The internship is aimed at the development of optimization algorithms for the turbines location problem within a water distribution network.

Water distribution networks are usually low energy efficiency systems, due to the large amount of water leakage, which is strictly related to the values of pressure in networks. Moreover, the leakage reduction is usually achieved by a pressure control strategy with dissipation devices, i.e. hydraulic valves, which contribute to further reduce the energy efficiency of the network.

A large energy recovery can be realized by the installation of energy production devices (EPDs), i.e. turbines, to exploit the excess of pressure that would be dissipated by regulation valves. Therefore, a turbine can both reduce the water pressure (with a consequent reduction of leakage) and recover energy. In particular, energy recovery is of considerable importance in pressurized systems: the priority of such a strategy is not just the production of energy, but also the increase of sustainability and efficiency of water exploitation.

The optimal location of a number of turbines in a water network arises several technical and computational problems:

1) The turbine behaviour has not to affect the main purpose of the water network, i.e. the water delivery to the end users;

2) The hydro-mechanical behaviour of a turbine depends on the hydraulic condition of the network, which are influenced by the turbine behaviour itself;

3) The hydraulic equations that can be used to model the water network are not linear;

4) For each pipe of the water network a turbine can be installed or not, therefore the optimization should include integer variables;

5) The operating condition of a water network are not constant, depending on the end-user demand.

6) A real water network can include thousands of nodes and pipes, dramatically increasing the largeness of the problem, in terms of both variables and constraints.

Thus, the problem can be written as a Mixed Integer Non Linear Programming (MINLP) problem. Several heuristic methods and only a few exact methods have been proposed in the literature. We propose to start from the model proposed in the paper "Fecarotta, O., & McNabola, A. (2017). Optimal location of pump as turbines (PATs) in water distribution networks to recover energy and reduce leakage. *Water Resources Management*, *31*(15), 5043-5059", aimed at the maximization of both energy production and water saving, for a given hydraulic network. The authors used BONMIN as general-purpose MINLP solver to solve the proposed mathematical model.

Although it leads to promising results, the previous research presents some weakness such as modeling simplifications, whose overcoming is the goal of the new research. The design of a new, more realistic mathematical model comes with more challenging non-linear constraints, which we plan to tackle by decomposition-based and relaxation-based methods.

The ideal candidate has an Engineering bachelor and master degree, some knowledge about water distribution network and the physics behind it, some background in optimization and modeling languages.