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Smart solution to improve water-energy nexus for water supply systems

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Abstract

In the last years, there has been a great interest in the complex relations between energy and water, known as the Water-Energy Nexus [1]. Natural resources, such as energy and water, enable economy growth and support quality of life. The Water-Energy Nexus is considered as one of the most important multidisciplinary challenges [2] that the global growing water market [3] has to face in the forthcoming years. Currently, many water systems are not managed sustainably enough. Water Utilities face other challenges, such as infrastructure aging and poor cost-recovery, leading to a lack of finance for O&M (Operation and Maintenance). Energy is required in all stages of water production and distribution, from pumping and treatment to transportation. Energy costs are a top-of-mind concern for water utilities, regardless of geography, size and level of water network efficiency [4]. On the other hand, Water Utilities are having a hard time to either improve their services or expand their network to unserved neighborhoods in developing countries.

The current trend of water transmission system to the creation of DMAs (District Metered Areas) offers great possibilities of non-structural solutions that use existing data and transform them into useful information to support decision making. The Smart Metering and the use of large amounts of data from a network enhance the use of software for decision support, but it is not the only way. Smart Solutions can also be applied to networks with less recorded data, which would enhance operators' knowledge to these data, turn them into useful information for decision-making either for the operation or the maintenance and network design. In this scope, a Smart Solution is presented. It is developed combining key factors of the energy consumption and the water supply into water networks management to obtain improvements from both water and energy fields. This non-structural solution increases resource efficiency and environmental performance of water distribution networks by using data acquisition and geographical visualization (real time & historical), weather and water demand forecasting, detection of networks events and hydraulic simulation of the network, and finally through a decision support system based on machine learning (pattern recognition and business rules techniques).

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As a conclusion, a non-structural solution for the Nexus issues can have a great impact on several matters (climate change, carbon footprint, WUs balance sheets, and water losses) with reasonable investment either in smart metering or networks with only a few sensors measuring.

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Keywords: Nexus, water energy; smart water networks; urban water distribution network management; Energy Management in water Distribution Systems; Water Utilities; Artificial Intelligence; Machine Learning; Pattern Recognition; Business Rules.

Nomenclature

AI	Artificial Intelligence
API	Application Programming Interface
BRMS	Business Rule Management System
BRT	Business Rules Technique
DMA	District Metered Areas
DSS	Decision Support System
ICT	Information and Communication Technologies
KPI	Key Process Indicator
PRT	Pattern Recognition Technique
WDS	Water Distribution System

1. Introduction

Water distribution systems face socio-economic, sustainability and resilience challenges, including overuse due to population growth, underestimation of the value of water, lack of coordination among actors, operational issues (ageing, leakages, quality), increasing energy prices and the need for responding to climate change issues. Much environmental data related to water are already being reported, from local to supranational level. Assessment of the resource efficiency or environmental performance of water utilities, though, still lacks a **holistic approach**.

Specifically, the **water-energy nexus** case raised the attention of water utilities, where considerable measures are taken to reduce energy consumption and increase energy recovery. Water-resource efficiency in its broader context is also of utmost importance for water utilities, which has defined water-energy nexus as one of their priority areas; it is also considered as one of the most important multidisciplinary challenges that the global water market is to face in the forthcoming years [5].

The Smart ICT solution depicted in this paper combines the key factors of the energy consumption and the water supply to improve the water networks' management in order to save water, energy and economic costs, using the renewable energy as possible and ultimately, obtain benefits in both, water and energy fields.

Given this framework, the solution provides a scalable, comprehensive and interoperable web-based Smart management platform, focused on water allocation and pump scheduling for water distribution networks. The platform provides a decision support system for short-term (operational) management of WDS based on:

- A reliable and customizable **demand forecasting system** based on DMA.
- A non-intrusive **data acquisition system**. Allows information gathering from existing SCADA systems.
- A full **spatial data infrastructure**. Including geo-database, map server and geographic information system.
- A **decision support system** to provide management recommendations. Highly innovative Artificial Intelligence and Data Analytics techniques have been developed in order to overcome the limitations of the classical approaches, mainly focused on mathematical solvers.