware that the volumes of drinking water are limited and that resources have to be managed rationally and protected whenever and wherever possible.

Cost-benefit analysis

This project programme foresees an analysis of at least two technically feasible options for water supply system development, their comparison, and – as the end result – a proposal for the optimum option by comparing the financial/economic parameters.

Financial analysis

The purpose of the financial analysis is to assess whether the cashflow of the future project generates suitable return rates, as measured by the financial internal rate of return (FRR) on investment (FRR/C) and their own capital (FRR/K), and the corresponding financial net present value (FNPV). Most of the project data on costs and benefits is provided by financial analysis. This analysis provides essential information on inputs and outputs, their prices and the overall timing structure of revenues and expenditures. The financial analysis is made up of a series of tables that collect the financial flows of the investment, broken down by total investment, operating costs and revenue, sources of financing and cash flow analysis for financial sustainability.

The financial model is used as a tool to predict financial performance and the formation of prices for the water service in a project area. The model deals with all the main investments and their impacts on, for example, prices or the adequacy of cash to sustain the business activity. The projections obtained by the model reflect the

Table 1 Ratio between undelivered and abstracted volume in particular counties in 2012
(Source: Audit Report Economically justified differences in public water supply tariffs (2012))

County	Abstracted m3	Delivered m3	Undelivered m3	Undeliv./Abstr. %
Bjelovar-Bilogora	5.248.617	3.147.713	2.100.904	40%
Slavonski Brod-Posavina	8.788.853	5.157.469	3.631.384	41%
Dubrovnik-Neretva	21.884.252	12.455.076	9.429.176	43%
City of Zagreb	120.000.000	61.200.000	58.800.000	49%
Krapina-Zagorje	9.085.420	4.503.129	4.582.291	50%
Osijek-Baranja	20.235.948	12.465.344	7.770.604	38%
Požega-Slavonia	4.931.506	2.884.731	2.046.775	45%
Primorje-Gorski Kotar	3.407.845	2.354.821	1.053.024	31%
Sisak-Moslavina	14.197.146	7.712.313	6.484.833	46%
Šibenik-Knin	22.809.091	9.815.874	12.993.217	57%
Virovitica-Podravina	4.735.300	2.899.528	1.835.772	37%
Vukovar-Srijem	12.745.389	8.708.606	4.036.783	32%
Zadar	37.752.924	12.694.932	25.057.992	66%

project's operating and financial objectives and are used for price scenarios. The selected project period is 30 years, which is deemed appropriate for an economically useful project lifetime.

The proposed investment should be considered in the context of the existing infrastructure, that is, the water supply and wastewater assets currently managed by the utility company. For that reason, the Guide to Cost Benefit Analysis of Investment Projects proposes an incremental approach that compares the cash flows in the 'with the project scenario' with the cash flows in the 'without the project' scenario.

The incremental approach is applied as follows:

- Cash flow projections for the utility company are developed in the 'without the project' scenario
- Cash flow projections for the utility company are developed in the 'with the project' scenario
- An incremental cash flow projection is developed considering the difference between the 'with the project' and 'without the project' scenarios from year to year.

The basis for the calculation of the additional drinking water price is full cost recovery, which includes operation and maintenance (O&M) costs and depreciation of assets. The model generates a number of financial indicators presented in association with the corresponding output tables. The standard financial indicators obtained by the model are the following:

- Financial net present value (FNPV/C, FNPV/K)
- Financial internal rate of return (FIRR/C, FIRR/K)
- Benefit-cost ratio (BCR)

The financial analysis results in a profit and loss account without the project and with the project, an investment return (the capacity for operating net revenues to sustain the investment costs regardless of the way in which they are financed), and calculation of the return on equity capital.

The outflows comprise the equity of the private investor (when it is paid up) and the country contribution at two levels (local and national). Other outgoings are also calculated, such as operating costs, as well as sales revenues as project inflows. For the calculation of financial sustainability, an EU grant is not initially considered. The calculation results in the financial internal rate of return (FIRR) of project investment, regardless of its financing sources.

Economic analysis

The economic analysis is made to show that the project has a positive contribution to society as a whole and that it is therefore worthy of the EU's financial support.

The project has various indirect economic, social and environmental impacts. Such investments can only be properly evaluated when these impacts are considered, as these impacts can often be identified as decisive in relation to the development. The cost element includes investment, operation and maintenance costs as well as financial costs; the economic benefits element includes financial incomes, the project's residual value and external economic benefits.

The economic analysis appraises the project's contribution to the economic welfare of the region or country. The scope of the project should be seen in a broader perspective, that is, its beneficial impacts on society as a whole instead of just the owner of the infrastructure as in the financial analysis.

The financial analysis cashflows are taken as the starting point for the economic analysis. In determining the economic performance indicators, some adjustments need to be made. These are:

- Fiscal corrections: indirect taxes (such as VAT), subsidies and pure transfer payments (such as social security payments) must be deducted. However, prices should be gross of direct taxes. Also, if specific indirect taxes/subsidies are intended to correct for externalities, then these should be included.
- Corrections for externalities: some impacts may be generated that spill over from the project to other economic agents without any compensation. These effects can either be negative (a new road increasing pollution levels) or

positive (a new railway reducing traffic congestion on an alternative road link). As, by definition, externalities occur without monetary compensation, these are not present in the financial analysis and therefore need to be estimated and valued.
- From market to accounting (shadow) prices: besides fiscal distortions and externalities, other factors can drive prices away from a competitive market (that is, an efficient) equilibrium: monopoly regimes, trade barriers, labour regulation, incomplete information, and so on. In all such cases, the observed market (that is, the financial market) prices are misleading; accounting (shadow) prices need to be used instead, reflecting the inputs' opportunity costs and consumers' willingness to pay for outputs. Accounting prices are computed by applying conversion factors to the financial prices.

Once the table for the economic analysis is ready, discounting is made by the selection of a correct social discount rate for the calculation of the internal economic rate of return (EIRR) of the investment.

Just as in any important business activity, water supply services are subject to a number of impacts that may affect the performance and the project. However, many of these impacts are interdependent, and may as such lead to an increased number of errors in defining sensitivity if all of them are used. For that reason, a simplified and summarised approach is used in which the sensitivity of four output indicators is assessed against five input/output indicators based on the variation of the input variable by 1% (both up and down).

Case study

Recognising the importance of the systematic approach to the reduction of water losses, the utility company Vinkovacki vodovod i kanalizacije doo started introducing this in late 2014. The programme is in its preparation phase, and the end result will be a product of cooperation of experts in the fields of hydraulic engineering, mechanical engineering, electrical engineering and the economy.

Water supply in the territory of Vinkovci and its surrounding areas is under the responsibility of Vinkovacki vodovod i kanalizacija doo. The distribution area spreads over 1405km², and covers the towns of Vinkovci and Otok, and the municipalities of Andrijasevci, Babina Greda, Cerna, Ivankovo, Nijemci, Nustar, Privlaka, Stari Jankovci, Stari Mikanovci, Torodinci, Tovarnik, Vodinci, Vrbanja, Jarmina and Markusica (Figure 2). There are 93,404 people living in the distribution area, with 90% of them connected to the public water supply system.

The water supply system is based on a regional water abstraction site and a number of local water abstraction sites that belong to individual separate water supply systems. The quality of water at the local water abstraction sites mostly doesn't satisfy the sanitary quality criteria and development plans foresee the connection of the local water supply systems to the regional system. The system includes 844km of pipelines made of various materials (ductile iron, cast iron, PEHD, PVC, iron and asbestos cement).

Based on the existing design documents covering the system, the site visit and continuous communication between the staff of the utility company and the authors preparing the water loss reduction programme, the database on the current status of the water supply system was updated. A cadastre of pipelines was prepared, the existing measuring points were defined, as well as the connection and coverage rates in the distribution area. A mathematical model of the current status was prepared and locations defined at which flows and pressures were measured (Figure 3), which were later used to calibrate the mathematical model on the current status and definition of DMAs/PMAs. An extended system balance and system analysis was prepared following the IWA methodology.

The project programme analysed the current trends in water consumption by consumers of all categories in order to assess future water demand. The methodology applied to the preparation of a detailed water demand analysis for a 30-year period was based on the Guide to cost benefit analysis of investment projects (July 2008), the applicable Croatian regulations, EU directives, projections of future population, projections of future economic and industrial development, projections of specific consumption in the future, the experience of design engineers, and the universally acknowledged guidelines from technical literature.

The mathematical model of the current status was upgraded with all the planned pipelines and facilities and the expected peak consumption that will occur in the future 30-year period. The functionality of the established DMAs/PMAs was tested on this model.

Two equivalent and comparable options will be analysed, and the most favourable option will be selected based on the CBA. A detailed analysis of the future status of the water supply system will be made for the selected option. In this phase of project preparation, guidelines will be provided for the future development of the water supply system, the optimal operation of the system will be defined with regard to network pressures, and an operating algorithm of energy-consuming devices (pumping stations) will be created. Optimal flow of water in the system will be ensured (water retention in the peripheral parts of the areas will be prevented), water loss reduction will be estimated, priority measures and projects will be put forward, and their phased implemented.

Finally, the outcome of the project programme will give a conceptual solution for the DMAs/PMAs and the SCADA system. This solution will exactly define the locations, hydraulic parameters and technical requirements for the design and construction of measuring and measuring/control shafts.

The water loss reduction programme prepared in this way is a solid basis for the feasibility study and the EU co-financing application procedure. Since the reduction of water losses is one of the objectives defined by the OPCC 2014-2020, proper calculation of the reduction of losses requires the implementation of a programme that will identify the status of the system and, based on detailed analyses, assess the reduction of losses and the efficiency and cost-effectiveness of establishing the DMAs/PMAs.

Conclusion

This article considers the water loss situation in Croatia. It identifies that much more effort is required from all the utility companies to achieve an acceptable level of water losses, that is, a satisfactory Infrastructure Leakage Indicator (ILI). It defines the concept of systematic reduction of water losses and emphasises the benefits that such an approach can bring. Reducing water losses with CBA provides better enactment of technical solutions and calculates anticipated financial benefits.

The necessity of controlling the water supply system stems from the wish to preserve natural resources, and achieve financial savings and more efficient management of the water supply system. Such an approach to the reduction of losses is also required as the basis for the preparation of feasibility studies and planning documents for water supply systems. ●

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