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water utility management
INTERNATIONAL

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WATER LOSS

The first seven years of the world's largest non-revenue water reduction programme

PLUS ...

The right to information - improving transparency for end users of water services

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Study urges change to global standards for water and sanitation access

A recent study from The Water Institute at the University of North Carolina and the London School of Hygiene and Tropical Medicine has called for a new, rationalised global standard for improvements to household potable water and sanitation access.

The study, published in online journal PLOS ONE, explains that current access benchmarks established by the WHO / UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP) treat water and sanitation differently, masking deficits in household water access.

The JMP will shortly be setting new targets for global progress in the new Sustainable Development Goals, which means the study is likely to be significant.

The problem is that existing benchmarks allow a potable water source to qualify as 'improved' if it is provided at community level, whereas for sanitation to be deemed 'improved' it has to be provided at household level.

Using the existing benchmarks, the figures suggest nearly three times as many people lack access to improved sanitation than to improved potable water sources.

The researchers recalculated the known progress using matching benchmarks, which showed that progress in sanitation outpaced water between 1990 and 2015.

Professor Jamie Bartram, of the Water Institute, said: 'Our findings have significant implications for how we measure progress towards universal access. Drinking water and sanitation are essential for good human health and the benefits are maximised when delivered at home.' ●

Study reveals officials overlooked inhalation risk in contamination incident

A new study has revealed that utility officials overlooked the risk of inhaling vapours from a chemical that leaked into a major West Virginia water supply last January, with the report leader saying that there is a need for tools that responders can use to select plumbing system cleaning methods that do not harm the people they are trying to protect.

Chemical storage tanks leaked over 10,000 gallons (37,850 litres) of an industrial solvent into the Elk river, contaminating 15% of the population's tap water. Over 300,000 people living near the state capital, Charleston, were told not to use the liquorice-smelling tap water except for flushing toilets.

The main contaminant was crude 4-methylcyclohexanemethanol (MCHM), which contained a variety of chemicals whose toxicity was unclear, according to the leader of the research team, assistant professor Andrew Whelton of Purdue University's Division of Environmental and Ecological Engineering and Lyles School of Civil Engineering.

Based on the federal Centers for Disease Control and Prevention (CDC) health-based drinking water screening level, officials from the water utility recommended that residents flush the contaminated water into storm drains, septic tanks and the sewer network.Professor Whelton explained that the CDC's health-based potable water limit for MCHM only considered ingestion and not inhalation.

The new report includes an examination of the research team's in-home survey, drinking water testing results, medical monitoring data, a detailed study of the events leading up to and following the spill, and recommendations for drinking water providers, states and the federal government.It describes medical data for 224 patients, with the most common adverse health effects found to be rashes and skin irritation, nausea, vomiting, diarrhoea, sore throat and respiratory problems.

The investigating team found MCHM in most of the homes they visited, and a smell of liquorice was detected after flushing plumbing systems, which suggested volatile chemicals were still present. Professor Whelton also said it was a major oversight that no one tested homes for the chemical right after the spill.

The report reveals two symptom peaks – one immediately after the incident and the other shortly after the recommendation to flush the plumbing was given. The team concluded that the federal screening level, 1000ppb, was inadequate, and that the lack of a real-time population health surveillance system prevented responders from detecting and intervening in instances where the flushing caused illness.

There is a wider threat, Professor Wheldon warned: 'West Virginia alone has now identified approximately 50,000 tanks and about 4000 are near water supplies. Many of these tanks contain chemicals that pose clear and present dangers to drinking water safety and human health.State and federal leaders must take action to help water suppliers better understand the threats they face and prevent chemical threats from being permitted near water supplies.' ●

water utility management INTERNATIONAL

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Water Utility Management International focuses on the interests of utility executives, policy makers and advisors around the world engaged with the key management issues faced by water and wastewater utilities. As well as senior utility managers, WUMI will be of interest to regulators, consultants, contractors, academics, and financial, technical and legal professionals.

Utility reform and achieving efficiency are central themes of the publication, encompassing topics such as benchmarking, investment planning, consolidation, public / private sector roles, leadership, IT, and human resources. Other regular themes include financing, regulation, charging policies, procurement, corporate governance and customer issues.

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Report warns of 'dire' damage from untreated wastewater

A new UN analysis warns of 'dire' damage to ecosystems and biodiversity because of the lack of capacity to treat wastewater around the world.

Just 20% of global wastewater is being treated, according to 'Wastewater management: a UN-Water analytical brief', which has been produced by the WHO, UNEP and UN-Habitat on behalf of UN-Water.

The report encourages governments to view treated wastewater as a valuable resource, and a priority for the post-2015 development agenda. It also warns of the threat untreated wastewater will increasingly pose to human health, economic activity and water security if it is not addressed.

Wastewater management has been neglected in the rush to commercialise drinking water production, a situation made worse by the fragmented water management system that exists in many countries, and the use of disparate technologies that are often designed separately and retrofitted to existing systems, UNEP executive director Achim Steiner argued.

The chair of UN-Water, Michel Jarraud, said: 'Wastewater has featured heavily in the discussions on the post-2015 development agenda. Countries have recognised that economic and sustainable development must incorporate water resources, wastewater and water quality. This publication contributes to the ongoing discussions and will hopefully serve to inform policymakers.'

The report found that around 70% of industrial discharges in developing countries go untreated, and eutrophication has reduced biodiversity in surface waters by around 33% globally.

Steiner noted: 'It is time to turn this environmental and human health challenge into an opportunity. Agriculture consumes 70% of global water withdrawal, but agricultural irrigation from reclaimed wastewater is on the rise, and is being used to irrigate 20 to 45 million hectares worldwide. ●

Research reveals major investment need for water and wastewater

New research reveals that water supply and distribution and wastewater treatment need major investment within the next five years if they are to remain adequate, but found a worrying lack of awareness about 'hidden infrastructure'.

The Urban Infrastructure Insights 2015 report, commissioned by Spanish environmental services, infrastructure and water group FCC from the Economist Intelligence Unit, found that 72% of people would reduce their water consumption if they had better information about their usage, which emphasises the need to enhance the information flow and harness citizen engagement.

The study surveyed over 400 policymakers and business executives on the state of global urban infrastructure and services, and how city leaders can engage with citizens and service providers to secure support and investment for such projects.

Despite the pressing need for maintenance and upgrades, the research revealed that the value of 'hidden infrastructure' is often only recognised by policymakers.Emerging markets fare worst in terms of infrastructure being inadequate, resulting in over-tapped water systems and other service deficits.

One suggested funding mechanism is greater government collaboration with the private sector through public-private partnerships (PPPs). This was encouraged by 82% of respondents and was seen as a means to deliver more innovative and cost-effective solutions. ●

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Cover photo credit: Miya / AM. See feature p16.

Regulation of Portugal's water service quality

Public water supply and urban wastewater management are of fundamental importance to society, and should be delivered at an acceptable quality for an efficient price. Regulation of these services should aim to protect users' interests by promoting the quality of service and ensuring socially acceptable tariffs, taking into account the operators' economic feasibility and safeguarding their interests. **PAULA FREIXIAL** discusses the role of ERSAR, the regulator of water and wastewater services in Portugal, and the benchmarking programme that it has introduced.

The quality of water services provided to consumers is a very important issue that must be defined, targeted and monitored, based on performance indicators.

The regulator of water and wastewater services in Portugal, ERSAR's regulation strategy is composed of three action plans: the first level, which is the structural regulation of the sector, which consists of contributing to the better organisation and clarification of regulatory rules; the second level, which is regulation of operators' behaviour, monitoring, throughout the life cycle, the operator's compliance with legal and contractual requirements, economic issues, the quality of service, the quality of water for human consumption and the interface with consumers; and the third level, which covers auxiliary regulatory activities, including the preparation and the regular dissemination of information and technical support to the operators.

In this context, ERSAR has the responsibility not only to promote the assessment of all operators' levels of service, but also to gather and disseminate this information; drafting and publishing comparative reports.

In partnership with the main Portuguese research centre in this field, the regulatory authority created a sound system to define and monitor the quality of the water services provided to the consumers.

The benchmarking of the utilities against one another using performance indicators promotes competition between operators in a monopolistic market and guarantees public visibility via an annual report. A set of 16 performance indicators are used to assess each service provided by each regulated utility (water and wastewater).

Regulation system

The regulatory model applied includes the use, by the regulatory authority, of methods for evaluating the quality of service provided to users by the operators and the comparison of the results with other similar entities operating in different geographical areas (benchmarking). Both results are subject to public exposure, as it is considered that this practice encourages the operators to be more efficient and naturally achieve a better position.

Three essential areas are considered for

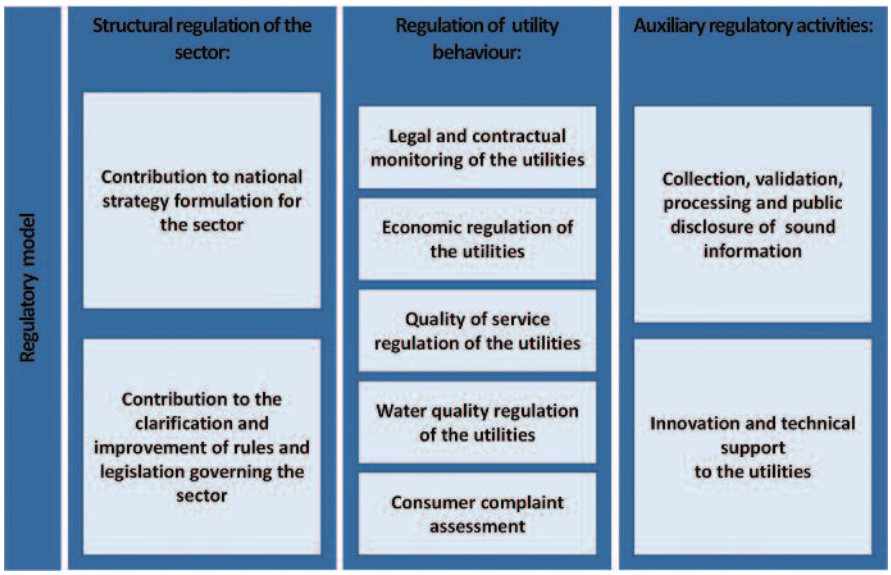


Figure 1: ERSAR's regulation model


Paula Freixial

an improved performance of water supply infrastructures:

- User interface
- Service management sustainability
- Environmental sustainability

The current assessment system includes 16 indicators for each service, covering the above mentioned areas, and is being applied to all mainland water services operators.

The application of this system is intended to contribute to the better protection of users' interests, with an optimised price-service quality ratio (effectiveness and efficiency), to better safeguard the operators' economic feasibility and their interests and to ensure the protection of the environmental aspects associated with their activity. Figure 3 shows the geographical distribution of indicator AA01b – physical access to services, as well as a comparison of quality of service.

The quality of service indicators are defined in the assessment guidelines document (Alegre, 2013) and are the core of this system, allowing for a quantitative assessment of the extent to which the main objectives of the service are being met. Figure 4 shows the system's components and data flows.

In addition to the quality of service indicators, the system also includes information to support the interpretation of findings. Such information comprises

WATER INDICATORS	Protection of user interests	**Accessibility of service for users** AA01 - Physical accessibility of the service AA02 - Affordability of the service **Quality of service provided to users** AA03 - Service interruptions AA04 – Safe water AA05 - Reply to written suggestions and complaints
	Operator sustainability	**Economic sustainability** AA06 – Cost recovery ratio AA07 - Connection to the service AA08 - Non-revenue water **Infrastructural sustainability** AA09 - Adequacy of treatment capacity AA10 - Mains rehabilitation AA11 - Mains failures **Physical productivity of human resources** AA12 - Adequacy of human resources
	Environmental sustainability	**Efficient use of environmental resources** AA13 – Real water losses AA14 - Fulfilment of the water abstraction licensing AA15 – Standardised energy consumption **Efficiency in pollution prevention** AA16 - Sludge disposal

WASTEWATER INDICATORS	Protection of users interests	**Accessibility of service for users** AR01 - Physical accessibility of the service AR02 – Affordability of the service **Quality of service provided to users** AR03 - Flooding occurrences AR04 - Reply to written suggestions and complaints
	Operator sustainability	**Economic sustainability** AR05 – Cost recovery ratio AR06 - Connection to the service **Infrastructural sustainability** AR07 - Adequacy of treatment capacity AR08 - Sewer rehabilitation AR09 - Sewer collapses **Physical productivity of human resources** AR10 - Adequacy of human resources
	Environmental sustainability	**Efficient use of environmental resources** AR11 – Standardised energy consumption **Efficiency in pollution prevention** AR12 – Proper treatment of collected wastewater AR13 - Emergency control discharges AR14 - Wastewater analysis AR15 - Compliance of discharge parameters AR16 - Sludge disposal

Figure 2: Indicators of the assessment system for the quality of the service

the operator's profile, the system profile, other contextual factors not included in previous profiles and the source data that feeds this information.

The methodology applied by ERSAR is based on a sequence of steps, in order for the system to be clear, rational and transparent. The annual procedure required to implement this methodology, from data collection by the operator to the disclosure of the final results by ERSAR, is shown in Figure 5.

Application of the assessment system

With the implementation of the assessment system and aware of the need for reliable information about the sector, ERSAR, as sector regulator, started in 2004 the publication of the RASARP (Baptista, 2004–2013), bridging this information gap. The concept of the assessment system is to raise the goals of the operators covered to their highest possible levels, corresponding to a desirable 'stage of excellence'.

The broadening of this system, applied to service providers across the whole of Portugal in 2011, was an important milestone and one of the first applications of its kind.

The success of the first three years of universal implementation of the assessment system is very positive, highlighting the operators' commitment to it. 100% of the water operators joined the assessment system, which is remarkable considering that there are 298 operators, of which 276 (15 bulk and 261 retail) provide public water supplies and 283 cover urban wastewater services (19 bulk and 264 retail), totalling 559 systems and more than 100 indicators for benchmarking activity. This assessment involved the training by ERSAR of 800 technicians from the operators and the conducting of 298 audits by a team of about 40 auditors.

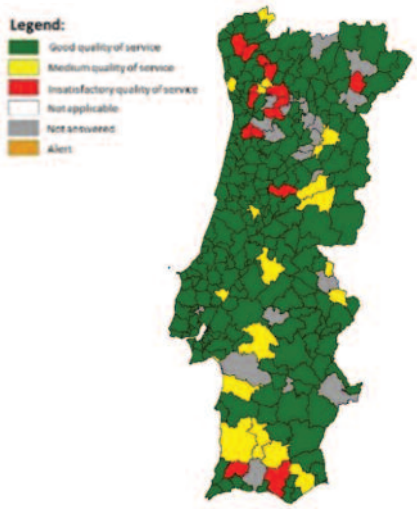
In the first year of application a huge effort was necessary on the part of the operators in order to gather all the information and provide as much data as possible. It is now accepted by the sector that the quality of service indicators, in addition to their regulatory objectives, are a particularly relevant tool to support systems management and to promote the ongoing improvement of the service's efficiency and effectiveness. Thus, ERSAR recommends the use of this instrument by all operators to assess the extent to which their own management objectives are being met, not only limited to these 16 indicators adopted for regulatory purposes, but encompassing a more complete set of indicators deemed relevant for each operator. Manuals of good practice are also available and may be consulted for this purpose on the ERSAR website (Alegre, 2004) and (Cardoso, 2004).

Regarding the results from the three first years of assessment, it was shown that the operators on average responded for about 75% of the applicable indicators, albeit with large variation in answering capability and in the quality of data reported. It is worth to highlight the existence of a significant number of operators that submitted all the requested data – 70 in water supply and 48 in wastewater services.

Reporting issues

Concerning the reporting of the required information, some aspects requiring improvement should be stressed, basically related the lack of a common method of applying accounting rules (hindering the reporting of accounts), and recording operation information and interventions within the network, as well as there being deficient or non-existent cadastres.

The findings have shown that the



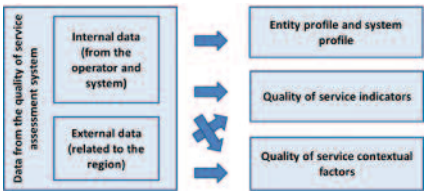


Figure 3: (Left and top right) Comparison of quality of service and accessibility in the Central and Lisbon region (%). Figure 4: (Bottom right) Components of the assessment system for the quality of the service.

OPERATOR TASKS	**Operator supplies data** ▪ Data collecting ▪ Self assessment of the quality of service ▪ Data input in quality of service module in ERSAR website ▪ Context factors selection (when applicable)
ERSAR TASKS	**ERSAR validates data for all operators** ▪ Compilation and cross validation of data ▪ Clarification of doubts ▪ Audits
	ERSAR processes data and interprets the results for each operator ▪ Analysis of indicators time evolution ▪ Interpretation of the indicators ▪ Contradictory procedure with each operator ▪ Indicators consolidation
	ERSAR processes data and interprets data for operators clusters ▪ Aggregation of the operators in clusters ▪ Summary of the results per indicator for each cluster ▪ Comparative analyses of the indicators per cluster of operators
	Publication and public disclosure of the quality of service annual report ▪ Preparation of the quality of service annual report ▪ Sending the information to each operator ▪ Public disclosure of the annual report

Figure 5: Annual assessment system of quality of the service

overall quality of service tends to be positive, with 'good' and 'average' classifications making up about two thirds of the bulk services assessment and about half of the retail services assessment.

With regards to water supply services, the most positive outcome of this assessment is the near universal access in place, particularly when in the early 1990s service accessibility was about 80%. According to a recent survey this value has reached 95%, i.e., the target set in the National Strategic Plan. It is also noteworthy that the quality of the water supplied by operators, once all tests have been made, reaches 99.85%, which represents a very remarkable progress when compared to the 80% estimated in 2000. Concerning the fulfilment of the parameter values, the percentage of supplied water with good quality is around 98%, indicating that tap water in Portugal has very high levels of quality.

Accessibility to sanitation services has also been increasing in the last decade, albeit at a slower rate compared to the water supply. Equally important are the positive results with regards to wastewater treatment, now at the level of 79% as a result of strong investment in recent years in treatment facilities in Portugal.

With the application of the quality of service assessment system what became evident was the level of application and adaptation undertaken by operators within their organisations in order to answer effectively the regulator's requests. It is also evident that there is a need to enhance information management in order to improve the quality of water services.

Aware of the challenges in the sector, we believe that the importance of the quality of service assessment has been unequivocally demonstrated, not just as a powerful tool to promote the efficiency and effectiveness of the activity performed by operators, but also as a way to provide relevant information to all stakeholders in the sector, namely the users of these essential public services.

As the service assessment system continues to run it seems that there are improvements in operators' responses and in several aspects of service quality. ●

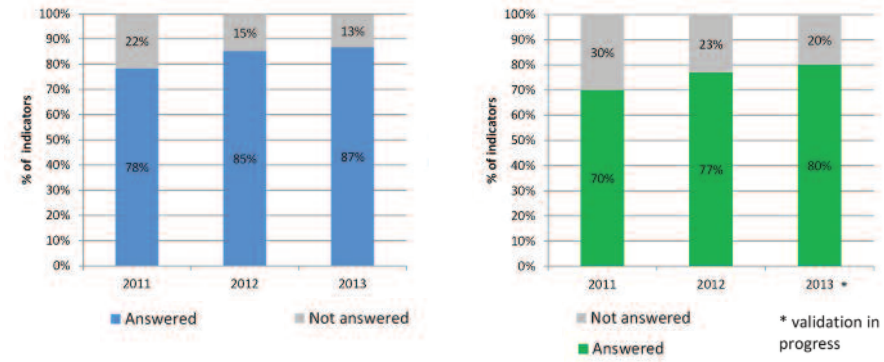


Figure 6: Percentage of responses in the first three years of application of the ERSAR assessment system

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Impact of commercial water losses on operators' unit costs and price of services

Commercial water losses are considered to be a major cause of water operators' inefficiency. In Portugal, abstracted water commercial losses reach 35% and a significant number of operators in retail systems have substantially higher levels of losses. **FILIPE RUIVO** and **MARIA MOINANTE** discuss the potential impact of water commercial losses on costs and prices charged for the water service and how regulation is aiming to support operators in achieving sustainable cost recovery.

Portugal's Strategic Plan for Water Supply and Sewerage for 2007-2013 (PEAASAR II) introduced various operational objectives, including: serving 95% of the total population of the country with public systems of water supply; reaching a usage level of the water captured and not lost ≥80%; optimising the operational management costs; and eliminating inefficiencies. In line with this, the indicator AA08ab non-revenue water (%), or business loss, defined in ERSAR's quality of service assessment, measures the percentage of water entering the system that is not billed (includes not only the real losses[1] and apparent losses[2], but also the unbilled authorised consumption[3]), which is a major cause of the inefficiency of the water supply management bodies.

For bulk systems, the cost of inefficiency of non-revenue water can be optimised to a technical threshold of 5%, and for retail systems the cost of inefficiency can be optimised to a technical threshold of 20%. Below the stated limits, it is considered that the management entities provide a good quality service (LNEC and ERSAR, 2012).

Between water abstraction and distribution to the end-user, many commercial losses may occur due to several factors: the condition of mains and other components, and the material they are made of; the frequency of leaks and ruptures; the average service pressure when the system is pressurised; the number and average length of connections; the total length of mains; the type of soil and ground conditions, which is particularly relevant in the way the occurrence of breakages and leakages become apparent or not; measurement errors; illicit connections; and fraudulent use of landmarks and hydrants (Alegre, 2005). The unbilled authorised consumption may include, among other purposes, fire fighting, flushing of pipes and collectors, and

municipal irrigation of green spaces. All these factors may result in environmental impacts, which can lead to either increased costs or reductions in revenue, and, in order not to compromise their sustainability (revenues must cover costs), the service operators may increase the price charged to users.

ERSAR has been encouraging and supporting the sector in view of increasing the efficiency of the supply chains in order to reduce the level of water losses through the implementation of an asset management policy, including the rehabilitation and renovation of infrastructures. As a regulator, ERSAR is responsible for ensuring a fair balance between users and operators, underpinning the protection of users' interests in relation to access, quality and price of the service, and safeguarding the economic viability of the operators.

In terms of pricing and its relation to the costs, it is considered important to note the following points.

In bulk systems the criteria for fixing tariffs or managing companies operating in the market under 'in house' concession schemes, in the legal regimes for granting state-owned systems, aim to: ensure, within the period of the concession, the amortisation of the initial investment charge of the dealership, net of reimbursements and outright grants; ensure the

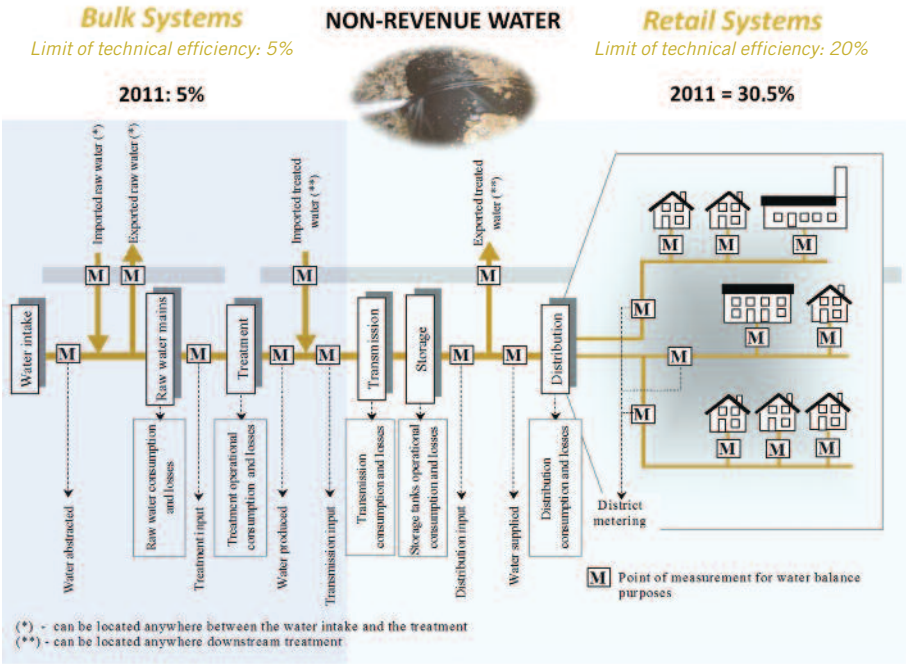

Figure 1: Definition of water supply system inputs and outputs and non-revenue water in 2011

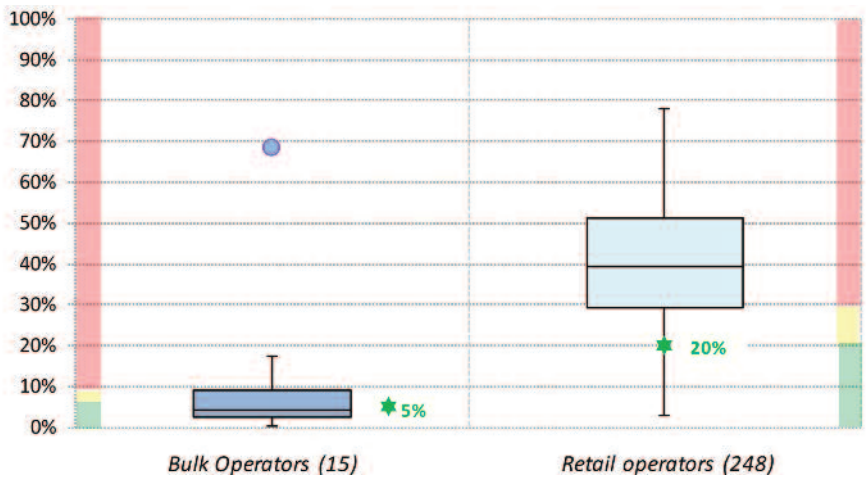

Figure 2: Diagram of extremes and quartiles: commercial losses in bulk and retail operators

maintenance, repair and renovation of all goods and equipment related to the award; ensure the amortisation technically required for any new investments for expansion and diversification of the system specifically included in the authorised investment plans; attend to the level of costs required for efficient management of the system and the existence of non-revenue from tariffs; ensure the recovery of charges legally fall on the provision of services, especially those related to tax; and ensure adequate remuneration of the concessionaire equity. It is still important to note that the tariffs are set so as to protect the interests of users, the efficient management of the system and sustainable conditions necessary to ensure the quality of service during and after the term of the concession. A common tariff must be applied for all service operators.

In retail systems, which are under municipal responsibility, the criteria for pricing depends on the management model, which can be: municipalities; local-owned companies; public partnerships between the state and municipalities; and private concessionaires of municipal systems. The management information, which gives information about the different types of costs incurred specifically with these services, is still insufficient in many cases, and in most cases prices do not reflect all costs incurred in providing the service.

After the first year of implementation of the quality of service assessment developed by ERSAR to all operators in mainland Portugal, it is important to have statistical information that allows us to assess the effect of non-revenue water on the level of costs and prices in order to find better ways of intervention in the sector.

Data collection and analysis

In addition to the items referred to in the literature, some statistical methods of data analysis collected and validated by ERSAR in assessing the quality of public water supply in mainland Portugal for the year 2011, and accountability, were applied in the preparation of this paper, including descriptive statistics, correlation and regression.

The indicators under analysis were:

- AA08ab– unaccounted for water (%), defined as: (dAA17ab / dAA14ab x 100), where dAA14ab is the water entering the system (m^3/year) and dAA17ab is the non-revenue water (m^3/year);
- Average price of the service (€/m^3), defined as: tariff income/dAA16ab, where dAA16ab is billed water (m^3/year);
- Unit costs (€/m^3), defined as: dAA51ab/dAA14ab, where dAA51ab is total costs (€/year).

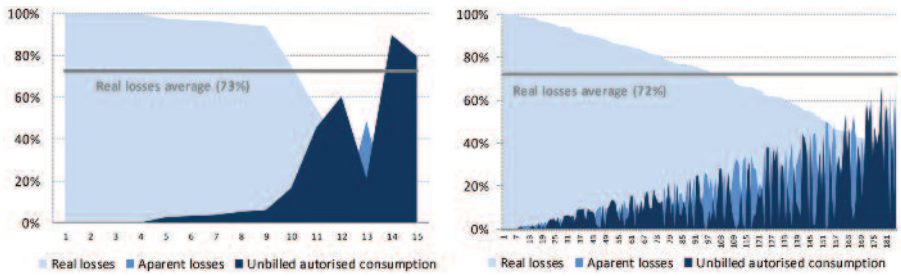

Figure 3: Non-revenue water in bulk (left) and retail (right) operators: % of real losses, apparent losses and unbilled authorised consumption

Commercial losses

In 2011, the commercial losses for water captured in mainland Portugal reached 35.5%; exceeding the 20% limit set in the quality of service assessment.

Figure 1 illustrates the principal inputs and outputs of a typical water supply system, from raw water intake to consumption by customers, comparing for bulk and retail systems the limits of technical efficiency (or good quality of service) with the result of the evaluation carried out in 2011 in mainland Portugal. Some systems will, of course, be simpler and will not have all of the features shown.

In the water supply bulk systems, losses reached 5% and are characterised by a low amplitude [0.4%, 17.4% without outliers]; 50% of the operators present loss levels below 4.1% (median) and losses located at the inter-quartile range [Q_1, Q_3] = [2.4%, 9.2%] are more concentrated in the bottom half. On the other hand, water losses from supply retail systems reached 30.5% and are characterised by a strong amplitude [3%, 78%]; 50% of the operators present loss levels below 39.3% (median) and losses located at the inter-quartile range [Q_1,Q_3] = [29.2%; 51.1%] are more concentrated in the bottom half (Figure 2).

Indeed, the problem is mainly in the retail systems, since about 90% of them have a degree of commercial losses of water above the good level of quality of service or the technical efficiency threshold.

Although the problems have different dimensions in both types of operators, if we break down the non-revenue water into its components, we can see that in both types of operators the main problem is the real losses (Figure 3).

The magnitude of the calculated values have, in theory, an impact on the efficiency of operators, in particular by increasing costs and, consequently, the price that has to be charged for the services, which tends to increase in order to cover the costs, or because there is no billing of water with related operating costs. However, the empirical evidence stemming from the tested sample does not always point so clearly to this relationship, due to some distortions, namely that in bulk services the total unit costs and tariffs have a strong positive correlation (ρ=0.81), but the variability of these

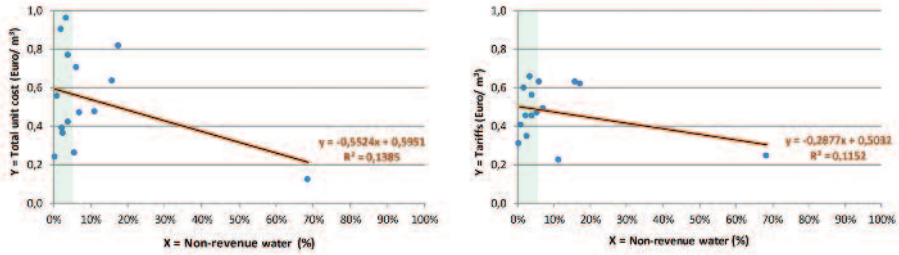

Figure 4: Non-revenue water in bulk operators: total unit costs (left) and price of service (right)

variables is little explained by non-revenue water ($R^2 \approx 0.1$). There are several operators that charge fees below the total unit costs (the highest) and do not reflect the actual cost or the total service in the rates, therefore not recovering the costs (Figure 4).

The legal framework of these operators, the intervention of ERSAR regarding economic regulation and quality of service in recent years, and the area of the value chain in which they operate, certainly contributed to these results.

In order to set their tariffs, operators of state-owned systems submit a budget and tariff project for the approval of the grantor (the state, represented by the Minister for the environment), which requires the (non-binding) prior opinion of ERSAR. There is a review mechanism, embodied in the direct regulation of the tariff. The concession agreements signed with the Portuguese state and the practice already established by ERSAR provide a model of cost plus ex-post. Indeed, the tariff review cycle (annual or multiannual) involves a critical analysis of all costs and its eventual impact on the tariff approved by the grantor, in whole or in part, considering the need to ensure accessibility for users.

In retail services the total unit costs and the average price of the service have a moderate positive correlation ($\rho=0.62$) and the variability of these variables also is little explained by non-revenue water ($R^2 \approx 0.1$) despite higher levels of water commercial losses. Most operators under the direct management models (municipal administrative bodies) do not have cost accounting systems in place to ascertain accurately the actual cost of the services. It follows that the price charged for services is set administratively, for political reasons, with little relation to costs (Figure 5).

It is considered important to note that in retail systems, one can distinguish two different processes for tariff approval:

- Municipal administrative bodies, where prices are fixed by the municipal council, although in the latter case based on its own budget of municipal services
- Local-owned companies, where prices are determined based on their own budget and approved by the city council, board of directors of the association of municipalities or regional board on a proposal of the board of directors of the company

The influence of ERSAR on the price established by operators in retail systems has been tenuous, bearing in mind their powers, and especially the power of municipalities in pricing due to local autonomy regime. Nevertheless, ERSAR has issued recommendations for the better definition and harmonisation of prices and also issues opinions (non-binding) on pricing updates in the case of operators with a contract.[4]

To ensure their sustainability, operators should apply unit prices that allow for the recovery of the cost of services (within the economic capacity of the population) but should also optimise the operational management, in order to eliminate inefficiencies and charge to the final user a sustainable level of costs.

Nevertheless, ERSAR has been encouraging and supporting the sector to increase the efficiency of water supply systems, to reduce the level of water losses through the implementation of a policy of asset management that includes infrastructures rehabilitation and renewal.

ERSAR has recommended a review of the practice that still exists in some cases, of non-billing of water consumption for watering gardens and municipal spaces, and other public uses or other unbilled consumption. Charging a fee to all water users tends to create more rational behaviours, so it is important as a measure to protect a resource that is scarce. Operators should also make an effort to reduce water theft, traditionally more common during periods of economic crisis, by strengthening inspections of building networks.

These practices enable a reduction of non-revenue water and consequent economic losses for operators, as well as greater equity in tariffs for water services to consumers.

Conclusions

Through the application of a quality of service assessment system, implemented by ERSAR since 2011 to all operators, it was possible to know and compare information that reflects levels of technical efficiency for various variables and indicators, allowing a comprehensive analysis of the sector. The publication of this information in a comparative form (benchmarking) induces operators to be more efficient at the various stages along the value chain of water supply service.

The level of non-revenue water has, in theory, an impact on the efficiency of operators, in particular by increasing costs and, consequently, the price that has to be charged for the services, which tends to increase in order to cover the costs, or because there is no billing of water with related operating costs. However, the empirical evidence stemming from the tested sample does not always point so clearly to this relationship. In mainland Portugal, non-revenue water is significant in retail systems, but the variability of unit costs and price of services is little explained by this variable.

To this extent, it is desirable to implement a better pricing methodology that can effectively reflect the real costs of the services and set standards for efficiency in the context of the on-going reorganisation of the water sector in Portugal to promote the sustainability of operators through an effective coverage of the costs

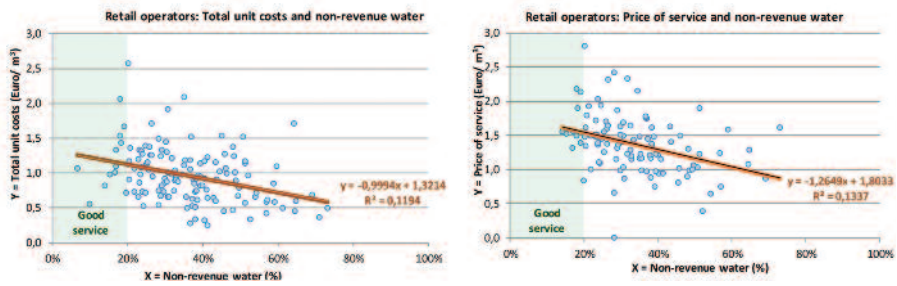

Figure 5: Non-revenue water in retail operators: total unit costs and price of service

of service provision, on the basis of productive efficiency, while, at the same time, affordable for users.

Last March (Law 10/2014) the new statutes of the Regulatory Authority for Water and Waste Services were published, reinforcing the powers of this entity in terms of pricing. Despite the measures already adopted by ERSAR in economic regulation (tariff analysis, recommendations, collection and processing information for all operators), regulation of service quality and regulation of water quality, it is expected that current changes to tariff regulation can complete the process to apply prices that are affordable for households but also promote an efficient service, using variables such as the level of water loss and the electricity consumption for water pumping that is being wasted by non-revenue water. ●

Notes

[1] *Real losses: physical water losses from the pressurised system, up to the point of the customer meter during the assessment period. The volume lost through all types of leaks, bursts and overflows depends on frequencies, flow rates, and average duration of individual leaks. (Note: although physical losses after the point of customer flow measurement are excluded from the assessment of real losses, they are often significant (particularly where customers are unmetered) and worthy of attention for demand management purposes).*

[2] *Apparent losses: accounts for all types of inaccuracies associated with production metering and customer metering, plus unauthorised consumption (theft or illegal use). (Note: Under-registration of production meters, and over-registration of customer meters, leads to under-estimation of real losses. Over-registration of production meters, and under-registration of customer meters, leads to over-estimation of real losses).*

[3] *Authorised consumption: the volume of metered and / or non-metered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorised to do so by the water supplier, for residential, commercial and industrial purposes, during the assessment period. It includes water exported. (Note (1): authorised consumption may include items such as fire fighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, building water, etc. These may be billed or unbilled, metered or unmetered, according to local practice; Note (2): authorised consumption includes leakage and waste by registered customers that are unmetered.)*

[4] *For the purposes of charging supply and sanitation, municipal and local authority services are subject to Article 16 of the Local Finance Law (Law nº. 2/2007, of 15 January), which provides that tariffs and the prices charged should not be less than the direct and indirect costs incurred in the provision of goods and provision of services.*

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CUSTOMER PROTECTION

The right to information – improving transparency for end-users of water services

A key factor in improving customer protection and empowerment is for water utilities and regulation authorities to provide sound information to end-users, which ultimately leads to improving the quality of the service provided. **ALVARO CARVALHO** and **DAVID ALVES** describe the process launched by the Portuguese Water and Waste Services Regulation Authority (ERSAR) in view of improving the quality of the information delivered by 343 Portuguese water and waste service operators on their websites and subsequent compliance levels.

The water sector constitutes a typical case of a network industry and, due to its high cost, the management of infrastructures creates situations of natural monopoly. As such, these markets are likely to produce information asymmetries, namely between water operators and the end-users of these services. For this reason, the provision of sound information to the end-users is increasingly regarded as a key factor in consumer protection and empowerment and for the accountability of water and waste operators. The latter are also increasingly aware that the lack of information or its bad quality can increase the potential for conflict with consumers and other players in the sector, with a likely increase in management costs. Sound information is therefore not only beneficial for consumers, but also for service providers. It is a fundamental tool for a good management of water utilities and ultimately for improvement in the quality of service provided.

European Union and member states' legislation and policies for consumers have witnessed a continuous development in recent years. National regulatory authorities are increasingly focusing on the issues related to consumer protection. In Portugal, The Water and Waste Services Regulation Authority (ERSAR) aims to protect consumer interests by promoting the quality of service rendered by the

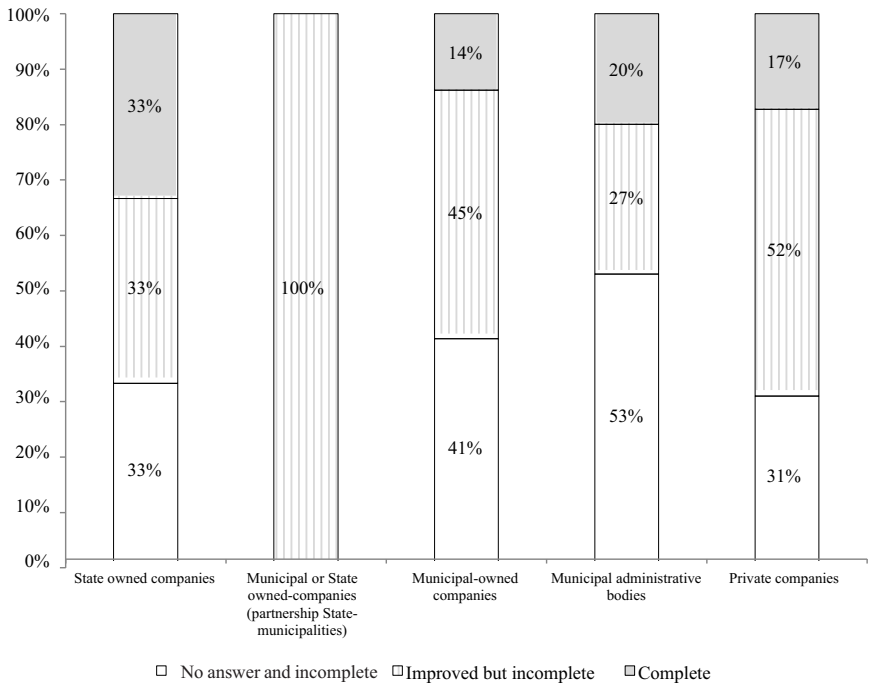

Figure 1: Compliance with the right to information on the websites of water and waste services operators according to operator's ownership

operators and guaranteeing socially acceptable prices. ERSAR also promotes a culture of concise and reliable information for all.

Fulfilling its obligations in this matter, ERSAR implemented some initiatives focused on the provision of sound information to end-users of these services, such as identifying the main contents of water and waste services invoices and issuing the Recommendation no. 1/2010 on this subject. It also published the Technical Guide no. 20 (Andrade et al., 2012), a detailed handbook about the relationship between operators and consumers that was accompanied by a programme of technical training for professionals of water and waste management utilities and by a communication initiative for consumers, with the development of a specific area for Frequently Asked Questions (FAQ) on the regulator's website and publishing a leaflet about 'Rights and duties of water and waste services consumers'.

The Portuguese law for the municipal water and waste sector (Decree-Law no. 194/2009) sets the rules on information duties of water and waste services operators towards the end-users of these services, namely in what concerns the information available in their websites. The fine for non-compliance with these rules was recently aggravated from a minimum of €10,000 ($11,290) up to a maximum of €500,000 ($564,000). ERSAR is responsible for enforcing and monitoring this legislation in Portugal.

Improving operator information

Following these initiatives, ERSAR launched a project aimed at improving the general quality of the information provided by the 343 Portuguese water and waste operators in view of stepping up their compliance with the aforementioned legal provisions.

For this purpose, ERSAR verified the existence of the following content on operators' websites: operator identification, competences and geographical scope; statutes and legal title for the management of the systems; annual reports and accounts; service regulations; tariffs; contract conditions; drinking water quality results, and other quality of service indicators; information on service suspension; contacts and opening hours. This was a challenging undertaking since this sector includes operators that differ in size, development stage, management model and in the services they provide (from single service water companies, to municipalities in charge of running all public services under local administration).

For this purpose, ERSAR outlined a three-phase process to take place between May 2012 and September 2013:

a) May-October 2012 – ERSAR searched and validated the contents of 343 water and waste operators' websites
b) March-April 2013 – the operators were called to comment on the results and perform the necessary adjustments to their websites
c) June-September 2013 – ERSAR performed a new search in the websites, cross-checked the results with the answers from the operators and disclosed the results to the operators and the public

Project results

The project showed that, if individually analysed, the majority of operators do comply with the rules for information for end-users, since in every aspect the compliance rate is above 50%. In several aspects this compliance rate is above 90% of the operators, but aspects like service regulations, contract conditions and information on service suspension are still lacking on many websites.

If a more stringent criterion is assumed, however, regarding the full compliance by operators with all the requirements, the overall results of the assessment showed that only 23.6% of the operators have full compliance after questioning and correction of the identified loopholes. Due to the intervention of ERSAR, 12.5% of the operators stepped up to full compliance and 27.1% made some improvements, but problems still remained after analysis. Almost half of the operators did not comment on the results and did not correct the loopholes identified (Table 1). This probably means that operators are not aware of the complete set of information they should provide on their websites and that some effort should be made in order to clarify and explain their main obligations. This should happen before entering into a more punitive regulatory intervention, since several operators did correct the information after being alerted to those incompliances.

Table 1: Overall results of the assessment

Assessment	No. of operators	%
Already provided all information	38	11.1%
Corrected all loopholes after questioning	43	12.5%
Corrected some loopholes but problems still remain	93	27.1%
No answer and problems still remain	169	49.3%
Total	**343**	**100%**

Table 2: Compliance with the right to information on the websites of water and waste services operators according to different criteria

Criteria	October 2012	June 2013	Variation (p.p.)
Operator identification, competences and geographical scope	99.7%	100.0%	0.3%
Statutes and legal title for the management of the systems	59.4%	59.4%	0.0%
Annual reports and accounts	89.8%	94.2%	4.4%
Service regulations			
Complete	68.5%	68.5%	0.0%
Incomplete	-	16.0%	-
Unavailable	31.5%	15.5%	-16%
Tariffs			
Complete	79.6%	84.3%	4.7%
Incomplete	4.1%	7.9%	4.4%
Unavailable	16.3%	7.9%	-8.2%
Contract conditions	60.3%	60.3%	0.0%
Drinking water quality results	85.0%	90.8%	5.4%
Information on service suspension	36.2%	50.7%	14.5%
Contacts and opening hours	99.7%	99.7%	0.0%

Results can also be analysed according to the nature of the operator's ownership (Figure 1). As pointed out, this sector includes operators that differ in management model, size, and development stage and in the services they provide. The Portuguese water and waste retail services are operated by 239 municipal administrative bodies, or 82% of the total, 29 municipal-owned companies and 29 private companies. The remaining four operators are three state-owned companies and one partnership between the state and the municipalities.

Full compliance with the right to information is consistently low regardless of the management model, in both public and private run operators. The strongest response to ERSAR's intervention came from municipal-owned companies (45%) and private companies (52%), and the answers delivered significant improvements, but still short of full compliance.

Furthering the analysis, the levels of compliance greatly differ depending on the different criteria outlined in the legislation (Table 2).

The highest compliance levels regard basic information on operator identification, competences and geographical scope, contacts and opening hours (nearly 100%). 90.8% of the operators present drinking water quality results, which can be explained by the historical precedence of these obligations and a much stronger legal and policy framework in this field. All other aspects (statutes and legal title for the management of the systems, annual reports and accounts, service regulations, tariffs, contract conditions and other quality of service indicators) have lower compliance levels. Overall, and in spite of a very uneven landscape, the results are not satisfactory. Sensitive issues for end-users, such as tariffs and contract conditions, need special attention by the operators.

The outcomes of phases a) to c) allowed for some improvement in the information made available to end-users: the only three operators that had no website launched their websites, there was an increase of 4.5% in the number of operators with tariffs available online and of 5.4% with drinking water quality data.

The process allowed ERSAR to clarify some aspects of the legislation and to assemble a set of recommendations to the operators in order to improve the standards of the quality of the information to end-users.

One legally binding aspect that was not clear for operators was that all municipalities must present the tariffs of drinking water supply services, wastewater management services and municipal waste management services in their websites even if the services are provided by a different operator.

The process also allowed ERSAR to disseminate good practices in this field.

Here are some examples:

- There must be clear information about fixed and variable tariffs, tariffs for domestic and non-domestic users or charges for connection and cut-offs in water supply
- For an easy access, tariffs should be presented in autonomous tariff documents preferably to their inclusion in regulations on taxes or price tables of the municipality
- The same applies to contract conditions, which are usually included in local regulations. Operators should create a specific area or field in the website to clearly outline all contract conditions applicable to end-users.
- Contract conditions must include clear and precise information about measuring, billing and collection, suspension of service, tariffs, complaints and conflict resolution
- No matter how scarce service suspensions (planned or unforeseen) are, websites should clearly identify the area where such events are reported
- A general recommendation is that, in cases of operators that also provide other services (municipalities are a clear example), relevant information should be aggregated in a dedicated area of the website

It should be noted that some operators go well beyond legal requirements and run detailed websites, sometimes with interactive menus where consumers can request service contracts, provide readings of water meters, make online bill payments, etc.

Experience shows that the method used to collect information and call for comments of the operators delivers interesting results and improvements in access to information, but it also has its shortcomings. In fact, we are facing time consuming technologically conservative procedures that demand personal handling of all data in a heavy routine where thousands of data need manual checking. In the future, a similar procedure should make use of ICT, which allow for monitoring the quantity and quality of the answers and a control of entries in real time. This should allow for important improvements in shortening the allocated time for the project while delivering results for the regulator, for operators and for consumers within a useful timeframe.

Conclusions

The project gave ERSAR a clear understanding of the shortcomings in the water and waste sector regarding the information available to end-users. The pivotal role of the regulator in consumer protection is to put in place a coordinated and focused intervention that pressures operators to step-up their levels of service quality.

The project allowed for improved regulatory intervention in view of strengthening the rights of consumers to access sound and reliable information as part of a wider effort to promote better water and waste services.

A softer intervention can bypass the

elaboration of a non-binding recommendation by the regulator for operators, stating guidelines and good practices in this matter, using national and international references. This appears as an important next step for capacity building in the sector.

A complete assumption of ERSAR's obligations in this matter will probably imply a bolder intervention from the regulatory authority. On the one hand, an increase in legislation enforcement is foreseeable, making full use of its powers to impose sanctions on operators.

On the other hand, the current procedure to monitor compliance with legal obligations is likely to be streamlined to an annual cycle, concurrent with the mandatory approval of some documents (namely, tariffs). This procedure should adopt quicker and more powerful tools embedded in the 'Portal ERSAR'; an information management system with an interface between regulator and operators. The use of this tool will pass to the operators the obligation to upload the relevant information that proves the fulfilling of their information duties towards consumers, namely by the upload of hyperlinks to selected contents of their respective websites. ERSAR will validate that information and build an information repository about each operator and, in the end of this process, ERSAR will publically disclose on the available platforms (website ERSAR, App ERSAR) all the relevant information aggregated in Operator's Characterization Sheets.

This should allow for the realisation of two central objectives in public regulation of water and waste services: the disclosure of sound and validated information to the public by the regulator, and the fulfilment of the fundamental right of end-users to all relevant information about the services provided. ●

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Best practices in water services tariff structures

Portugal's water regulator, ERSAR, developed tariff guidelines for water and wastewater services in order to achieve their financial and environmental sustainability. **CRISTINA RODRIGUES** discusses the development of the tariff regulations and the compliance of operators with the guidelines.

The social value of water is much higher than its economic value, namely given the fact that the right to water and sanitation have been recognised as human rights by the United Nations. This is one, but not the sole, principle that justifies state intervention.

Water services are provided in a natural monopoly and, in many countries, water operators are mainly public entities, which may increase inefficiency, and, therefore, should be mitigated by a regulatory intervention that simulates a competition market.

The provision of water services sometimes requires the intervention of a regulatory agency in order to prevent abuses of a dominant position and mistrust over the quality of the services provided. In fact, although drinking water in developed countries is of a good quality, there is still a preference for bottled water. According to a study published by the Portuguese regulatory agency, in 2007, 43-45% of the users did not usually drink tap water, despite its excellent quality (in 2007, Portugal 97% of the population had access to a safe water supply).

For the purposes of the present analysis, economic efficiency and affordability are two of the most important reasons for state's intervention. Economic efficiency is achieved when the marginal prices equal the marginal costs. Affordability can be accomplished by a price determination methodology that ensures that all users can access water services: two-tier tariffs combined with increasing block tariffs, in which the first block is highly subsided. This methodology was first presented by Coase (1946). He argued that a multi-tier pricing system, of which a two-tier tariff is the simplest form, ensures the operator's economic sustainability. Ramsey pricing, another methodology, considers heterogeneous consumers, proposing a non-uniform price structure that maximises the social well-being balanced with the operator's economic sustainability. As far as water services are concerned, Ramsey pricing may penalise end-users with an inflexible consumption limit, particularly economically-disadvantaged ones.

As mentioned before, lower prices in the first block ensure essential uses of water (e.g., drinking water and baths / showers) and safeguard human health. Higher prices in the subsequent increasing blocks aim to penalise non-essential water usage (such as watering gardens or filling pools) and water waste and highlights scarcity issues. The application of this methodology requires cross-subsidisation. It also promotes a sustainable cost recovery which is deemed a more realistic and pragmatic view.

Quentin et al. (2005) point out that block definition has to considerer the household size or the situation of families that share the same meter. Other issues important to guarantee the protection of users interests include: the value of tariffs charged should be proportional to the period the service was provided, to ensure that the variation of the billing

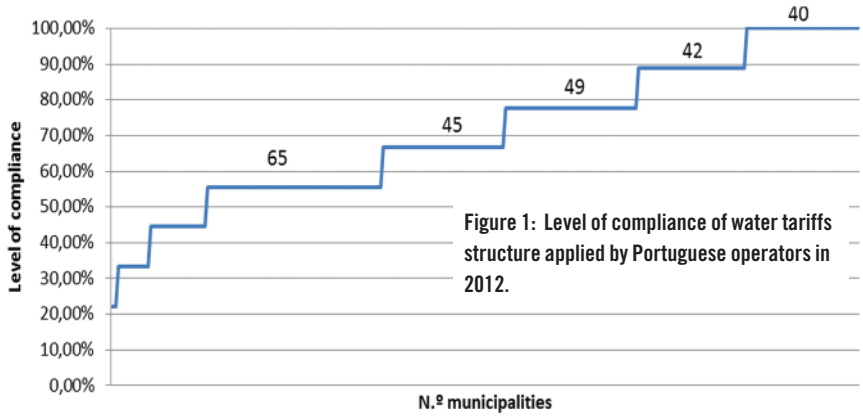
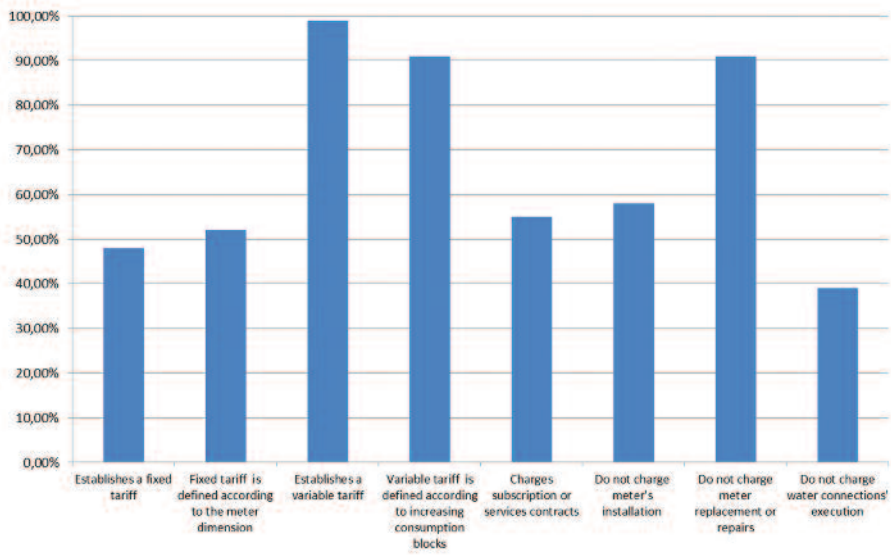


Figure 1: Level of compliance of water tariffs structure applied by Portuguese operators in 2012.

Figure 2: Answers about water tariffs structure applied by Portuguese operators in 2012.



period does not affect the price of service to the end-user; and no tariffs should be charged regarding access to water services (such as the subscription to or amendment of a water supply contract or the provision and installation of an individual meter), in order to prevent the existence of economic barriers to such essential services.

In Portugal, the above discussions were considered in the first regulatory instrument published by The Water and Waste Services Regulation Authority (ERSAR) – Tariff Guidelines. This recommendation was a response to the myriad tariff structures used in Portugal, which included no tariffs, only fixed tariffs, only variable tariffs with increasing tariff blocks or decreasing tariff blocks, etc. It also constitutes a recommendation on the formation of tariffs for drinking water supply and urban wastewater services provided to end-users, in conformity with provisions of paragraph d) of n.º 4, article n.º 11 of Decree-Law n.º 194/2009, of 20th August.

Portuguese tariff guidelines

The tariff structure recommended by the Portuguese regulator, in the Tariff Guidelines, has two parts: a fixed and a variable tariff. The proposed tariff structure is shown in Table 1.

Any additional services provided by operators should only be charged when requested or as the result from a breach of contract by the end-user. These services include: the implementation, maintenance and renewal of water connections; the subscription to or amendment of a water supply contract; and the installation, reading, repair or replacement of meters, security gauges or shut-off valves, unless for a reason attributable to the user. ERSAR's stance is that these services are necessary for water supply and sewerage functions and should not be subject to autonomous tariffs, with costs instead being recovered in the main tariff.

In 2012 an evaluation of the tariff structure applied to domestic end-users in 278 Portuguese municipalities was undertaken. Operators answered two questionnaires about their adopted tariff structure: one for the water services and another concerning wastewater services. The water service questionnaire concerning tariffs billed to domestic end-users, had nine questions: two concerning fixed tariff; three about the variable tariff and four regarding auxiliary services. The wastewater service questionnaire has seven questions: two concerning fixed tariff; one about the variable tariff and four regarding auxiliary services.

The questions related to the fixed tariff aim to show whether they are billed for a 30-days period, and if its value is equal to all domestic end-users with meters that do not exceed 25mm. The purpose of questions concerning the variable tariff is to assess whether increasing block tariffs are applied. The questions about the auxiliary services seek to determine if tariffs, such as construction and maintenance of connections, contracting services and meter installation (that according to the Tariff Guideline Recommendation should not be billed at all because of the free access to water services) are billed.

Three years after the publication of ERSAR's non-binding Tariff Guidelines Recommendation, the results showed that the average level of compliance with the tariff structure applied in 2012 was 70%, as shown in Figure 2. Compliance with regards to some of the specific

Table 1: Tariff structure recommended by ERSAR

Service	Tariff	Domestic end users	Observations
Water	Fixed	Two levels	For consumers with a meter exceeding 25mm shall be applied the non-domestic fixed tariff
	Variable	Four increasing blocks	1.º block =< 5m³ 5m³>2.º block<=15 m³ 15m³>3.º block<=25 m³ 4.º block > 25m³
Wastewater	Fixed	One level	
	Variable	Four increasing blocks	90% of the water consumption Blocks are equals to the ones applied in the water services

questions is shown in the Figure 3.

In Portugal's water sector, almost all tariff structures included a variable tariff. About 93% of variable tariffs applied are formed of increasing blocks. A fixed tariff is applied by nearly half of the operators and its structure depends on the dimension of the meter installed. Some tariff structures do not include a fixed tariff, which can be explained by a misunderstanding of the Public Services Law that prohibits the billing of minimum consumptions and meter rentals.

Connection and subscription charges represent the most difficult issue to resolve. Only 39% of operators do not charge for new connections. Additionally, 55% charge for the subscription or amendment of water contracts and 43% charge for the provision and installation of a meter, breaking the principle of free access to water services.

With regards to wastewater services, as shown in Figure 4, the average level of compliance with the tariff structure applied in 2012 is approximately 68%. Only 40 operators fully comply with the Tariff Guidelines Recommendation.

More than 90% of operators do not charge for repairs or the replacement of a meter, unless for a reason attributable to the user, and the provision and installation of an individual meter. On other hand, the subscription to or amendment of wastewater contracts is charged by nearly 75% of operators.

About 45% of the operators charge a fixed tariff and 70% of those have only one tariff for all domestic end-users, as recommended by ERSAR. 2014 should have been the end of the adaptation period. However, wastewater services show a significant delay: 15% of the operators still do not comply with half of the questionnaire items.

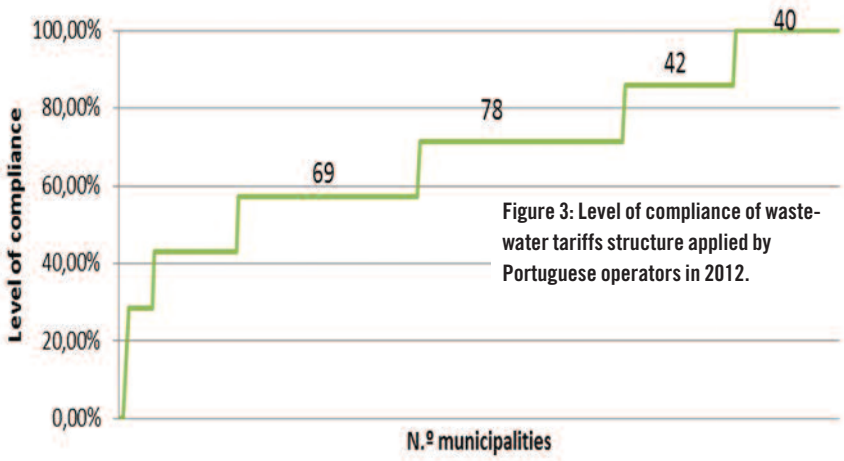
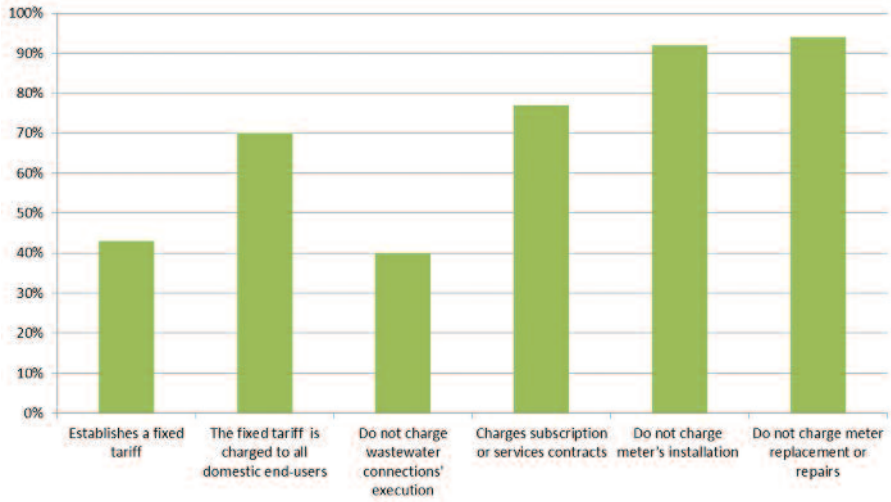


Figure 3: Level of compliance of wastewater tariffs structure applied by Portuguese operators in 2012.

Figure 4: Answers about wastewater tariffs structure applied by Portuguese operators in 2012.



Conclusions

Facing the issues of compliance with the Tariff Guidelines of the adopted tariff structure by the Portuguese operators and considering that five years have passed since their publication, the need to hasten this process it is recognised by all stakeholders. To this purpose, more effective regulatory mechanisms have been defined by the legislator and are already being prepared by ERSAR. The Portuguese regulator is formulating a binding Tariff Code.

Thus, a new process of tariff setting is being developed in accordance with legislation approved in 2013. It starts when operators ask the regulator's opinion about the proposed tariff, followed by the decision of the municipality (that has to justify any disagreements with the regulator's recommendation) and the reporting of the approved tariffs to the regulator. In order to evaluate the compliance of the approved tariffs with the Tariff Code and other relevant binding rules, ERSAR has implemented a financial audits programme. In case of a breach of the Tariff Code and other relevant binding rules, the regulator initiates an inquiry that may end with the imposition of corrected tariffs.●

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The first seven years of the world's largest non-revenue water reduction programme

Since 2007, Maynilad has reduced NRW in Manila by more than 800MLD (800,000 m³/d) (as of May 2014). **ROLAND LIEMBERGER** and **IRINEO DIMAANO** summarise the first seven years of this programme and provide key data.

In 2007, Maynilad Water Services, Inc. (Maynilad), the private water and wastewater service provider of the West Zone of Metro Manila (Philippines), had an enormous challenge ahead: to achieve 100% coverage within the next few years with basically no additional water resources. Some three million additional people needed access to piped water supply and the only way to meet this demand was to reduce water losses from the deteriorated distribution network.

Realising the significant challenge ahead, Maynilad contracted Miya, an international group specialised in urban water efficiency, to design the non-revenue water (NRW) reduction strategy and help with its implementation.

Key data

In 2007, before the start of the NRW management programme, the system characteristics were:

- NRW: 1506 MLD (66%)
- Length of mains: 4100km
- Number of customers: 703,000
- Continuous supply in 46% of the network
- Average pressure less than 10m

Six years later, the situation was as follows:

- NRW: 765 MLD (39%)
- Length of mains: 5897km
- Number of customers: 1,104,247
- Continuous supply in 97% of the network
- Average pressure 18m

The annual key data from 2007 to 2013 can be seen in Table 1 and demonstrates the achievements made since the start of the programme.

Phasing

The Maynilad NRW management programme can be divided into four distinct phases:

- 2007: NRW assessment and problem analysis
- 2008: NRW management strategy design
- 2009/2010: capacity building and transfer of technology
- Since 2008: large-scale implementation

When the situation was analysed in 2007 it came as a surprise that Maynilad had a generous infrastructure replacement budget, but did not pay enough attention to the operational aspects and related financial and human resource requirement of NRW management.

The NRW management strategy was designed in 2008, giving a strong focus on NRW operations and better targeted infrastructure replacement.

The challenge in 2009 was to provide sufficient training to a motivated but totally inexperienced team of some 400 engineers. International specialists for the various fields of NRW management were brought to Manila to train the young Filipino engineers.

International specialists were brought to Manila to train young engineers. Credit: Miya / Andrews L Mariano

Cost and financial benefits

Table 2 shows the reduction in capital expenditure (CAPEX) in 2009, and specifically 2010, which was made possible by a stronger focus on NRW operations, which enabled better targeting of investments for infrastructure replacement.

During the six years from 2008-2013 a total of $359 million was invested in NRW management, resulting in average cost of $484 per m³/d NRW reduction. Billed volume increased from 778 MLD to 1216MLD, which meant total additional water sales of 627 million m³ during this six year period. Conservatively valued at 30 Peso per cubic metre ($0.7) this increased water sales generated revenues of $437 million.

Institutional and human resource challenges

The size of the programme required drastic institutional changes. A NRW management department was established and all activities concentrated on this department. By establishing this one-stop-shop, it ensured that the NRW management team (together with Miya) was not only accountable for the results but also had all the means to achieve them.

Leak repair management serves as an excellent example to illustrate this. Before the start of this programme many different units were responsible to hire contractors and issue job orders for leak repair. This situation was highly unsatisfactory and nobody really knew how

Table 1: 2007 – 2013 Key data (annual data)

	2007	2008	2009	2010	2011	2012	2013
System input volume (MLD)	2284	2405	2426	2206	2143	2082	1981
Billed volume (MLD)	778	870	978	1026	1118	1177	1216
Non-revenue water (MLD)	1506	1534	1449	1180	1025	905	765
Average pressure (m)	<10	<10	11	14	16	17	18
Continuous water supply (% of system)	46%	58%	65%	71%	84%	96%	97%
Number of customers	703,000	730,623	784,334	857,002	950,378	1,043,193	1,104,247
Average customer consumption (m^3/d)	1.11	1.19	1.25	1.20	1.18	1.13	1.10
Population supplied (million)	6.5	6.7	7.1	7.4	7.9	8.2	8.4
Coverage (%)	81%	82%	86%	88%	93%	95%	96%
Length of mains (km)	4100	4200	4450	5000	5392	5477	5897

many leaks were repaired and how long it took to get the repairs done.

Leak repair management was therefore centralised under the NRW management department, which was then responsible for all leak repairs irrespective of geographical location and pipe diameter. By establishing this focused group it was possible to get more than 4000 leaks per month repaired and keep the backlog of repairs within limits.

When the NRW management department was created in January 2008 it had four managers and an executive assistant. By the end of 2008, 230 engineers had been recruited and this number nearly doubled in the following years (see Table 3). Only a fraction of these engineers were experienced water supply engineers from other departments of Maynilad (although with little to no experience in NRW management), but the vast majority were graduate engineers from the best technical universities of the country.

The challenge was then to train these newly recruited engineers as fast as possible and this was done with a mixture of classroom and primarily on-the-job training. Based on this experience, a standardised NRW management training and certification programme was developed but unfortunately this programme failed. The problem was that the often demanding exams did not bring any career benefits.

Passing NRW exams should have either been made a requirement for promotion or triggered some financial benefits, but since neither was the case, NRW managers and staff saw little reason to take the exams, and even if they did, many did not study hard enough to pass them. A great opportunity was wasted and it is now under discussion to plan a new start and get the framework conditions right.

Another human resource problem that has not yet been addressed is the absence of a technical / professional career path. So whenever an engineer did an excellent job and management wanted to raise his salary the only option was to promote him to some managerial position. This had two serious disadvantages: the experienced person was really missed in the position they held before and on the other hand, not every good engineer is necessarily a good manager.

Network zoning and DMA establishment

In 2007 the vast Maynilad water distribution network (then 4100km of mains and 700,000 service connections) was a totally interconnected and unstructured maze with incomplete network drawings and no hydraulic model. A few, often inaccurate, gauging points on the backbone of the system was all that was available. Clearly, the system was unmanageable.

It was tried to quickly split the system into large hydraulic zones (with reasonable success as it was often not clear whether these zones were really hydraulically discrete) and then further divided into small DMAs (between 500 and 1000 customers). The first 131 DMAs were established in 2007 and by May 2014 the total number of DMAs had reached 1430, which means that DMA coverage is in excess of 90% of the network. Clearly not all these DMAs are perfect (especially the early ones which were designed without a calibrated hydraulic model) and a lot remains to be done in the years ahead.

In order to prioritise the NRW reduction works in the DMAs, DMA categories were defined, based on the international physical loss target matrix (previously sometimes referred to as the WBI banding system) with an allowance for commercial losses added.

The four categories were defined as follows:

- A - World Class, no need for further NRW reductions
- B - Good NRW performance but

Table 2: 2007 – 2013 NRW management CAPEX and OPEX

Million USD	2007	2008	2009	2010	2011	2012	2013
OPEX	n/a	5	9	14	15	16	16
CAPEX	n/a	57	46	38	43	48	52
Total	n/a	62	55	52	58	64	68

Table 3: 2007 – 2013 NRW management staff numbers (end of year)

	2007	2008	2009	2010	2011	2012	2013
NRW staff	-	235	332	421	425	447	438

Table 4: Maynilad DMA NRW categories*

	NRW in liters per connection per day (w.s.p. = adjusted to 24h/day)					
	< 10 psi	11 - 20 psi	21 - 35 psi	36 - 50 psi	51 - 65 psi	66 - 80 psi
A	< 85	< 120	< 150	< 200	< 250	< 300
B	85 - 170	120 - 250	150 - 300	200 - 400	250 - 500	300 - 600
C	170 - 350	250 - 500	300 - 600	400 - 800	500 - 1000	600 - 1200
D	> 350	> 500	> 600	> 800	> 1000	> 1200

* The work on this matrix formed the basis of the International NRW Matrix later published by R Liemberger in 2010

Table 5: Maynilad DMA NRW performance – May 2014

	<10 psi	10-20 psi	21-35 psi	35-50 psi	51-65 psi	Total
A	2	120	278	32	14	446
B	1	77	118	25	3	224
C	4	90	147	13	2	256
D	9	239	230	22	4	504
Total	16	526	773	92	23	1430
A	13%	23%	36%	35%	61%	31%
B	6%	15%	15%	27%	13%	16%
C	25%	17%	19%	14%	9%	18%
D	56%	45%	30%	24%	17%	35%
Total	1%	37%	54%	6%	2%	100%

room for improvement
- C -High or very high levels of NRW, DMA needs immediate attention
- D - Extremely high NRW levels, immediate investigations and action planning required.

Table 5 shows a snapshot (May 2014) of the levels of NRW in Maynilad's DMAs. 47% had low or for the time being acceptable levels (category A and B) but NRW is still high or very high in the remaining 53% of the DMAs.

Trunk main inspection

In 2009 it was realised that losses from trunk mains were higher than common wisdom suggests and because of the low pressures and thick layers of road pavement even large bursts were not visible on the surface.

It was decided that a thorough trunk main inspection programme was needed and the chosen technology used was Sahara. A combination head for tethered in-pipe video and microphone was used. More than 450km of large diameter pipes have been inspected to date and the following has been detected:

- Small and large leaks
- Illegal connections
- Unknown off-takes to already decommissioned (and therefore completely deteriorated) parts of the network
- Unknown appurtenances such as sluice valves and butterfly valves

Physical loss reduction

From the beginning of the project it was clear that the reduction of physical losses will be the main challenge. The numbers in Table 6 prove this; until the end of 2013 there have been:

- 28,000 leaks detected
- 240,000 visible and non-visible leaks repaired
- 1366km of pipelines and associated service connections replaced
- 84,000 leaking service connections replaced

Reduction of commercial losses

The activities undertaken to reduce commercial losses can be grouped as follows:

- Improvement of metering of large customers
- Rectification of metering in 'blighted' areas
- Detection of illegal connections
- General domestic meter replacement

The improvement of large customer metering was the first priority since the top 7% of Maynilad's customers accounted for 25% of the billed volume and 48% of all revenues (December 2008). The right-sizing and replacement of the meters of the largest customers was therefore of utmost commercial importance. Starting with the largest 100 key accounts in 2009, meanwhile more than 3000 of the top customers have been installed with properly sized, top quality water meters.

Long 'spaghetti' lines in the blighted areas caused unnecessary leakage, made meter reading difficult and time consuming and were prone to illegal (sub) connections. By transferring all customer meters to the main roads and clustering them in blocks (meter banking) of 50, 100 or more, these three problems were solved at once.

There is no specific illegal connection detection programme. Illegal connections are detected as a by-product of leak detection or other field activities. Large scale domestic meter replacement is done based on a set of criteria to ensure that the average meter under-registration is kept within limits.

Data collection and management

It has long been recognised that NRW management is data hungry. Thousands of flow and pressure measurement points, all equipped with SMS or GPRS data

Table 6: 2007 – 2013 Physical loss reduction activities

	2007	2008	2009	2010	2011	2012	2013	Total
Non-visible leaks detected	no record	no record	2177	4959	5638	6679	8289	27,742
Leaks repaired	17,497	12,698	18,149	45,152	44,328	51,959	48,612	238,395
DMAs established	131	264	187	110	138	441	101	1372
Pipeline replacement (km)	250	290	200	88	202	160	176	1366
Service connection replacement (number)	6824	4952	7078	15,753	15,465	18,127	15,760	83,959

Table 7: 2007 – 2013 Customer meter improvement

	2007	2008	2009	2010	2011	2012	2013	Total
Replacement of large accounts meters	-	-	100	1052	591	1007	530	3280
Replacement of domestic meters	-	82,000	69,000	87,000	117,000	106,000	236,000	615,000

Table 8: 2007 – 2013 Water loss performance indicators

	2007	2008	2009	2010	2011	2012	2013
NRW l/conn./d (w.s.p.)	2935	2658	2239	1610	1172	885	688
Infrastructure Leakage Index (ILI)	352	255	181	104	68	50	38

After six years NRW has dropped from 66% to 39%. Credit: Miya.

transfer, have been established during the last six years. It is of course impossible to manually collect, sort and analyse this enormous amount of data.

Therefore the best and most comprehensive software system, 'Netbase', developed by Crowder Consulting in the UK, has been installed. In a unique way Netbase links time series data (flow and pressure) with all corporate data systems (like GIS, billing system, work management system, etc.). One can therefore access all data by a single user interface, combine various data and generate reports and analyses.

Results and conclusions

During the first seven years of the project, Maynilad invested more[1] than $359 million in NRW reduction. The results[2] are impressive:

- NRW reduced by 741 million litres per day (741,000m^3/d)
- System input volume reduced by 303MLD and at the same time billed consumption increased by 438MLD
- Additional two million people supplied (by connecting 401,000 additional customers between 2007 to 2013)[3]
- Level of service (water quality, supply time, pressure) greatly improved

The water loss performance indicators in Table 8 give a clear indication of the magnitude of the achievements:

- NRW expressed in litres per connection per day (w.s.p.)[4] has been reduced from 2935 l/conn./d to 688 l/conn./d – which is a reduction of 77%
- Even more impressive is the achieved reduction of the Infrastructure Leakage Index (ILI)[5] which dropped by staggering 89%
- However, the numbers also show that there is still a long way to go, as one would certainly target a single digit ILI for a well-run water utility, even if in a low or middle income country

The project demonstrates that even in a distribution network as deteriorated as the one in Manila, significant NRW reduction can be achieved without replacing the entire system. A well balanced mix of cost effectively targeted infrastructure replacement and professional NRW management operations is the key to successful NRW reduction. ●

Notes

[1] *Data from 2007 not available*

[2] *The volumes are the difference between annual daily average 2013 and 2007*

[3] *May 2014: 460,000*

[4] *w.s.p. stands for when the system is pressurised and means that the indicators have been adjusted to continuous supply*

[5] *The ILI is the ratio between the present volume of physical losses and the minimum achievable. For example, the national average in Australia is about 1.5 – this means physical losses are only 50% more than the minimum achievable. In low and middle income countries ILIs of 80 or more are frequently observed.*

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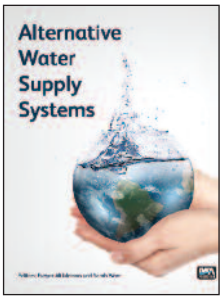
Alternative Water Supply Systems

Editors: Fayyaz Ali Memon and Sarah Ward

● Owing to climate change related uncertainties and anticipated population growth, different parts of the developing and the developed world (particularly urban areas) are experiencing water shortages or flooding and security of fit-for-purpose supplies is becoming a major issue.

The emphasis on decentralised alternative water supply systems has increased considerably. Most of the information on such systems is either scattered or focuses on large scale reuse with little consideration given to decentralised small to medium scale systems. Alternative Water Supply Systems brings together recent research into the available and innovative options and additionally shares experiences from a wide range of contexts from both developed and developing countries.

Alternative Water Supply Systems covers technical, social, financial and institutional aspects associated with decentralised alternative water supply systems. These include systems for grey-water recycling, rainwater harvesting, recovery of water through condensation and sewer mining. A number of case studies from the UK, the USA, Australia and the developing world are presented to discuss associated environmental and health implications.



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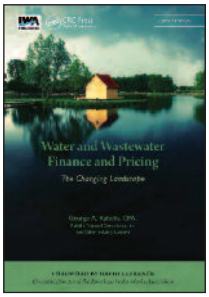

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Transforming Our Cities: High-Performance Green Infrastructure

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Author: Marcus Quigley

● Traditional approaches to stormwater management include construction of large, centralised end-of-pipe or interceptor solutions that can be extraordinarily expensive. The goal of this research is to look beyond conventional approaches to stormwater infrastructure and examine the effectiveness of various decentralised controls that use natural elements to dampen stormwater surges.

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