PAPER 12

ACHIEVEMENTS ON Non Revenue Water (NRW) REDUCTION: 2 DETAILED CASE STUDIES

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ABSTRACT

All around the world, water resources are subject to significant stress from human water demand. Water demand is made of the domestic and industrial consumption but also the network losses. Identifying and reducing these water losses is therefore a major functional requirement regarding the sustainability of drinking water utility.

Indeed, the way for water utilities to gain significant volume of resources and ensure a sustainable service is mostly based on the reduction of the large amounts of produced drinkable water which are lost in the network. The understanding of the loss types and the associated volumes is not an easy task and is the key first step to define a proper action plan. Suez, a French-based utility, has a long track record of performing such assessments in many operational contexts and has collected a great experience in this technical analysis. The two case studies presented here are part of this experience.

However, the economic feasibility of the reduction measures is the second key issue for the utility. As a matter of fact, the cost of each cubic meter saved varies depending on the method used. The utility may have limited budget resources to execute the defined action plan. Therefore, the selection of these water loss reduction activities should be assessed based on studies and successful experiences, to compose the most cost-effective combination possible. This combination is unique for each network, but some common elements can be discerned.

This paper provides detailed feedback on 2 case studies: Bordeaux (France) and Sao Paulo (Brazil). In these two cities, significant reduction of water losses was achieved and carefully documented by Suez during the years of execution, considering all the parameters and reporting several performance indicators in a way to have a holistic panorama and understanding.

The results shared present a detailed breakdown of the reduction achieved, by type of activity and with quantified evaluations, with both volume and cost breakdowns. The International Water Association having identified and documented the 4 pillars to tackle the real losses, the feedback will be presented on this scheme for better divulgation.

This feedback gives actual inputs regarding the cost benefits analysis which is a key part of any NRW reduction action plan. With the establishment of an effective and adequate water loss management action plan, the utilities can recover the large volumes of water lost through leaks and pipe bursts.

1. INTRODUCTION

Water utilities traditionally put a lot of energy and Operational Expenditure (OPEX) in leak detection and in the speed and quality of repairs. Depending on each case, this approach can give results with a skilled workforce and/or high-level service providers. But with ageing infrastructure, soon a point is reached when the increase of efforts will not bring more results and it will become a challenge not only to keep reducing NRW but even to maintain stability thereof.

The natural tendency of degradation of the drinking water network can be balanced by maintenance and renewal programs together with appropriate operational procedures. Reducing system losses is a global challenge that involves the entire organization of a water service authority. It goes beyond leak detection campaigns.

The methodology and activities described in this paper are directly based on the return of experience from expert engineers and the implementation of innovative methodologies and technologies.

SUEZ has been developing, deploying, and improving methodologies on its own drinking water networks bringing to the utilities the optimum results in terms of reduction of water losses, reduction of associated costs (both CAPEX and OPEX), improvement of operational capabilities, and improvement of level of service.

This paper aims to provide detailed feedback on the NRW assessment methodology and action plan definition and deployment, from two real case studies with a very different collaboration formats with local authorities: the City of Bordeaux, in France, and the City of Sao Paulo, in Brazil.

2. METHODOLOGY

Water losses are a combination of Physical Losses and Apparent Losses. Both need to be carefully evaluated to quantify expected outcomes of targeted actions. The International Water Association (IWA) has identified and documented the 4 pillars to tackle the physical losses challenge and bring physical losses down to the Unavoidable Annual Real Losses (UARL), the Unavoidable Background Leakage (UBL) and theoretical values. In the same way, 4 main pillars have also been identified and documented to deal with apparent losses challenge and bring commercial losses down to the Unavoidable Apparent Losses theoretical value.

An overview adapted to the characteristics of the network is essential to give a strategic vision and define an action plan with targeted goals.

1.1. Water balance and diagnosis

Improvements can only be achieved based on a specific diagnosis with the participation of the utility's different services and the subsequent development of an action plan.

That is the reason why we developed tools for Diagnosis & Strategy definition to support our operational units.

These tools are based on the operational feedback given by our operations like the two case studies presented in this article.

1.2. Action plan definition

The same expertise-based tools used for the qualitative and quantitative diagnosis is used for strategic planning. These tools are used to assess and suggest actions for reducing both Real Losses and Apparent Losses. Water Losses are divided into different categories requiring different types

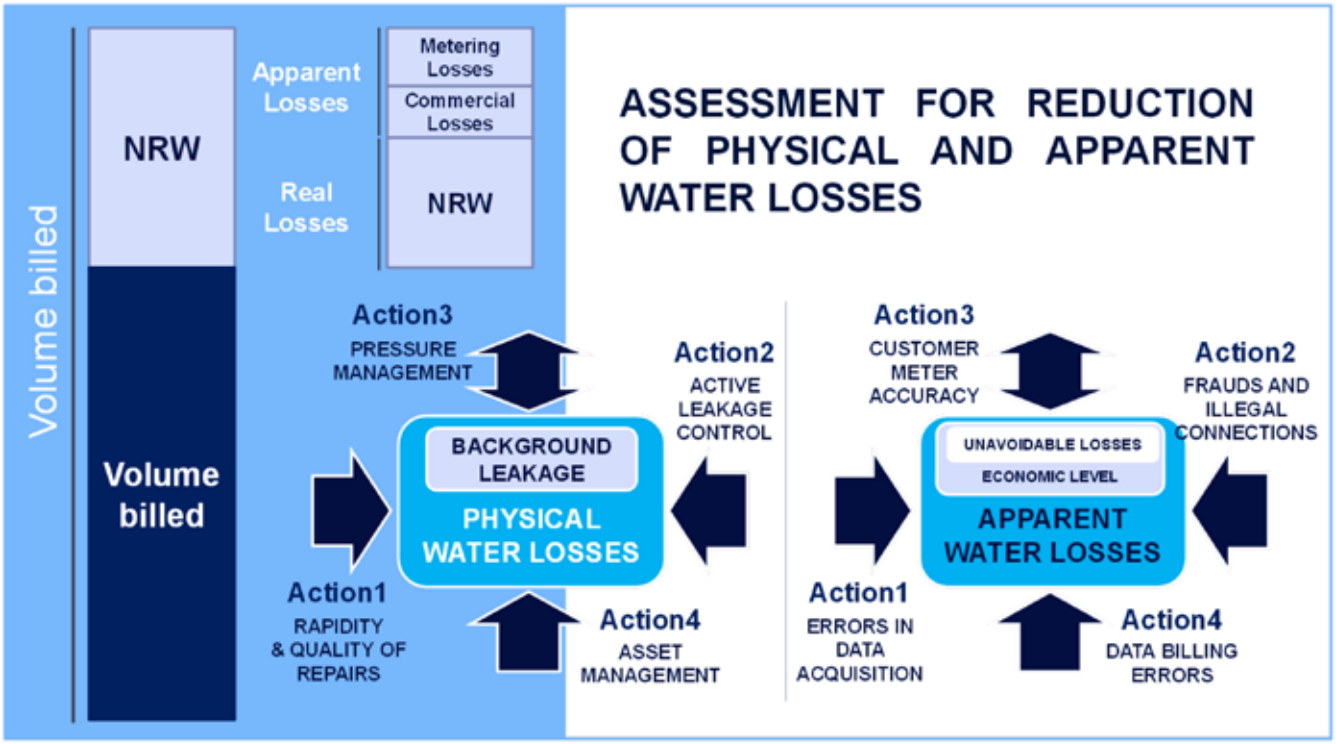

FIGURE 1: *Assessment for reduction of water losses*

of actions which can be carried out thanks to expertise and dedicated field solutions. Actual water losses are modelled to forecast NRW reduction, define, implement, and monitor an action plan dedicated to a specific network.

Diagnosis & Strategy methodology is, thus, composed of 4 steps:

- Data Collection & NRW Baseline
- Operational Assessment
- NRW Forecast
- Action Plan definition

REDUCTION OF REAL LOSSES

Physical Water losses exist in every system, whatever its configuration, age, material used or socio-economical context (industrial zone, municipal, etc.). Thus, each system is different. According to that principle, solutions to reduce NRW cannot have the same impact everywhere.

As stated by IWA, there are 4 main type of actions to deal with physical losses reduction:

- Rapidity and quality of repairs
- Active leakage control
- Pressure management
- Asset management

Our experience has shown us that, to reduce NRW volumes it is necessary to acquire a good understanding of the hydraulic functioning of the system through data collection and validation in order to analyze where the possible improvements are.

Figure 2 illustrates this idea by a simple example: depending on the network position on a graph combining volume losses (Infrastructure Leakage Index: ILI) and burst rates, different types of actions will be prioritized.

This kind of knowledge is an essential first step to initiate a process defining the technical and economic solutions better suited to local needs and context to reduce NRW.

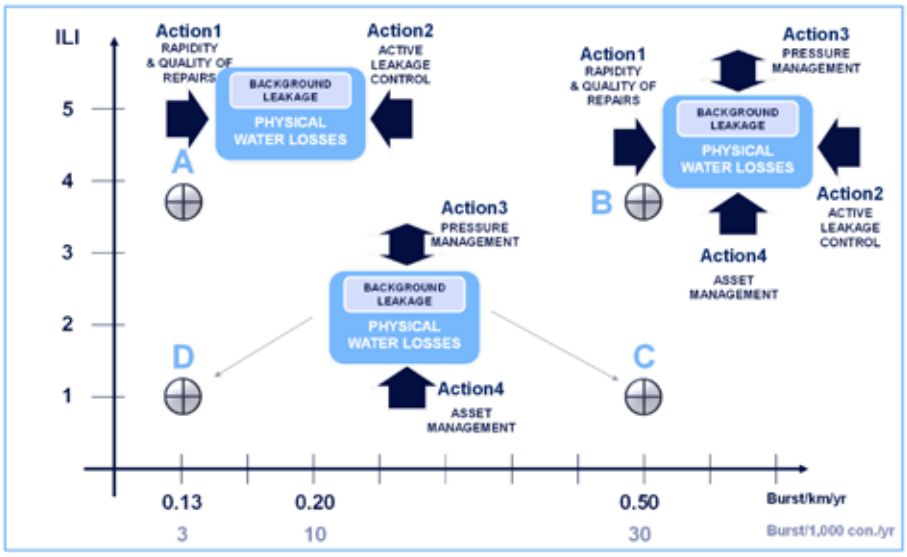

FIGURE 2: *Main actions related to IWA indicators and level of performance*

REDUCTION OF APPARENT LOSSES

Water Losses (WL) in drinking water networks can be Apparent Losses (through metering inaccuracies, poor data gathering, or theft, also) referred to as commercial losses.

According to World Bank 2016 figures, Apparent Losses in developed countries could account up to 20% of total NRW, while in developing countries it could account up to 40% of total NRW. In some cases, Apparent Losses can amount to a higher volume of water

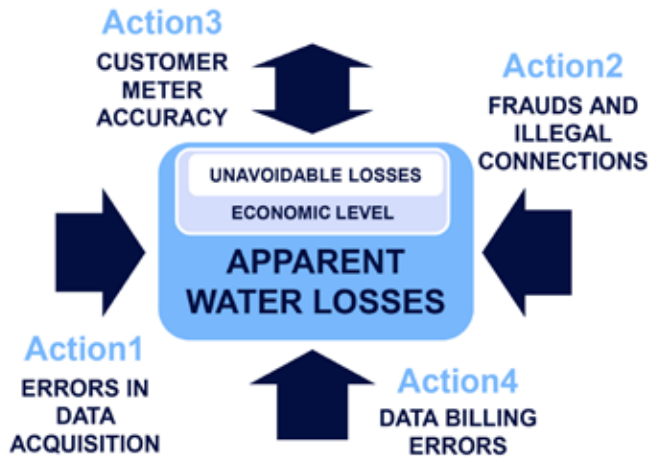

FIGURE 3: *Actions for reducing apparent losses*

than Real Losses and often have a greater value, since reducing Apparent Losses increases revenue (volumes invoiced), whereas Real Losses reduce production costs.

To be able to implement an efficient Apparent Losses reduction plan requires many types of expertise. The diagram below was developed by the Apparent Losses Initiative, launched by the International Water Association in 2007. It is now widely used internationally as a simple means of explaining the four basic categories of activity that need to be under control for effective operational management of Apparent Losses.

The four main categories of actions to get Apparent Losses under control are listed below:

- Errors in data acquisition
- Fraud and illegal connections
- Customer meter accuracy
- Data billing errors

Return of experience and data from SUEZ long term delegated management contracts have been incorporated to the methodology described, to cover the entire water cycle value chain and related customer management processes: relations with end-users and consumers, meter reading and the collection of payments made by end-consumers.

IMPLEMENTATION OF ACTION PLANS

SUEZ action plans are a combination of services structured in Figure 4.

3. RETURN OF EXPERIENCE ON DEVELOPMENT AND EXECUTION OF STRATEGIES AND ACTION PLANS FOR REDUCTION OF WATER LOSSES IN DRINKING WATER NETWORKS

This paper gives detailed feedback on two case studies: Bordeaux andSao Paulo. In these two cities, significant reduction of water losses was achieved and carefully documented during the years of execution, considering all the parameters, and reporting several performance indicators in a way to have a holistic panorama and understanding. This feedback gives actual inputs regarding the cost and benefits analysis which is a key part of any NRW reduction action plan.

FIGURE 5: *City of Bordeaux, France. @Valentin Wechsler on Usplash*

3.1. Case of Bordeaux, France

Bordeaux Métropole is the public entity in charge of the entire water cycle in the metropolitan area of Bordeaux, Southwest France, operating the service all along its value chain: drinking water production, conveyance, distribution, wastewater collection, treatment, and recovery. In 1992 a Public-Private Partnership (PPP) was established between the Bordeaux Metropole and SUEZ through a 30-year concession contract for the management, operation, and maintenance of the drinking water network.

Scope

At the end of 2006 Bordeaux Métropole, asked SUEZ to reduce the existing NRW volumes, which were around 20%, through an O&M

FIGURE 4: *Main pillars for NRW reduction and operational improvement in Water Networks*

contract with Performance Based remuneration, within a term of 5 years (2006-2011).

Main objectives and activities regarding this project were set because of the deployment of this expertise-based methodology for Initial Water Losses Assessment, to determine the following best matching cost-efficiency strategies and services to be deployed:

- Leak inspection planning and leak detection campaigns over 1,912km
- Network sectorization
- Optimal pressure regulation and control to reduce NRW
- Renewal of service connections
- Pipe renewal strategy and execution
- Optimized meter renewal plan
- Real Time Monitoring

Key figures at the commencement of the term are indicated in Table 1:

TABLE 1: *Key figures in Bordeaux before the assessment and implementing actions*

800 thousand number of inhabitants in Bordeaux Metropole	**233 thousand** number of customers in Bordeaux Metropole	**3,160 km** of water pipes in the drinking water network
50 million cubic meters of drinking water supplied each year	**188 thousand** number of service connections	**24%** water losses before actions

Actions executed

Improve the network efficiency and the quality of the distributed water while reducing NRW levels. An action plan was implemented and executed to reduce physical losses and apparent losses on the network:

- Reduction of physical losses

Leak detection

- Advanced Leak Detection activities over 8,600km between 2007 and 2011, improving leakage detection efficiency in 45% in terms of km/leakage.
- Study and execution of the District Metered Areas (DMA) division of Bordeaux Metropole drinking water network. Sectorization Level I (14 District Metered Areas) and Sectorization Level II (25 District Metered Area).

Advanced pressure control

- Pressure modulation over 2 big areas covering the 30% of the water distribution network (over 800km of network and 150,000 customers) with an average reduction of 1 bar (daytime) and 2 bars (nighttime).
- Pressure regulation achieved outcomes of 25% reduction of leaks in service connections and 19% reduction on distributed volume.

Asset management

- Use of Data Driven models to assess and implement optimized strategies for asset management (mainly renewal planning) on service connections and water distribution pipes. Models used included time-dependent variables like climate.
- Following optimised strategies were implemented on the study period (2007 – 2011): Renewal of Low Density Polyethylene (LDPE) and Lead service connections, and targeted pipe renewal

- Reduction of apparent losses

Revenue improvement

- Use of property Data Driven models to assess and implement optimised strategies for meter renewal prioritisation, strategies assessment and evolution of unmetered volumes

Results

The following results were achieved at the end of the project:

TABLE 2: *Key figures in Bordeaux after the assessment and implementing actions*

-14 pts NRW level reduction achieved from 24% to 10%	**2.7 million** cubic meters of drinking water preserved each year	**25%** of burst reduction in service connections

Figure 6 and Figure 7 represent the contribution of each action deployed to the global reduction of NRW losses, and the cost saving due to interventions.

FIGURE 6: *Contribution of actions implemented to the reduction of NRW level*

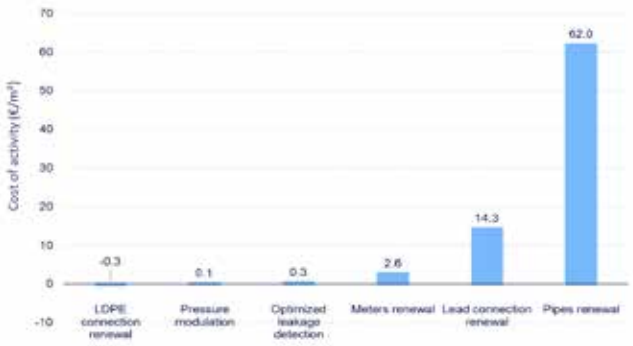

FIGURE 7: *Cost comparison of spared m3 by action*

FIGURE 8: *City of Sao Paulo, Brazil. @Konevi on Pixabay*

3.2. Case of Sao Paulo, Brazil

SABESP (Companhia de Saneamento Básico do Estado de São Paulo) is a mixed capital company founded in 1973 which is currently responsible for supply, collection, and treatment of water in the 375 municipalities of State of São Paulo. SABESP is one of the world's largest sanitation companies providing water and sewage services to over 28 million people. Since 2010 SABESP is collaborating with private companies in the framework of O&M Performance Based Contracts for reduction of NRW and improvement of water networks.

Scope

In 2019 SABESP awarded SUEZ with a 5-year (2019-2024) O&M contract with Performance Based remuneration for the reduction of the existing NRW volumes in the district of Grajaú located in the South Zone of São Paulo.

Main objectives and activities regarding this project were set because of the deployment of expertise-based methodology for Initial Water Losses Assessment, to determine the following best matching cost-efficiency strategies and services to be deployed:

- Leak inspection planning and leak detection campaigns over 1,322km
- Network sectorization
- Optimal pressure regulation and control to reduce NRW
- Renewal of service connections
- Pipe renewal strategy and execution
- Network reinforcement planning and execution
- Optimized meter renewal plan

Key figures at the commencement of the term are indicated in Table 3 below:

TABLE 3: *Key figures in Sao Paulo before the assessment and*

344 thousand number of inhabitants in Grajaú district (Sao Paulo)	**162 thousand** number of customers in Grajaú district (Sao Paulo)	**660km** of water pipes in the drinking water network
40 million cubic meters of drinking water supplied each year	**144 thousand** number of service connections	**44%** water losses before actions

Actions executed

Improve the network efficiency and the quality of the distributed water while reducing NRW levels. An action plan was implemented and executed to reduce physical losses and apparent losses on the network:

- Reduction of physical losses

Leak detection

- Advanced Leak Detection activities over 1,320km of the distribution network between 2019 and 2021, reducing the initial losses from 1,490,099m^3/month (44% NRW) to 1,066,220m^3/month (32% NRW).
- Study and execution of the District Metered Areas (DMA) division of Grajaú sector in São Paulo drinking water network. Sectorization Level I: including 19 District Metered Areas, 15 new Pressure Reduction Valves and optimization of 27 existing Pressure Reduction Valves (PRV).

Advanced pressure control

- Smart pressure control and transient mitigation to reduce operations costs and improve service level
- Pressure modulation covered 660km of water networks for 161 thousand customers, reducing peak 40mH_2O to 30mH_2O (from 4 to 3 bar)
- Design and build of the Marilda reservation with 10,000m^3 to change the water distribution by pumps to gravity.

Asset management

- Use of water network models to assess and implement optimised strategies for asset management (renewal planning) on service connections and water distribution pipes.
- Following optimised strategies were implemented on the study period (2019). Renewal of 16 km of LDPE using trenchless technology and 657 Lead service connections

- Reduction of apparent losses

Revenue improvement

- Evaluation and improvement of client's meter renewal plan for the increase of billed water
- Execution of optimised strategies for meter renewal on the study period (2019-2021) led to under metering reduction with relevant volumes recovered. 5,000 meters were replaced according to an initial action plan

Results

The following results were achieved at the end of the project:

TABLE 4: *Key figures in Sao Paulo after the assessment and implementing actions*

-12pts NRW level reduction achieved from 44% to 32%	**5 million** cubic meters of drinking water preserved each year	**21%** of burst reduction in service connections

Figure 9 and 10 represent the contribution of each action deployed to the global reduction of NRW losses, and the cost spared by action.

FIGURE 9: *Contribution of actions implemented to the reduction of NRW level*

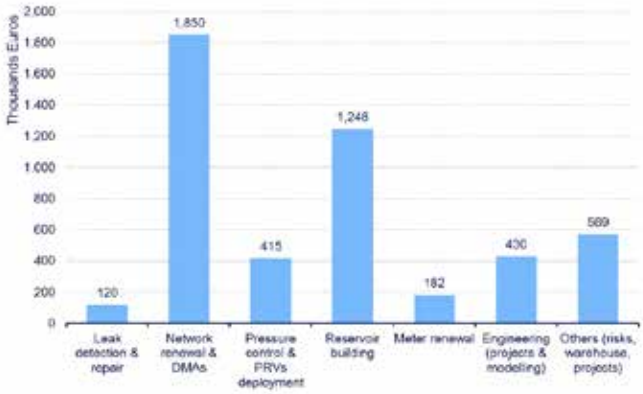

FIGURE 10: *Cost comparison by action*

4. CONCLUSIONS

The action plans of SUEZ are a combination specific services designed for NRW reduction and Operational Improvement, which integrates the expertise as operator with the best combination of advanced field technologies, data analytics, Artificial Intelligence optimization models, decision support systems and real time monitoring platforms, to allow operators to define, implement and monitor the most optimized NRW Losses action plans.

Reducing the water losses is not only a response to water scarcity and resources preservation, but it is also a way to reduce OPEX and avoid CAPEX.

As an example, the pressure management system put in place in Bordeaux allowed to reduce the OPEX by 170k€/year, with a payback period of around 10 years.

The saved volume of water due to this specific activity is equivalent to the production of a 750k€ water treatment plant.

5. RECOMMENDATIONS

Reducing the water losses is a major requirement regarding the sustainability of a drinking water utility.

An adequate loss reduction plan is unique for each network, consequently it should be based on detailed studies and diagnostic, as well as actual experiences.