Decomposition and feasibility restoration for Cascaded Reservoir Management

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Abstract

The *hydro unit commitment* problem handled at EDF is difficult to solve and we propose here to decompose it into subproblems that will be easier to solve (less constraints and less variables).

Let us consider for instance a Y-shaped hydro valley. The idea is to decompose it into three subparts (one subpart for each branch of the Y). The resulting subproblems must be totally independent: each subproblem has to involve its own variables and constraints. It means that constraints must not contain any variable of another subpart. But the flow equation of the reservoir connecting the three branches of the Y contains variables of the two subparts above. It is called a « linking constraint ». The idea is then to dualize with respect to this constraint.

We denote by F the objective function of the complete problem. It corresponds to the operational cost that we want to minimize. The feasible set is denoted X and it contains all bounds on variables and all constraints, except the linking constraint, that can be written $g(x) = 0$. The complete problem is :

$$F^* = \min_{x \in X} F(x) \quad \text{s.t.} \quad g(x) = 0 \tag{1}$$

and the dual problem is :

$$\max_{\lambda} \Theta(\lambda), \quad \text{where} \quad \Theta(\lambda) = \min_{x \in X} \{F(x) + \lambda^T g(x)\} \tag{2}$$

The Lagrangian $\mathcal{L}$, defined by : $\mathcal{L}(x, \lambda) = F(x) + \lambda^T g(x)$, can be split into three parts (one part for each subproblem). The dual problem (2) simply rewrites :

$$\Theta(\lambda) = \min_{x_A \in X_A} \mathcal{L}_A(x_A, \lambda) \;+\; \min_{x_B \in X_B} \mathcal{L}_B(x_B, \lambda) \;+\; \min_{x_C \in X_C} \mathcal{L}_C(x_C, \lambda).$$

This leads to three independent subproblems (denoted A, B and C) that will be solved using CPLEX.

Then, a *cutting plane* method will be considered to solve the dual problem (2) in order to get a « good » lower bound of F^*. Instead of maximizing Θ, this method consists in maximizing an approximate function. The algorithm will provide an optimal dual point λ^* and the corresponding optimal primal points, denoted x_A^*, x_B^* and x_C^*.

Finally, these three points will be aggregated: $x^* = (x_A^*, x_B^*, x_C^*)$. x^* $(\in X)$ is infeasible for the complete mathematical model (1) because the linking constraint is not satisfied. We use a *local branching* method which aims to define a « local search » centered in x^* to try to make this point feasible. We implement the branching by using *callbacks* of CPLEX.