

# Combinatorial Nature of Hydro Unit Commitment Problem through the Lens of Nonlinear Optimization

## Scientific description

This subject falls within the scope of the Unit Commitment Problem (UCP) in electrical power generation. This problem is to decide when to start and stop power generation units to meet the electrical demand over a discrete time horizon (daily), while respecting strict technical constraints. Today, EDF's production schedule is obtained using a price decomposition method, by Lagrangian relaxation of the coupling demand constraints. The sub-problems resulting from this decomposition correspond to individual units or groups of similar units: hydraulic valleys, nuclear or thermal units. This approach is notably used in the short-term optimization tool *Apogene*, used daily at EDF.

The optimization problem for hydroelectric production, called the Hydro Unit Commitment problem (HUC), is one of the sub-problems of the UCP. It considers a hydraulic valley, where a set of reservoirs is interconnected by a graph structure composed of multiple Y-shaped blocks in the general case. Each reservoir is associated with a plant consisting of several units that can operate in turbine mode, pump mode, or both modes but (usually) not simultaneously. Most hydro units are modeled to operate on discrete operating points defined by a pair of a water flow and an associated power production. Each operating point generates a revenue depending on its associated power and the energy price signals obtained from the Lagrangian relaxation scheme. The main objective is to maximize the total profit generated by hydraulic production plus the value associated with the reservoir volumes at the end of the horizon.

While physical non-linearities of the HUC have been looked at through MINLP, piecewise linear programming and other nonlinear programming approaches, the combinatorial aspects of the HUC have been recently investigated with MILP approaches. Even though the relationship between the discrete variables are often nonlinear, such non-linearities induced by the combinatorial nature of the problem have not yet been investigated through a quadratic or more generally a nonlinear programming perspective.

At EDF, the HUC is modeled by integer linear programs, which contain hidden linearizations of quadratic subfunctions. We aim of this internship is to reconsider the problem from the point of view of quadratic optimization with the objective of deriving better formulations, decomposition schemes, bounds and valid inequalities such as perspective cuts.

## Internship supervisors and contact

The internship will be supervised by Safia Kedad-Sidhoum (Cnam), Sourour Elloumi (ENSTA), and Cécile Rottner (EDF).

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## Location

The internship will be hosted by the laboratory CEDRIC of the Conservatoire National des Arts et Métiers, 2 rue Conté, 75003 Paris

\* The internship is part of a PGMO project