An optimization framework to support water supply systems in the energy transition

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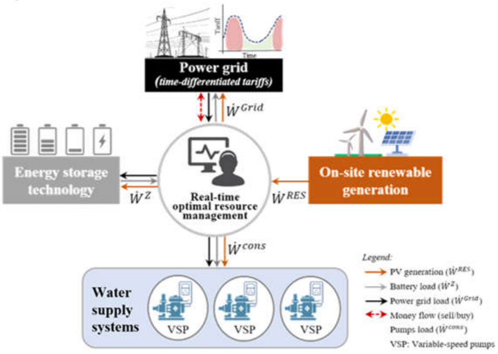
Background

CHALLENGE:

The urgency of **climate change**, combined with **economic motivations** and **technological advances**, is driving an **energy transition** that is **swiftly creating challenges for water utilities.**

The energy transition, which include features like **on-site renewable generation**, **flexible loads**, **dynamic energy markets** and **storage systems**, requires demand-side management strategies that water utilities do not yet widely practice.

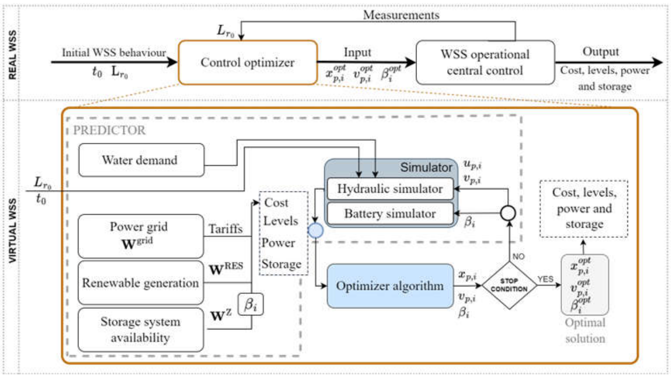


OBJECTIVES:

Promoting the **cost-efficient** water-energy operation of WSS by optimizing the integrated management of energy resources.

Methodology

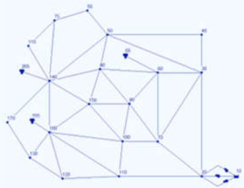
Development of an **optimization framework** which includes the integration of **hydraulic and battery** simulator with **optimization algorithms** to compute solutions until achieving the optimal solution.



$x_{p,i}$ – Pumps operating time for each optimization time – step; $x \in [0,1]$ β_i – Battery relative power input control for each optimization time – step,; $\beta \in [-1,1]$
$v_{p,i}$ – Pumps relative speed for each optimization time – step; $v \in [0,1]$ L_{r_0} – Initial level for each water storage tank

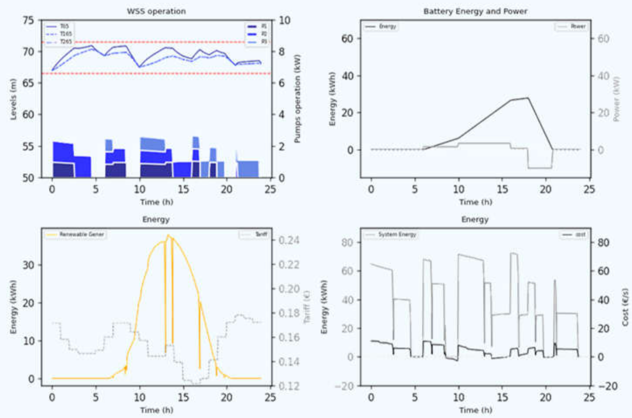
Results

Laboratory validation using the Anytown water supply system (WSS):



- **1** Reservoir (water source)
- **3** Variable-speed pumps
- **3** Water storage tanks
- **19** Water consumption points

Optimal WSS operation using SLSQP[1]



Optimization algorithm[1]	Energy cost (€)	Function evaluation (n°)	Computational time (s)
Trust-region constrain (*GB*)	1,135.51	10,449	3,063.25
SLSQP (*GB*)	1,138.05	2,037	535.22
Differential Evolution (*MH*)	1,146.10	21079	32,099.57

GB: Gradient-based; MH: Metaheuristic.

[1] https://docs.scipy.org/doc/scipy/reference/optimize.html

Adoption of the **proposed framework** can contribute to **real-time efficient WSS operations** by promoting **integrated management of resources** and achieve potential savings for the water utility.

Conclusion & Future work

Water utilities must adapt to a decarbonized energy system where their traditional operational practices are incompatible with the changing energy paradigm. The **proposed methodology can support water utilities succeed in their energy transition challenge.**

Next step: Validation in an operational environment.

Institutions

INESC Coimbra – Instituto de Engenharia de Sistemas e Computadores de Coimbra

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