Hydropower and energy efficiency in water systems *(2012-2016)*

PhD student : Irene Samora
Thesis director : Helena Ramos (IST)
Thesis co-director : Anton Schleiss (EPFL)

This research project is funded by Fundação para a Ciência e a Tecnologia (FCT) and EPFL

Introduction

Water and energy are closely connected – water is needed for almost all energy operations and the energy production also has a large impact on water quality.
As energy needs grow, water consumption will increase accordingly. In this scenario, new techniques, such as hybrid installations, micro-hydro and optimization routines, are emerging.
It is a common misconception that hydropower is achieved exclusively in large dams. A micro-hydropower scheme can consist of generating energy in small rivers and water supply, irrigation, wastewater or drainage systems.
Nevertheless, conventional turbines are not cost-effective for micro-hydro and are considered to have a negative ecological impact. As a result, special converters are needed for the exploitation of this source of renewable energy.

Objective

To answer to nowadays needs for sustainable energy sources that are, at the same time, economically viable and environmentally friendly, the systems must be efficient. The best efficiency is obtained when the system is designed in the way that maximizes the energy produced and minimizes the caused damage, not violating any imposed constraint. The purpose of this research is an experimental and computational investigation of energy conversion and efficiency in water systems.

It is intended to cover an area of hydropower potential that is still much unstudied – low heads and/or low flows. In particular, it is intended to propose a new turbine, a five blade tubular propeller, adequate for drinking water systems – Figure 1.

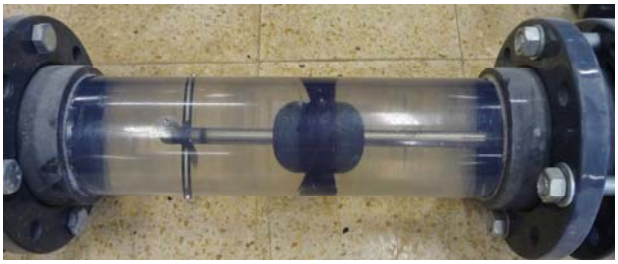

Figure 1 - 5BTP prototype.

Another aspect to be covered in this research is the optimization. It is intended to optimize the operation in the water systems to maximize the energy production while ensuring their main functionality. For this maximization, focus will be given to the selection of the adequate energy converter and its position in the system, depending on the variation of flows and heads, and to operational rules.

Research procedure

The methodology proposed integrates modeling and laboratory studies, as well as the study of optimization algorithms.

In the first phase, a theoretical and methodological research is conducted to support the investigation and to provide a summary of previous studies.

In the laboratory testing, the 5BTP will be submitted to different flows and head conditions. The goal is to obtain a spectrum of characteristic curves of micro-converters – Figure 2. Following the laboratorial testing, the CFD modelling of the 5BTP will be calibrated to allow extrapolating the behavior of similar propellers with different dimensions.

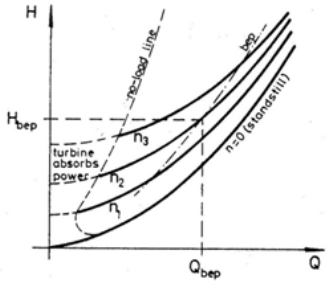

Figure 2 – Typical characteristic curves a turbine with variable speed (Chapallaz, J. M., Eichenberger, P. and Fischer, G., 1992. Manual on Pumps Used as Turbines).

In parallel, an analysis to evaluate the performance of the case study systems is done, taking into account losses, efficiencies, pressure and flow requirements and the final use of the generated energy. Turbine selection and location according to the head and flow patterns is to be optimized. The operational rules that guarantee the quality of the service and the scheduling of turbine operation are variables in the process. This optimization depends of some constraints, such as physical limitations of the systems, rules or economic constraints. To solve a problem with such a variety of variables and solutions, evolutionary algorithms will be used and multi-criteria optimization will be performed.

With case studies from both Switzerland and Portugal, an assessment of the energy potential of the existing systems will be performed.

Results

Scientific contribution of this research is to be expected in:

- Characteristic curves for a new propeller turbine for drinking water network
- Tools for turbine selection and location according to the system characteristics
- Multi-criteria optimization of the integrated operational system
- Improvement of energy efficiency in water systems
- Case study in Lausanne drinking water network
- Potential evaluation for Switzerland and Portugal