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Comprehensive and efficient sectorization of distribution networks

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Abstract

Improving water distribution networks efficiency has become a primary goal for water suppliers. Distribution network sectorization seems to be an useful technique to reach that goal. Several advances have been implemented in order to improve water distribution efficiency in networks planning and management through a sectorized layout approach.
For every network there are many options to establish an outline of sectors. This paper describes a method to assess the potential efficiency improvement of different sectorization options based on a sustainable global asset management. This new tool for assessment has been built based on a methodology that analyzes scenarios from a holistic perspective, identifying the key factors in the sectorization process by costs and service vulnerability parameters.
This project is going to be tested in the Community of Madrid (Spain), where Canal de Isabel II Gestión is the company commissioned for the integral water cycle in the region (more than 6,5 million inhabitants and 188 municipalities). Within this area, the company has already implemented over 600 hydraulic sectors in 18.000 km of pipes with an investment of 15 million euros.

Keywords: Water distribution network; DMA; efficient sectorization; sectors configuration; vulnerability; costs; level of service.

1. Introduction

The great variety of contexts and characteristics of existing distribution networks patterns makes difficult to apply a general efficient management, operation, control and maintenance criteria. Current water networks configuration is the result of different design policies through its history likewise different service requirements

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and constraints. This situation is not contributing to an efficient management. Hence, possibilities of reorganization and homogenization of existing networks to improve their efficiency should be investigated.

In this context, it seems that Network Sectorization technique (NS) could be a good solution. This practice has been mainly developed to improve water distribution networks control, for a better planning and management. It is always based on a network division in smaller isolated zones delimited by boundary valves and controlled by monitored flow and pressure meters at their inlets. These measured hydraulic sectors are occasionally called "district meter areas" (DMA).

Nowadays, there are several examples of operative sectorized networks. However, some important aspects have not been properly considered to optimize sectorization process. There are few researches related to the appropriate sector size and scope, as well as the adequate sectors configuration. In Butler (2000) some recommendations concerning network division were defined based on empirical considerations related to leakage management and control. Later, Di Nardo and Di Natale (2011) proposed a methodology to identify a cost-effective configuration of permanent districts by searching minimum dissipated power paths and using some graph theory principles.

Various methodological approaches focused on establishing the optimal sectorization have already been reported but they are usually based on optimizing just only a few specific issues on network management. Some researches analyze hydraulic sector distribution according only to pressure management optimization. Thus, Awad et al. (2010) uses Genetic Algorithms to identify the optimal DMA boundaries and to determine the optimal type, location and setting of the Pressure Reducing Valves (PRVs) to reduce excessive outlet hydraulic pressure at certain times of the day. Other researchers such as Gomes et al. (2012) define sectors configuration by considering the economic balance in terms of water loss reduction and implementation cost. The individual optimum sectors size has also been studied. Some approaches are focused on the smallest detectable leak from background leakage and legitimate night demand, while others are mainly focused on operational costs reduction. Hunaidi et al. (2007) establish an economically optimum DMA size based on theoretical models for the cost of DMA-based leakage management strategies.

Additionally, aspects of energy efficiency improvement have also been studied for a better distribution network management. In Reynolds (2010), a strategy to increase the efficiency by searching the optimal pumping system based on real-time monitoring and optimization of the whole system is proposed.

Therefore, there is a need to consider all management factors with influence in global efficiency for the sectorization process assessment. This way, targets might be studied and combined all together for assessing the most efficient sectorization in a global analysis.

This paper describes a method to analyze and compare different possible options in a sectorization process, searching for the most efficient approach from a holistic perspective. It is built based on a methodology that analyzes every scenario from a global point of view, comparing most relevant aspects in a sectorization program. Therefore, a comprehensive analysis is developed in order to assess and compare existing or scheduled sectorization outlines. It allows optimal solution selection from the available alternatives towards a sustainable global asset management.

2. Project strategy - Methodology

In this context, a tool for assessing sectorized network configurations according to a comprehensive efficiency criterion is proposed. The key focus of this tool is the assessment of networks efficiency by a multi-objective function. It considers the main factors in order to efficiently accomplish a specific level of service with the sectorized network configuration.

The proposed methodology is based on a tradeoff between network sectorization costs and benefits. Achievable benefits are quantified in a risk assessment framework, by measuring network's vulnerability rate. This rate reflects the risk of non-fulfillment the predefined level of service, so that each alternative's benefit increases as vulnerability rate is reduced. It allows identifying the most efficient sectorization approach from a group of options looking for a compromise between costs and performance. To achieve it, a specific assessment method has been designed.