POLYTECHNIQUE MONTRÉAL

CIRRELT

PROGRAMME

3E COLLOQUE DE LA CHAIRE DE RECHERCHE INDUSTRIELLE CRSNG/HYDRO-QUÉBEC EN OPTIMISATION STOCHASTIQUE DE LA PRODUCTION D'ÉLECTRICITÉ

Le lundi 25 novembre 2013, 9h-17h30

Salle 6254 – Pavillon André-Aisenstadt
Université de Montréal, 2920 chemin de la Tour

FRAIS D'INSCRIPTION : 30 $

https://symposia.cirrelt.ca/ColloqueChaireCRSNG-HQ/register

Ce colloque, organisé en collaboration avec Rio Tinto Alcan et Hydro-Québec, permettra aux participants de prendre connaissance de certains des développements les plus récents dans le domaine des modèles et des méthodes d'optimisation stochastique pour la production d'électricité. Trois conférenciers de l'étranger et six chercheurs québécois présenteront leurs travaux sur plusieurs sujets d'importance.

Les communications seront faites en anglais.

8h30 – ACCUEIL & CAFÉ (Salle 6245)

8h55 – MOT DE BIENVENUE

9h00 – WARREN POWELL, directeur, Princeton Laboratory for Energy Systems Analysis (PENSA)

Energy and uncertainty: Clearing the jungle of stochastic optimization

The efficient and robust planning of energy systems requires dealing with a wide range of sources of uncertainty. While the modeling and algorithmic community enjoys a well-established framework for solving deterministic problems, stochastic optimization is fragmented into a jungle of modeling and algorithmic strategies. In this talk, I will provide a unified framework for modeling sequential decision problems under uncertainty. I then present four fundamental classes of policies, which unifies the fields of stochastic optimization. This framework is then applied to the challenge of modeling the PJM grid and energy markets.

10h00 – FRÉDÉRIC BABONNEAU, EPFL, Lausanne, et Ordecsys, Genève, Suisse, et **JEAN-PHILIPPE VIAL,** Ordecsys, Genève, Suisse

On using robust optimization in some problems in electricity generation planning

Robust optimization is becoming more and more popular in Operations Research as a tool to cope with uncertainty that is present in many modeling situations, but generally neglected. Actually there are many major obstacles to a satisfactory treatment of uncertainty. For instance, the information on the probability distributions is often partial and incomplete, and even if the distributions are known, computing probabilities and expectations turns out to be numerical challenge. Robust optimization acknowledges these facts and proposes an approach which enables efficient and numerically tractable

computation of “reasonable” solutions on the basis of limited information. In the energy area and particularly in electricity power generation and distribution, increasingly many components—demand, electricity prices, variability of renewable power generation devices—become uncertain. In this presentation, we shall first review a few basic concept and show how they often lead to relatively simple formulations. We shall illustrate the talk with two examples. The first one concerns a long-term energy planning model of the Markal family and aims at studying how the penetration of new technologies is impacted by the uncertainty on their expected cost, efficiency, and on the evolution of energy prices. The second one is more on the operational side and proposes a way to handle uncertain water supply in the management of hydroelectricity production in a valley with several dams.

11h00 – PAUSE-CAFÉ (Salle 6245)

11h30 – STEIN-ERIK FLETEN, Norwegian University of Science and Technology

Is there power in derivatives ?

Commodity producers with storage facilities profit from time-varying prices. When asked, the same producers claim to use derivatives to form price expectations. However, investigating the production from 13 Norwegian hydropower stations with reservoirs, only a modest relationship between power production output and electricity derivative prices is found. This paradox is explained by studying the reservoir level. Nearly empty reservoirs give producers flexibility to wait for higher prices and more price information while nearly full reservoirs means the producers risk spilling and have little flexibility. With reservoir levels changing naturally over the hydrological year, changing flexibility explains how derivatives can be used in production planning without having much empirical explanatory power regarding actual production levels. The price signal has to be quite strong to make the operators deviate from a reversion in reservoir levels toward their normal seasonal levels. When controlling for the flexibility, by looking only at weeks with similar inflow expectation and reservoir level, the price signal is significant in explaining production.

This is joint work with Daniel Haugstvedt, Norwegian University of Science and Technology, and Jussi Keppo, National University of Singapore

12h30 – Lunch inclus (Salle 6245)

13h45 – MICHEL DENAULT, Service de l'enseignement des méthodes quantitatives de gestion, HEC Montréal

An approximate dynamic programming, simulations and regressions approach to value and control a hydropower system

We investigate the control of a stochastic system, in the presence of both an exogenous control-independent) stochastic state variable and an endogenous (control-dependent) state variable. Our solution approach relies on simulations and regressions for both types of variables, as the endogenous variable is gradually integrated into the simulation paths. Unlike most approaches found in the literature, no discretization of the endogenous variable is required. The algorithm is applied to optimize the storage decisions for a hydropower system in half-day increments, over long periods, and with multiscale seasonalities.

This is joint work with Jean-Guy Simonato and Lars Stentoft, HEC Montréal.

14h15 – PASCAL CÔTÉ, Rio Tinto Alcan

Stochastic optimization and ensemble streamflow prediction: A comparison study for Rio Tinto Alcan's hydropower system

The following presentation is about the comparison of different stochastic optimization methods. The optimization method has been integrated with a 2 reservoir equivalent system of the Saguenay-Lac-St-Jean hydropower system manage by Rio Tinto Alcan. Methods were compared by using a test bench study where the one-stage decision is made by re-optimizing the mid-term problem using, at each period, the ESP forecast of the next 35 weeks. A numerical comparison between our actual deterministic approach, a scenario tree method, SDP and SSDP will also be presented. We also investigate the impact of using over and under disperse ESP forecast in the operation of the system.

This is joint work with Marco Latraverse, Rio Tinto Alcan.

14h45 – PIERRE-LUC CARPENTIER, Chaire CRSNG/Hydro-Québec en optimisation stochastique de la production d'électricité, CIRRELT et MAGI, Polytechnique Montréal

Decomposition methods for planning hydroelectricity generation over the mid-term horizon

Traditional scenario tree-based stochastic programming methods (TSPMs) (e.g. progressive hedging, nested Benders) are often used for managing large-scale hydro-dominated power systems over the mid-term horizon. These methods are applicable on high-dimensional systems (20-40 reservoirs) and can handle multi-lag autoregressive stochastic processes without increasing their computational burden. Unfortunately, the computational requirements (time, memory) of TSPMs grow exponentially with the scenario tree branching level (number of branching stages and outcomes per stage). Consequently, these methods can only be used if a relatively low branching level is used (1-6 branching stages, 1-5 outcomes per stage). Most reservoir management problems cover many time periods and contain several spatially-correlated and continuously-distributed random parameters (e.g. load, inflows, price...) which cannot be modeled accurately using such a low branching level. In this talk, different approaches are proposed to enhance the computational performance of TSPMs when managing hydroelectric reservoir systems over an extended planning horizon. Because of their low computational requirement, these approaches can be used to better describe random parameters with a finer discretization scheme.

15h15 – PAUSE-CAFÉ (Salle 6245)

15h45 – AMAURY TILMANT, Département de génie civil et de génie des eaux, Université Laval

A Methodology for Analyzing the Economic Value of the Coordination of Reservoir Operation

The coordination of reservoir operation is critical for water systems' efficiency. Improved coordination requires sharing information, demanding a clear understanding of the potential gain and its distribution among the users to motivate engagement in coordinated operations and bearing of transaction costs. In a multi-user, multireservoir system, the evaluation of the potential coordination gain is not trivial because it requires the simultaneous evaluation of numerous trade-offs. This paper presents a methodology to identify the likely upper and lower bounds in multireservoir system benefits, providing a reference framework for analyzing the economic value of coordination. The methodology is applied to a large scale multireservoir system in Brazil. The method relies on the comparison between two management scenarios. The first one mimics typical

system operation based on individually-designed rule curves, which are likely to perform on the lower bound. This is compared with system-wide optimization through an Stochastic Dual Dynamic Programming algorithm to represent fully-coordinated reservoir operation (upper bound). For our case study, results indicate that better coordination reduced spills and improved releases timing according to reservoirs characteristics and location, allowing overall gains of 8% in energy and 7.9% in revenues, with revenues mostly improved by coordination in dry years. Larger reservoirs presented the highest gains in absolute terms, while the smaller ones presented the highest relative increases. By indicating individual gains at each reservoir, valuable information is produced to support future negotiations and benefit sharing among different agents, being water agencies or power companies.

This is joint work with Guilherme Fernandes Marques, Centro Federal de Educação Technológica de Minas Gerais, Belo Horizonte, Brésil.

16h15 – FRANÇOIS BOUFFARD, Department of Electrical and Computer Engineering, McGill University

The ups and downs of umbrella constraint discovery in electricity generation scheduling

Recent work on umbrella constraint discovery (UCD) has shown great promise in streamlining the solution of security-constrained optimal power flow (SCOPF) problems. The solution of the UCD problem itself is not trivial, however. In this talk, we present a significant, yet simple, improvement to the decomposition approach used to solve UCD. This improvement exploits the inherent structure of the parent SCOPF problem. Moreover, given the promising results from UCD-SCOPF, we have moved on to apply UCD to the solution of the classic thermal unit commitment problem with the hope that it could identify strong branching and time decoupling opportunities. We prove that, unlike SCOPF, the unit commitment problem does not have a favorable structure for which UCD can be effective. From these experiences, we can draw conclusions on the desirable features of mathematical programs for which UCD can be most effective, and we make recommendations for other important electricity generation planning problems.

16h45 – DAVID MUNGER, Chaire CRSNG/Hydro-Québec en optimisation stochastique de la production d'électricité, CIRRELT et MAGI, Polytechnique Montréal

Objective-aware scenario trees: Early sprouts

We derive a criterion that guides the construction of scenario trees. Our rigorous criterion innovates (1) by introducing parameters accounting for the structure of the objective function in order to prioritize sampling where the objective is most sensitive to variations in the stochastic process, and (2) by adapting that sampling to a representative class of functions. We present early sprouts of scenario trees we have obtained for very simple cases and discuss emerging structures.

17h15 – DISCUSSION

17h30 – FIN DU COLLOQUE