Operator splitting techniques for a stochastic multi-zonal long-term energy production planning problem

P. Mahey[1], J. Koko[1], A. Lenoir[2] and Marchand L.[3]

1. LIMOS, UMR CNRS 6158 et Université de Clermont
philippe.mahey@isima.fr

2.EDF R&D, Dept OSIRIS, Clamart
3. Dept Math., Univ. Sherbrooke, Canada

Mots-clefs : stochastic optimization, decomposition methods

We propose here to investigate new variants of proximal splitting methods (like the family of Douglas-Rachford splitting) and test them on a complex stochastic optimization problem derived from a real-life long-term energy planning model.

We consider a set of geographical zones Z interconnected by a network of economic agreements to import or export electricity. Each arc $e = (z, z')$ carries the flow of imported energy denoted by f_{et} in each period of the time horizon $t \in [1, \dots, T]$. We denote d_{zt} the total demand and i_{zt} the input of water resource for zone $z \in Z$ at step t (random information) . The variables are the local production levels p_{zt}, the control of hydroelectrical reserve u_{zt} and the interzonal flows f_{et}. The multistage stochastic program we face up is the following :

$$\min_{p,x,u \in L^2} \quad I\!E\left[\sum_{t=0}^{T-1} \left(\sum_{z \in Z} c_z(p_{zt}) + \sum_{e \in E} l_e(f_{et})\right)\right]$$

$$\text{s.t} \quad p_t + u_t - Af_t = d_t \qquad (1)$$

$$x_{z,t+1} = x_{zt} - u_{zt} + i_{zt} \quad \forall z \in Z, \forall t \qquad (2)$$

$$+ \text{ Zonal constraints on random variables } p_{zt}, u_{zt}, f_{et} \qquad (3)$$

We apply the Douglas-Rachford (or equ. Proximal Decomposition, see [1]) splitting method to the dynamic reformulated model. It consists in solving by a Dual Dynamic Programming technique the local subproblems :

$$\min_{(q_z, u_z, f_z, \phi_z)} \quad \mathcal{C}_z(q_z, u_z, f_z, \phi_z) + 1/2\lambda(\|f_z - f_z^k - \lambda v_z^k\|^2 + \|\phi_z - \phi_z^k + \lambda w_z'^k\|^2)$$

update the dual variables and project back on a customized coupling subspace and its orthogonal (see details in [2] for the deterministic model).

Numerical results are presented on realistic instances with $|Z| = 12, T = 365$ and piecewise linear convex production costs that show the efficiency of the decomposition approach.

References

[1] P. Mahey, S. Oualibouch, Pham D.T., Proximal decomposition on the graph of a maximal monotone operator, SIAM J. Optimization 5 (1995), pp. 454–466

[2] P. Mahey, J. Koko, A. Lenoir, Xu L., Splitting method to solve the deterministic dynamic long-term multizonal production planning problem, LIMOS report 2014,

Aknowledgements : PGMO program (Fondation Mathématique Jacques Hadamard and EDF)