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Optimization of hydropower production in a water supply network using CasADi

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Installation of (micro-)turbines in water supply networks has become an attractive strategy for small hydropower production in urban environment. It has virtually no impact on ecosystems and offers side-benefits such as leakage reduction by turning excess pressure into hydropower. Our research aims at improving the modelling and optimization of existing tools for sizing and selecting the optimal location of turbines in urban water supply systems.

A critical component of the analysis is the hydraulic model of the system. In most existing studies, the flow variables in the water supply network are computed under the assumption of a quasi-steady flow. Here, we opt for an in-house hydraulic model which achieves a more realistic description of time-varying flow. We will present comparisons of the two approach to assess the potential benefits of the unsteady computation.

For optimizing the size and location of turbines in the network, most research uses *meta-heuristics* [1-3]. In this research, we explore an alternative operational strategy, based on the detailed hydraulic computation of the water supply network prior to the installation of turbines, followed by *formal optimization* techniques. Both the hydraulic model and the optimization technique are implemented in the CasADi framework for nonlinear optimization and optimal control [4].

The operationality of our developments is shown for a range of standard case studies as well as a real-world case study representing the urban water supply system of Liege, Belgium, which includes 3,600 km of pipes and more than 200 hydraulic structures, such as interconnected reservoirs. Monitoring data from around 700 gauges throughout the water supply network are used to provide a deep understanding of the system operation and a validation of the hydraulic model.

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