INTERNET OF THINGS GROUP 4

PHASE 1

Smart Water Management

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Abstract

Water management towards smart cities is an issue increasingly appreciated under financial and environmental sustainability focus in any water sector. The main objective of this research is to the technological breakthroughs associated with water and energy use. A methodology is proposed and applied in a case study to analyze the benefits to develop smart water grids, showing the advantages offered by the development of control measures. The case study showed the positive results, particularly savings of 57 GWh and 100 Mm^3 in a period of twelve years when different measures from the common ones were developed for the monitoring and control of water losses in smart water management. These savings contributed to reducing the CO_2 emissions to 47,385 t $CO_{2\text{-eq}}$. Finally, in order to evaluate the financial effort and savings obtained in this reference systems (RS) network, the investment required in the monitoring and water losses control in a correlation model case (CMC) was estimated, and, as a consequence, the losses level presented a significant reduction towards sustainable values in the next nine years. Since the pressure control is one of the main issues for the reduction of leakage, an estimation of energy production for Portugal is also presented.

Introduction

The water industry is subject to new challenges regarding the sustainable management of urban water systems. There are many external factors, including impacts of climate change, drought, and population growth in urban centres, which lead to an increase of the responsibility in order to adopt more sustainable management of the water sector . The coverage of the costs, the monitoring of the non-revenue water (NRW) and the knowledge of the customers' demand for the fairness in revenues are some of the main challenges the water management has to solve . Due to the population growth increasing and a concentration of water needs, a consequent requisite of water management is necessary. Under this reality, the use of advanced technologies, as well as the adoption of more robust management models, are necessary to better suit the water demand

Objective

Smart water management aims at the exploitation of water, at the regional or city level, on the basis of sustainability and self-sufficiency. This exploitation is carried out through the use of innovative technologies, such as information and control technologies and monitoring . Hence, water management contributes to leakage red touction, water quality assurance, improved customer experience, and operational optimization, amongst other key performance benefits .A smart city can be defined as the city in which an investment in human and social capital is performed, by encouraging the use of "Information and Communication Technology" (ICT) as an enabler of sustainable economic growth, providing improvements in the quality of life of consumers, and consequently, allowing better management of water resources and energy .It is important to recognize that the concept of a smart city is not limited further development in order to meet the necessary conditions for a smart city

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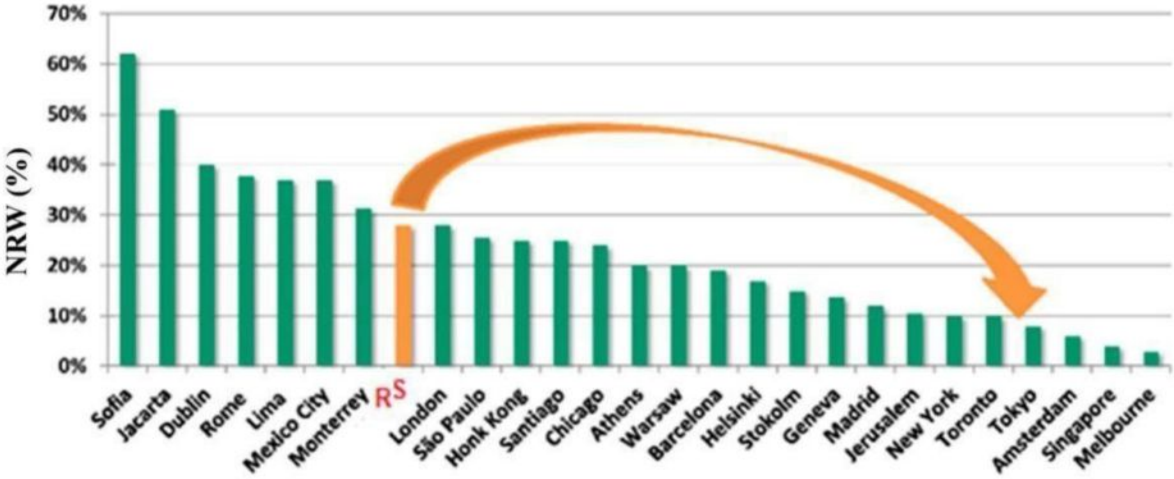


Figure 1. More efficient cities in terms of non-revenue water in the 1990s (based on [11]).

In order to reduce the water losses in 12 years for values less than 15%, RS adopted a well- defined strategy that was focused on: (i) segmentation and continuous monitoring of the network; (ii) development of analysis using internal resources; (iii) optimization of the process of active water losses control; (iv) continuous improvement based on the experience and results; (v) definition of what really is primordial in real cost (investments) control. The reduction of NRW was carried out on both leakage and illegal connections, which were detected through intensive monitoring and metering of the water distribution network.

Problem Statement

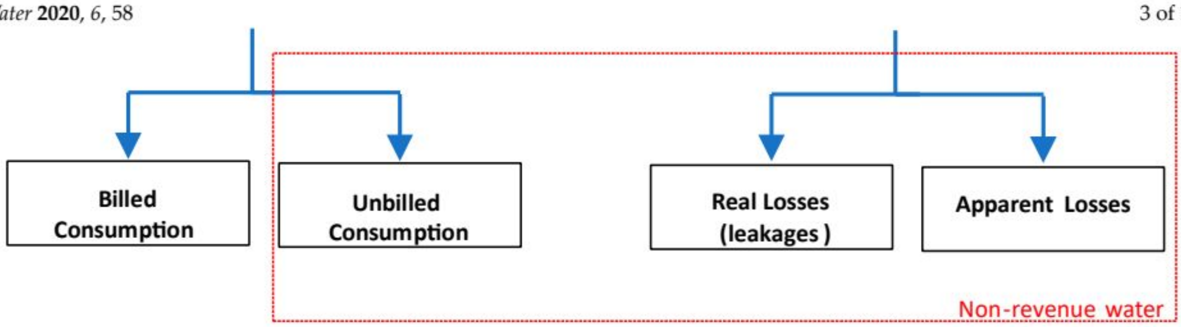
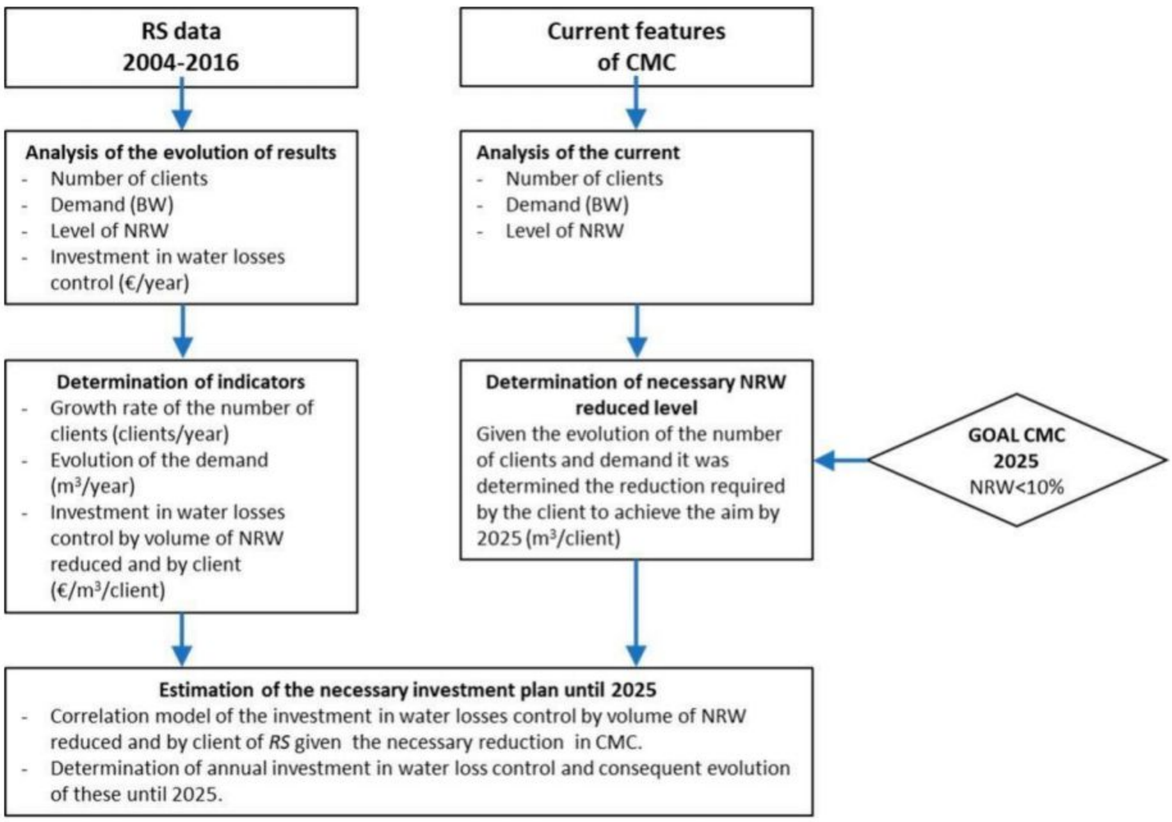


Figure Distribution of the water balance in a drinking system.

Water losses reflect a measure of the quality of management and operation of each system and, consequently, of any water company. Figure shows there are two types of water losses: apparent and real. The apparent or economic losses correspond to the illegal consumption, while the real losses correspond to water losses, ruptures or burst pipelines, reservoirs or service connections up to the point where the customer is connected, and water evaporation in reservoirs. The apparent and real loss volume cannot be exactly separated, and therefore, the improvement of their values should be made using recorded readings as well as increasing the monitoring (i.e., water metering) of the water network. Regarding the water losses control, this proposed strategy shows how to reach the economic level of leakage (ELL)

Flow chart



Flowchart of the methodology to apply the correlation model from reference systems (RS) to correlation model case (CMC).

Scope of the project

This decrease of NRW over 12 years was mainly due to the control of the losses in the distribution system (low level zone). In contrast, the BW decreased more than 20 Mm^3 in this period in the distribution system due to environmental concern of society, the leakages control, as well as the reduction of the unbilled water. The policy of monitoring and water loss control of RS was focused in particular on the distribution system (low level zone) since the NRW level was too high in comparison to the treatment and transport of water. The considered goal was ambitious, reducing the NRW in the distribution network for sustainable values, setting a goal of water losses less than 9% by 2016. This work positioned RS in the fifth position of the more efficient cities worldwide . The reduction of water losses was 67.85% compared to values of 1990 (Figure 1), which were considered as the best reference for this water company.

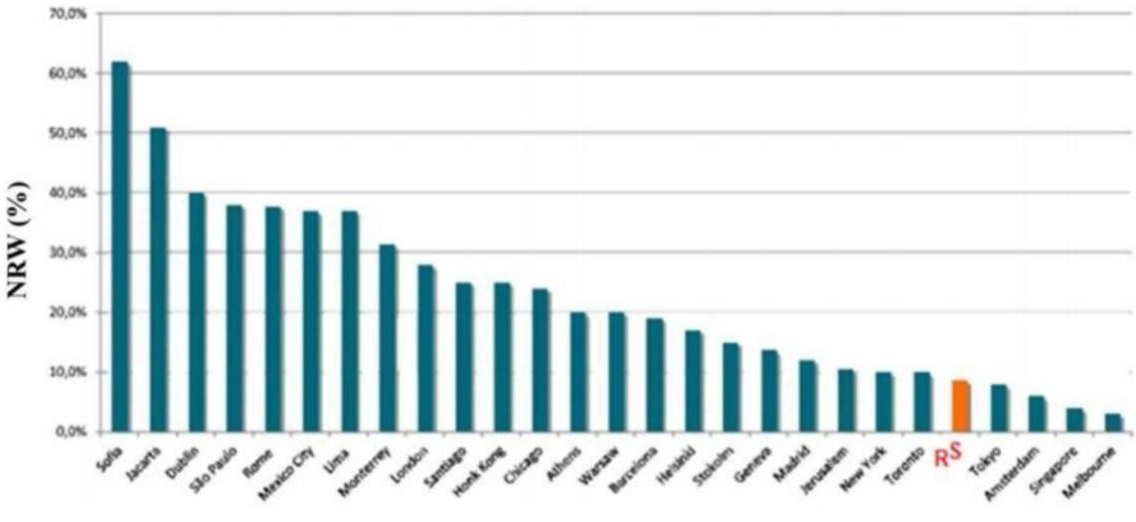


Figure. More efficient Cities at NRW level in 2016

Furthermore, RS still had a decrease in operating costs to the supply network. Despite the reduction of these costs, the unit cost of water produced was not sensitive to this variation and remained close to 0.30 €/m^3. This is mainly due to fixed costs of the water supply network, the decrease in demand, and an increase of unit costs of external supplies and services (ESF) in these years, in particular, the electricity.

Still, the energy bill, which is the main constituent of the ESF, contradicted the trend of growth in the market, due to the associated gains with the energy optimization enabled by monitoring and water loss control. In 12 years, RS obtained an energy saving of approximately 65 GWh, reducing the energy bill from more than €6.5 million. In addition to the energy reduction, another more direct result and representative of this policy of monitoring and water losses control was the reduction of the levels of NRW in the network, which allowed a saving close to 200 Mm^3 (€60 million) in 12 years.

To reach this saving, the investment in monitoring (e.g., smart watering devices, pressure sensors, communication devices), as well as the control of water losses, were necessary. This investment was €20 million in 12 years. This value was around 30% of the total revenue in this period. This reduction of the consumed energy contributed with a theoretical reduction of 47,385 $tCO_{2\text{-eq}}$ according to [36]. The development of this strategy enabled to reduce the overall costs in the operation of the network further, offering a saving of about €46 million in 12 years of operation.

The RS data was used to estimate the major socio-economic indicators to determine the investment required to reach a certain NRW level. The annual growth rate of the number of customers was obtained through the average annual growth recorded by RS from 2004 to 2014, using a growth rate of 0.3% for the developed correlation model. In order to determine the BW progression, firstly, a canonical correlation was prepared considering the evolution of the number of customers in the distribution system in an attempt to assess the dependence of billed water with the number of customers. The obtained regression models are shown in Table 1.