Enhancement of water and energy efficiency in water supply systems

Summary

This research aims to enhance water and energy efficiency in water supply systems through a systemic and objective-oriented framework, robust and well-tested energy balances and energy efficiency metrics. These provide guidance on the type of water-energy inefficiencies, allowing comparison of different improvement solutions and fostering continuous improvement.

The research approach encompasses relevant scientific developments applied in a living lab of water utilities with different system configurations and maturity levels. The scientific development involves: the mathematical formulation of an energy balance, flexible in terms of data requirements, compactible with the water balance and calculated, in detail, through the system hydraulic simulation; the development of energy efficiency metrics that highlight the nature of inefficiencies in water supply systems (i.e., related to equipment, water losses or system configuration); and the systematization of the previous developments in a framework that follows the Plan-Do-Check-Act principles. The application in a large dataset of water utilities is carried out in three steps. The first step consists of the application of the energy balance and energy efficiency metrics in a top-down approach to identify sources of inefficiency at a macro level. The second step consists of applying a bottom-up energy balance in calibrated mathematical models of the water distribution systems, for an in-depth analysis of energy consumption; this allows a comprehensive discussion of the different mathematical formulations of the energy balance and related energy efficiency metrics. The third step focuses on a more detailed application to illustrate the framework, with a particular emphasis on the analysis of unconventional energy improvement solutions.

The main outcomes of this research are: i) an integrated framework for the energy efficiency diagnosis, the prioritisation of subsystems and the comparison of energy efficiency improvement solutions; ii) a novel energy balance for water supply systems with different implementation formulations; iii) real-life values for energy balance components and energy efficiency metrics in 110 systems; iv) tools for computing the different energy balance formulations and calculating performance metrics; and v) examples of unconventional solutions resulting from the application of the framework that may lead considerable water-energy efficiency improvements.

Keywords

Water-energy nexus, energy efficiency, energy balance, energy efficiency metrics, water supply systems.

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