SPS Newsletter

The Newsletter of the Stochastic Programming Society

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Send your comments to the Editor:

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Chair's Column

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Dear Colleagues,

Welcome to the first-ever newsletter of the Stochastic Programming Society! Our first newsletter comes at a time when many of us are forced to work at home, teach online from home, and limit our physical exposure to each other. It is a time when decisions under uncertainty and risk severely impact our daily lives.

One of the goals of the Committee on Stochastic Programming is to increase communication among our members and to create a stronger sense of community. Toward this end, in addition to our existing email list and website, we are initiating this newsletter, where we share important announcements, highlight research advances and real-world impact of our field.

I am also happy to announce that Stochastic Programming Society now has social media presence. Please follow us on Twitter and LinkedIn:

https://twitter.com/stoprogsociety

https://www.linkedin.com/groups/13799735/

I would like to extend special thanks to Francesca Maggioni, who has agreed to be the editor of the SPS Newsletter. Special thanks also goes to Phebe Vayanos (Twitter) and Bernardo Pagnoncelli (LinkedIn) for their efforts. Please continue sending us your events and announcements.

Talking about announcements, we have an **early announcement: The date for the next ICSP in 2022 is set.** You need to make it to the end of the newsletter to find out. (No, you do not have to solve a stochastic program to find out.) Please mark your calendars and block off that week!

It is exciting to see that our research area has been receiving increased recognition. Here are some highlights:

- Prof. Alex Shapiro has been elected to the National Academy of Engineering (NAE), one of the highest honors accorded to an engineer, for his contributions to the theory, computation, and application of stochastic programming;
- Prof. Jorge Nocedal has been elected an NAE member, for his contributions to the theory, design, and implementation of optimization algorithms and machine learning software, which include both deterministic and stochastic optimization;
- An increasing number of research output and grants awarded on stochastic programming and its interface with other areas of optimization and machine learning;
- Many conferences have a growing number of talks on various aspects of stochastic optimization, from theory to modeling to computations, with many talks appearing under other streams such as energy, finance, and healthcare.

The first issue of the SPS Newsletter presents articles on the International Conference on Stochastic Programming (report on the past conference by Asgeir Tomasgard, and announcement of the next one by David Woodruff); research highlights from Student Paper Prize Awardees, and In Memoriam of our colleagues who we lost in the last few years. I would like use this opportunity to thank Asgeir and the organization committee for a great conference in Trondheim and looking forward to our next big event in 2022.

In addition to research and conference highlights, we are also presenting a series of articles on Real-World Impact of Stochastic Programming. Many thanks to COSP members Bernardo Pagnoncelli and Wim van Ackooij for initiating this series.

I wish all of you healthy, happy, creative days, and I look forward to seeing you at the next meeting that we are allowed to have.

ICSP XV Conference Report

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The 15th International Conference on Stochastic Programming was organized in Trondheim during July 29–August 2, 2019. The conference chair was Prof. Asgeir Tomasgard from NTNU, and the program committee chair was Prof. Stein W. Wallace (NHH) with co-chair Prof. Laureano F. Escudero (Universidad Rey Juan Carlos). In the weekend berfore the conference, the traditional pre-conference tutorials were given by Alejandro Jofré, Andrzej Ruszczyński, David Woodruff, Lei Zhao, Trine Krogh Boomsma, and Uday V. Shanbhag.

The conference included plenaries, parallel sessions, 3 invited sessions, and 23 mini symposia, each featuring a semi-plenary and a stream of talks. The 6 Plenary talks were given by Claudia Sagastizábal, George Lan, Güzin Bayraksan, Jong-Shi Pang, Stein-Erik Fleten, and Rüdiger Schultz.

With around 300 participants the conference covered topics like

- Risk-Averse Stochastic Programming

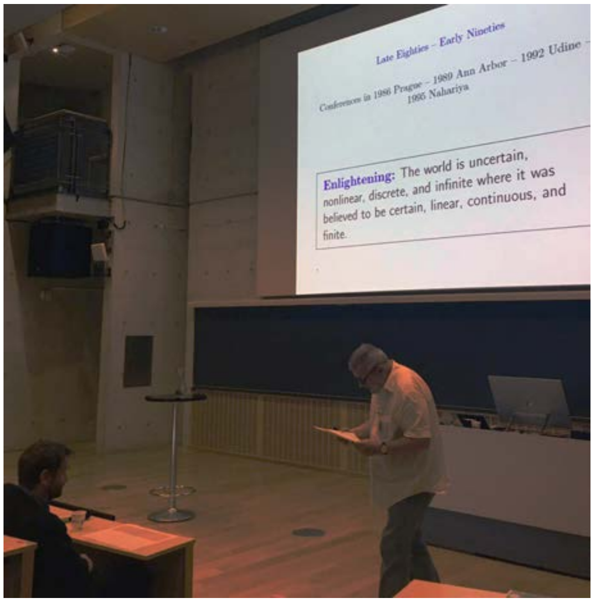

Figure 1: Insights from the closing plenary by Prof. Rüdiger Schultz

Figure 2: The Dupačová-Prékopa Best Student Paper Prize winner Philip Thompson and head of the prize committee Prof. Nilay Noyan

- Stochastic Programming in Energy
- Decomposition Techniques for Large-Scale Stochastic and Robust Energy System Models
- Equilibrium Models in Energy and Transportation
- New Frontiers in Financial Decision Making under Uncertainty
- Robust and Distributionally Robust Optimization
- Methods and Computations in Stochastic Programming
- Equilibrium and Variational Inequalities

A five-day Ph.D. course was given the week before the conference, organized by Stein W. Wallace, Suvrajet Sen, Stein-Erik Fleten, and Asgeir Tomasgard. The course had around 50 participants.

The Dupačová-Prékopa Best Student Paper Prize in Stochastic Programming was sponsored by EWGSO and awarded to Philip Thompson (Instituto de Matemática Pura e Aplicada (IMPA), Brazil, advisers: Alfredo N. Iusem and Alejandro Jofre) for the paper by Alfredo N. Iusem, Alejandro Jofre, Roberto I. Oliveira, Philip Thompson, "Variance-Based Extragradient Methods with Line Search For Stochastic Variational Inequalities", *SIAM Journal on Optimization*, 29 (1): 175–206, 2019 with runner up Weijun Xie (Georgia Tech, adviser: Shabbir Ahmed), and finalists Rui Peng Liu (Georgia Tech, adviser: Alex Shapiro) and Junyi Liu (University of Southern California, adviser: Suvrajeet Sen).

The ICSP XV Dupačová-Prékopa Student Paper Prize

Stochastic line-search for stochastic approximation: adaptation to Lipschitz constant

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The 2019 Dupačová-Prékopa Best Student Paper Prize was awarded to Philip Thompson (IMPA) at ICSP XV for the paper "Variance-Based Extragradient Methods with Line Search for Stochastic Variational Inequalities," coauthored with Alfredo N. Iusem, Alejandro Jofré, and Roberto I. Oliveira, published in SIAM Journal on Optimization, 29(1): 175–206, 2019. Below is a summary of this paper.

Consider the classical stochastic optimization problem (SO): solve the problem $\min_{x\in\mathbb{R}^d}\{f(x) := \mathbb{E}[G(\xi,x)]\}$ given a random function $G : \Xi\times\mathbb{R}^d \to \mathbb{R}$. Here f has L-Lipschitz continuous gradients and the expectation is taken with respect to a random variable ξ. The *Stochastic Approximation* (SA) methodology was first proposed by Robbins and Monro: $x^{k+1} := x^k - \alpha_k\nabla G(\xi^k,x^k)$, given an i.i.d. sample sequence $\{\xi^k\}$ and positive stepsize sequence $\{\alpha_k\}$. This is a first instance of the *stochastic gradient method* (SG).

Another problem of interest is the so called *stochastic variational inequality* (SVI): Given a closed convex set $X\subset\mathbb{R}^d$ and a random operator $F:\Xi\times X\to\mathbb{R}^d$ with L-Lipschitz continuous mean operator $T(x) := \mathbb{E}\left[F(\xi,x)\right]$, the *stochastic variational inequality* problem (SVI), denoted as $\mathrm{VI}(T,X)$, is the problem of finding a point $x^*\in X$ such that, for all $x\in X$, $\langle T(x^*), x-x^*\rangle \geq 0$. In case of monotone operators, the SA version of the extragradient method (SEG) is given by the subsequent iterations $z^k := \Pi\left[x^k - \alpha_k F(\xi^k,x^k)\right]$ and $x^{k+1} := \Pi\left[x^k-\alpha_k F(\xi^k,z^k)\right]$. Here, Π denotes the Euclidean projection onto X. The mentioned unrestricted SO problem is a special instance of the SVI with $X := \mathbb{R}^d$, $F(\xi,x) := \nabla_x G(\xi,x)$ and $T := \nabla f$. By now the literature on stochastic approximation is very large spanning the communities of statistics and stochastic approximation, stochastic optimization and machine learning. Many variants of SG and SEG are now available and a proper review is out of the scope. We refer for the recent review [1]. A proper review for SVIs are out the scope. See e.g. references in [2, 3].

As widely known in practice, the performance of SG and SGE are sensitive to the choice of stepsize sequence. *Small stepsize* policies like $\alpha_k = \theta k^{-1}$ or $\alpha_k = \theta k^{-1/2}$ with an additional final iterative average have the advantage of not requiring precise knowledge of L. Still, they can be slow and still quite sensitive to θ, motivating some sort of adaptation [4, 5]. Fairly recently, *variance-reduction* methods were proposed either using gradient aggregation methods (SAG, SAGA, SVRG, Catalyst, etc) or mini-batching methods (see e.g. [1] and references there in). These methods aim for a *constant stepsize* policy $\alpha_k := \mathcal{O}(L^{-1})$, improving the iteration complexity without serious compromise on the sample complexity[1]. The downside of these methods is that they require knowledge of L. Different approaches to L-adaptation in SG and SGE have been considered: stochastic line-search [6, 7], including [8] reviewed in this article, adaptation via probabilistic models or heuristics (see references in [7] and [9]) and AdaGrad [10] and its variants such as Adam. For those with convergence guarantees, the interesting works by [6, 9] are based on martingale-difference methods. They are based on a probabilistic model requirement which, in a general setting, would typically still require knowledge of some parameters related to the confidence level of the ap-

[1]These methods assume that the stochastic oracle can be queried multiple times per iteration.

proximation. Previous work still imposed strong uniform approximation assumptions that are not obvious from the standard i.i.d. sampling assumption. The interesting recent article [7] establishes a simplified line-search analysis without dynamic mini-batching under the *interpolation assumption*: this is satisfied by certain Neural Networks but not for a generic stochastic optimization problem. Finally, we should mention the success and widespread use of AdaGrad and its variants in the machine learning community. The success of AdaGrad does not come without limitations: it does not attain the improved iteration complexity of variance-reduced methods and strongly requires an uniform boundedness assumption on the gradient.

In [8], we have proposed a stochastic line-search method which does not require any parameter knowledge, assuming the standard i.i.d. sampling assumption and that mini-batches are possible. Concerning the tolerance $\epsilon > 0$, we provide an efficient dynamic mini-batching policy attaining the optimal $\mathcal{O}(\epsilon^{-2})$ sample complexity (up to log factors) and the improved iteration complexity $\mathcal{O}(\epsilon^{-1})$ for monotone SVIs and smooth convex SOs shared by variance-reduced methods. Our guarantees are valid under *local variance assumptions*. Hence we allow the less standard setting where the variance $\mathbb{E}[\|F(\xi,x)-T(x)\|^2]$ is not bounded over x (multiplicative noise). See also [11] for the convex setting and [12, 13] for the strongly-convex setting. At the core of our analysis is to properly address the fact that simple line search methods[2] with efficient mini-batching break the martingale difference property of stochastic approximation. We handle this fact and mutiplicative noise by making use of a novel iterative localization argument based on empirical process theory. We invite the reader to see [8] for more details.

[2] By this we mean line search methods using cheap stochastic approximation with no a priori confidence level requirements.

REFERENCES

[1] L. Bottou, F. E. Curtis and J. Nocedal. Optimization methods for large-scale machine learning, *SIAM Review*, 60(2), 223-311, 2018.

[2] A.N. Iusem, A. Jofré, R.I. Oliveira and P. Thompson. Extragradient method with variance reduction for stochastic variational inequalities, *SIAM Journal Optimization*, 27(2), 686-724, 2017.

[3] A.N. Iusem, A. Jofré and P. Thompson. Incremental constraint projection methods for monotone stochastic variational inequalities, *Mathematics of Operations Research*, 44(1), 236-263, 2019.

[4] F. Yousefian, A. Nedich, and U. V. Shanbhag. On stochastic gradient and subgradient methods with adaptive steplength sequences *Automatica*, 48(1), 56-67, 2012.

[5] R. Pasupathy, H. Honnappa and S.R. Hunter. Open problem-adaptive constant-step stochastic approximation, *Stochastic Systems*, 9(3), 307-310, 2019.

[6] C. Paquette and K. Scheinberg. A Stochastic line search method with convergence rate analysis, *https://arxiv.org/abs/1807.07994*.

[7] S. Vaswani, A. Mishkin, I. Laradji, M. Schmidt G. Gidel and S. Lacoste-Julien. Painless stochastic gradient: interpolation, line-search, and convergence rates, to appear in *NeurIPS 2019*.

[8] A. Iusem, A. Jofré, R. I. Oliveira and P. Thompson. Variance-based extragradient methods with line search for stochastic variational inequalities, *SIAM Journal Optimization*, 29(1), 175-206, 2019.

[9] R. Chen, M. Menickelly and K. Scheinberg. Stochastic optimization using a trust-region method and random models, *Mathematical Programming*, 169(2), 447-487, 2018.

[10] J. Duchi, E. Hazan and Y. Singer. Adaptive subgradient methods for online learning and stochastic optimization, *Journal of Machine Learning Research*, 12, 2121-2159, 2011.

[11] A. Jofré and P. Thompson. On variance reduction for stochastic smooth convex optimization with multiplicative noise, *Mathematical Programming*, 174 (1-2), 253-292, 2019.

[12] L.M. Nguyen, P.H. Nguyen, M. van Dijk, P. Richtárik, K. Scheinberg and M. Takác. SGD and Hogwild! Convergence without the bounded gradients assumption, *ICML* 2018.

[13] R.M. Gower, N. Loizou, X. Qian, A. Sailanbayev, E. Shulgin and P. Richtárik. SGD: general analysis and improved rates, *ICML* 2019.

The ICSP XV Dupačová-Prékopa Student Paper Prize

On deterministic reformulations of distributionally robust joint chance constrained optimization problems

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The Runner-up of the 2019 Dupačová-Prékopa Best Student Paper Prize was awarded to Weijun Xie (Georgia Tech) at ICSP XV for the paper "On Deterministic Reformulations of Distributionally Robust Joint Chance Constrained Optimization Problems," coauthored with adviser Shabbir Ahmed, published in SIAM Journal on Optimization, 28(2):1151–1182, 2018. Below is a summary of this paper.

Setting: We consider a distributionally robust chance constrained program (DRCCP) of the form:

$$v^* = \min_x \quad c^\top x, \tag{1a}$$

$$\text{s.t.} \quad x \in S, \tag{1b}$$

$$\inf_{\mathbb{P}\in\mathcal{P}} \mathbb{P}[\xi : F(x,\xi) \geq 0] \geq 1-\epsilon, \tag{1c}$$

where $x \in \mathbb{R}^n$ is a decision vector; the vector $c \in \mathbb{R}^n$ denotes the objective coefficients; the set $S \subseteq \mathbb{R}^n$ denotes deterministic constraints on x; the random vector ξ supported on $\Xi \subset \mathbb{R}^m$ denotes uncertain constraint coefficients with a realization denoted by ξ; the mapping $F(x,\xi) := (f_1(x,\xi),\ldots,f_I(x,\xi))^\top$ with $f_i(x,\xi) : \mathbb{R}^n \times \Xi \to \mathbb{R}$ for all $i \in [I] := \{1,\ldots,I\}$ defines a set of uncertain constraints on x; the ambiguity set $\mathcal{P}$ denotes a set of probability measures $\mathbb{P}$ on the space Ξ with a sigma algebra $\mathcal{F}$; and $\epsilon \in (0,1)$ denotes a risk tolerance. In (1) we seek a decision vector x to minimize a linear objective $c^\top x$ subject to a set of deterministic constraints defined by S, and a chance constraint (1c) that is required to hold for any probability distribution from the ambiguity set $\mathcal{P}$ with a probability of $1-\epsilon$. Note that when $|I| = 1$ the constraint (1c) involves a *single* chance constraint and if $|I| \geq 2$ it involves a *joint* chance constraint.

Figure 1: The Dupačová-Prékopa Best Student Paper Prize runner up Weijun Xie attending ICSP XV via Skype (photo credit: Kai Pan)

Assumption: The primary difficulty of (1) is due to the distributionally robust chance constraint (1c). Let us denote the feasible region induced by (1c) as

$$Z = \left\{ x \in \mathbb{R}^n : \inf_{\mathbb{P}\in\mathcal{P}} \mathbb{P}[\xi : F(x,\xi) \geq 0] \geq 1-\epsilon \right\}.$$

In this paper we study deterministic reformulations of the set Z and its convexity properties. Our study is restricted to the convex, moment constrained setting (see, e.g., [1, 2]). That is, we assume that the ambiguity set $\mathcal{P}$ is nonempty and is defined by moment constraints:

$$\mathcal{P} = \{\mathbb{P} : \mathbb{E}_\mathbb{P}[\phi_t(\xi)] = g_t, t \in \mathcal{T}_1, \mathbb{E}_\mathbb{P}[\phi_t(\xi)] \geq g_t, t \in \mathcal{T}_2\}$$

where for each $t \in \mathcal{T}_1 \cup \mathcal{T}_2$, the moment function $\phi_t : \Xi \to \mathbb{R}$ is a real valued continuous function and g_t is a scalar. Furthermore, for each $t \in \mathcal{T}_1$, the function $\phi_t(\xi)$ is linear, and for each $t \in \mathcal{T}_2$, the function $\phi_t(\xi)$ is concave.

Main Contributions: The DRCCP set Z is nonconvex in general, making (1) a difficult optimization problem. In this paper we first provide a deterministic approximation of Z that is nearly tight and then identify a variety of settings under which Z is convex. The main results of this paper are summarized next.

1. We propose a deterministic conservative approximation of set Z, which is in general nonconvex and can be formulated as an optimization problem involving biconvex constraints.

2. If there is a single uncertain constraint, i.e. $|I| = 1$, we prove that the proposed deterministic approximation is exact and reduces to a tractable convex program. This result is a generalization of existing works (e.g., [3, 4, 5]) to arbitrary convex ambiguity sets rather than those involving only first and second moment constraints.

3. We prove that if the ambiguity set $\mathcal{P}$ contains only one moment inequality, i.e. $|\mathcal{T}_1| = 0$ and $|\mathcal{T}_2| = 1$, then Z is a tractable convex program; and if the ambiguity set contains only one moment linear equality, i.e. $|\mathcal{T}_1| = 1$ and $|\mathcal{T}_2| = 0$, then Z is equivalent to the disjunction of two tractable convex programs.

4. We prove that if $\Xi = \mathbb{R}^m$ and the moment functions $\{\phi_t(\xi)\}_{t\in\mathcal{T}_1\cup\mathcal{T}_2}$ are linear, then Z is equivalent to the feasible region of a robust convex program.

5. We prove that if Ξ is a closed convex cone, the function $f_i(x, \xi)$ for any $i \in [I]$ is of the (separable) form $f_i(x, \xi) = w_i(x) - h_i(\xi)$ where $h_i(\xi)$ is positively homogeneous on Ξ, and the moment functions $\{\phi_t(\xi)\}_{t\in\mathcal{T}_2}$ are positively homogeneous on Ξ, then set Z is convex. This result is a generalization of [6], where the authors assumed that $w_i(\cdot)$ and $h_i(\cdot)$ are affine functions for each $i \in [I]$.

6. When the decision variables are pure binary (i.e. $S \subseteq \{0, 1\}^n$) and uncertain constraints are linear, we show that the proposed deterministic approximation can be reformulated as a mixed integer convex program. We also present a numerical study to demonstrate that the proposed reformulation can be effectively solved using a standard solver.

REFERENCES

[1] A. Shapiro and S. Ahmed. On a class of minimax stochastic programs, *SIAM Journal on Optimization*, 14, 1237–1249, 2004.

[2] A. Shapiro and A. Kleywegt. Minimax analysis of stochastic problems, *Optimization Methods and Software*, 17, 523–542, 2002.

[3] G.C. Calafiore and L. El Ghaoui. On distributionally robust chance-constrained linear programs, *Journal of Optimization Theory and Applications*, 130, 1–22, 2006.

[4] W. Yang and H. Xu. Distributionally robust chance constraints for non-linear uncertainties, *Mathematical Programming*, 155, 231–265, 2016.

[5] S. Zymler, D. Kuhn and B. Rustem. Distributionally robust joint chance constraints with second-order moment information, *Mathematical Programming*, 137, 167–198, 2013.

[6] G.A. Hanasusanto, V. Roitch, D. Kuhn and W. Wiesemann. Ambiguous joint chance constraints under mean and dispersion information, *Operations Research*, 65(3), ii-iv, 2017.

In Memoriam: Marida Bertocchi

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Maria Ida (*Marida* for friends and colleagues) Bertocchi was born in Bergamo on August 14th, 1951. She passed away on November 16th, 2016 after a sudden and dramatic illness and a very complex surgery. This article is dedicated to her memory, following a memorial in her honor held in Bergamo on May 28th, 2017 and a special session held at the XV International Conference on Stochastic Optimization (ICSP XV) in Trondheim.

Since the 80's, Marida's extremely kind, positive and productive personal and professional attitudes led her to become rapidly a central and influential figure of the University of Bergamo in particular and the Italian mathematical community at large. Throughout her career Marida fostered many international collaborations and supported young scholars on a variety of mathematical fields and application areas with unbounded energy, good humour, outstanding social skills and a keen intellect.

Her academic excursus started after graduating at the Faculty of Mathematics of the University of Milano in 1974. In 1979, Marida joined the Faculty of Economics of the University of Bergamo and in 1985 she was appointed Associate Professor. In 1989, after being awarded the Full Professorship, she moved to the University of Urbino, before returning in 1992 to the University of Bergamo, where she has been ever since. Marida was very active at all training levels, from undergraduate to doctoral studies: after being appointed Chair in Mathematical Methods for Economics and Finance, she started a very successfull and well-known PhD program in *Computational Methods for Financial and Economic Forecasting and Decisions*, later named *Analytics for Economics and Business*, that she coordinated until 2016. She served as University Vice-chancellor in the academic year 1995-1996 before becoming Elective Dean of the Faculty of Economics for two terms, from 1996 to 2002 and later on head of the Department of Mathematics and Statistics from 2009 to 2012.

Her early research interests were primarily in optimization and numerical analysis [1, 2], before being increasingly committed to computational and applied topics of stochastic programming. Marida's interest in stochastic programming developed since 1992 thanks to a lasting cooperation and friendship with Jitka Dupačová, when they met at the XVI AMASES Conference in Treviso (Italy), where Jitka gave a plenary talk on the topic. They started a fruitful collaboration on several financial optimization areas [3, 4, 5]. Later on, also thanks to the growing group of colleagues and collaborators introduced or already working in this field, including the two of us, Marida's research interests spread to methodological topics [6, 7] and new application areas in energy and finance [8, 9, 10, 11, 12] always involving stochastic modeling and advanced computational approaches.

Marida has been a very active member of the Stochastic Programming community. Among the founding members of the *European Working Group in Stochastic Programming* (SP) established in Neringa (LT) in July 2012, she organized and was behind several SP conferences and streams within International meetings, from the extremely successfull 2007-2009 International Cariplo PhD program to the XIII International SP Conference held in Bergamo in 2013.

In June 2016, right before getting ill, Marida attended the 14th International Conference on Stochastic Programming in Buzios, Brazil. On September 15th, 2016, already ill, she gave a plenary lecture on Stochastic Programming in Economics and Finance at the 40th AMASES Conference in Catania. Her strength and devotion during her lecture impressed all the participants in the meeting who will always remember her last lecture.

Shortly after, Marida was diagnosed with a very severe form of cancer, that despite a complex and challenging surgery, took her away, very sadly in mid November 2016. Since then, not only us but also her former colleagues, Adriana Gnudi, Rosella Giacometti, Sergio Ortobelli and Vittorio Moriggia, as well as younger members of the research group are committed to further strenghten and consolidate Marida's scientific and human legacy.

A World Scientific volume including a selected collection of Marida's articles was just published few weeks ago [13], while a special issue in her memory in Annals of Operations Research entitled "Stochastic Optimization: Theory and Applications" with guest editors Giorgio Consigli, Darinka Dentcheva and Francesca Maggioni is forthcoming.

REFERENCES

[1] M. Bertocchi and E. Spedicato. Computational experience with conjugate gradient algorithms, *Calcolo*, 16(3), 255–269, 1979.

[2] V. Moriggia, M. Bertocchi and J. Dupačová. Highly parallel computing in simulation on dynamic bond portfolio management, *Proceedings of the APL98 Conference*, pp. 215–221, 1998.

[3] M. Bertocchi, V. Moriggia and J. Dupačová. Sensitivity of bond portfolio's behavior with respect to random movements in yield: a simulation study, *Annals of Operations Research*, 99(1), 267–286, 2000.

[4] M. Bertocchi, V. Moriggia and J. Dupačová. Bond portfolio management via stochastic programming, *Handbook of Asset and Liability Management*, 1, 305–336, 2008.

[5] J. Dupačová and M. Bertocchi. From data to model and back to data: a bond portfolio management problem, *European Journal of Operational Research*, 134(2), 261–278, 2001.

[6] F. Maggioni, E. Allevi and M. Bertocchi. Bounds in multistage linear stochastic programming, *Journal of Optimization Theory and Applications*, 163(1), 200–229, 2014.

[7] F. Maggioni, E. Allevi and M. Bertocchi. Monotonic bounds in multistage mixed-integer linear stochastic programming, *Computational Management Science*, 13(3), 423–457, 2016.

[8] M. Bertocchi, G. Consigli and M.A.H. Dempster (Eds.). *Handbook on stochastic optimization methods in finance and energy. New financial products and energy market strategies*, Fred Hillier International Series in Operations Research and Management Science, Springer (US), 2011.

[9] M. Bertocchi, S. Schwartz and W.T. Ziemba. *Optimizing the aging, retirement and pension dilemma*, John Wiley & Sons Inc., Hoboken, New Jersey, 2010.

[10] R. Giacometti, S. Ortobelli and M. Bertocchi. A Stochastic model for mortality rate on Italian data, *Journal of Optimization, Theory and Applications*, 149, 216–228, 2011.

[11] R. Giacometti, M.T. Vespucci, M. Bertocchi and G.B. Adesi. Hedging electricity portfolio for a hydro-energy producer via stochastic programming, *International Series in Operations Research and Management Science*, 163, 163–179, 2011.

[12] F. Maggioni, M.T. Vespucci, E. Allevi, M. Bertocchi, R. Giacometti and M. Innorta. A stochastic optimization model for gas retail with temperature scenarios and oil price parameters, *Ima Journal of Management Mathematics*, 21(2), 149-–163, 2010.

[13] R.L. D'Ecclesia, S.A. Zenios and W.T. Ziemba (Eds.). *Collected works of Marida Bertocchi* Book Series: World Scientific Handbook in Financial Economics Series, Vol. 8, 2019.

In Memoriam: Maarten van der Vlerk

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Maarten van der Vlerk was born in the year 1961 in Assen, The Netherlands. He became a doctoral student at the University of Groningen in the Department of Econometrics under the supervision of Wim Klein Haneveld and Leen Stougie in 1990. Invited and encouraged by his supervisors, Maarten placed a research focus on the integer programming side of stochastic optimization.

He obtained his PhD at the University of Groningen in 1995 for his thesis “Stochastic Programming with Integer Recourse”. After a period at CORE (Louvain-la-Neuve) he returned to Groningen and in 1999 he received a prestigious research fellowship from the Royal Netherlands Academy of Arts and Sciences (KNAW).

He would go on to be named professor of Stochastic Optimization at the Faculty of Economics and Business, and director of the bachelor and master programmes Econometrics & Operations Research and Econometrics, Operations Research & Actuarial Studies. He was also member of the general board of the LNMB, the Dutch Network on the Mathematics of Operations Research, and from 2004 until 2007 he was Chair of the Stochastic Programming community.

On October 9, 2016, Maarten van der Vlerk passed away at the age of 54.

From the mid 1990s on, stochastic integer programming became the field where Maarten van der Vlerk’s research earned highest recognition in the stochastic programming community and beyond. A permanently recurring research target of Maarten, and his various coauthors, has been convex approximation of the notoriously non-convex, discontinuous, mixed-integer expected recourse function, together with its algorithmic utilization. Papers devoted to these topics range over a time span of more than 20 years, see also [1]. Prominent examples include [2], [3], and [4].

Maarten was not only a brilliant researcher, internationally renowned for his work in Stochastic Programming, he was also an outstanding teacher with a gift for imparting knowledge. He won the FEB lecturer of the year award in 2014. His courses, Stochastic Programming and the Specialization Course Applied Operations Research, were in the top five of his faculty almost every year. From information meetings for prospective students until their master degree ceremonies, his dedication to students was exemplary.

Maarten was also a very active member of the Stochastic Programming community. He developed the *Stochastic Programming Bibliography* early in his career, and served as Secretary and then Chair of COSP. He was a tutorial speaker at several ICSP conferences, and he organized a workshop on Stochastic Integer Programming in Groningen in 2004. His Stochastic Programming lecture notes, that he shared with many colleagues, have recently been published as textbook [5] by Springer.

Apart from beautiful mathematics Maarten enjoyed many other good things in life, which he happily shared with his friends and colleagues: music, in particular Bach, and tennis, which he made a fixed point of the social program of any stochastic programming meeting. We will miss Maarten's boisterous laugh, his warm smile, his sense of humor, and his ability to make everyone around him a better person.

REFERENCES

[1] D.P. Morton, W. Romeijnders, R. Schultz and L. Stougie. The stochastic programming heritage of Maarten van der Vlerk, *Computational Management Science*, 15(3-4), 319–323, 2018.

[2] M.H. van der Vlerk. Convex approximations for complete integer recourse models, *Mathematical Programming*, 99, 297–310, 2004.

[3] W.K. Klein Haneveld, L. Stougie and M.H. van der Vlerk. Simple integer recourse models: convexity and convex approximations, *Mathematical Programming*, 108, 435–473, 2006.

[4] W. Romeijnders, R. Schultz, M.H. van der Vlerk and W.K. Klein Haneveld. A convex approximation for two-stage mixed-integer recourse models with a uniform error bound, *SIAM Journal on Optimization*, 26, 426–447, 2016.

[5] W.K. Klein Haneveld, M.H. van der Vlerk and W. Romeijnders. *Stochastic programming: Modeling decision problems under uncertainty,* Graduate texts in Operations Research, Springer, 2020.

In Memoriam: Shabbir Ahmed

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Our friend and colleague Shabbir Ahmed passed away on June 19th, 2019 at the age of 49 after a hard-fought battle with cancer. Shabbir was born in Bangladesh, received a B.Eng. in mechanical engineering from Bangladesh University of Engineering and Technology in 1993, and M.S. and Ph.D. degrees in industrial engineering from the University of Illinois at Urbana-Champaign in 1997 and 2000. Shabbir joined the Industrial and Systems Engineering faculty at Georgia Tech in 2000, and he held the title of Anderson-Interface Chair and Professor at the time of his passing. Shabbir leaves behind his loving wife Rasha and daughters Raeeva and Umana.

At the memorial session held in Shabbir's honor at the ICSP meeting in Trondheim, his former students and colleagues spoke of Shabbir's many contributions to the field. But the most resounding message heard from the speakers was how deeply Shabbir cared about his students and in fostering the next generation of researchers in stochastic programming. As more than one speaker recalled, Shabbir would often say that students "were the blood" of any good research program. Shabbir graduated 28 Ph.D. students during his 19 years at Georgia Tech.

Shabbir's selfless focus on students carried over to his service work. Shabbir served as the Secretary of Stochastic Programming Society (SPS) from 2007-2010, and he re-aligned SPS as an official technical section under the Mathematical Optimization Society (MOS). However, Shabbir's proudest accomplishment during his tenure was the creation of the Stochastic Programming Society Student Paper Prize.

Shabbir's academic contributions are almost too numerous to mention, with nearly 100 journal articles and more than 8000 citations to his credit. Many of his seminal contributions were in stochastic programming. He made significant contributions to the fields of stochastic integer programming [1, 2, 3], chance-constraints [4, 5, 6, 7], and risk-averse methods [8, 9, 10]. Shabbir worked vigorously on the application of stochastic programming in important practical domains such as supply chain planning [11], vehicle routing [12], and energy systems [13].

For his pioneering work on piecewise-linear optimization, Shabbir was awarded the INFORMS Computing Society Prize in 2017. In 2018, he won the Farkas Prize for his outstanding contributions to the optimization community from the INFORMS Optimization Society. Shabbir was elected a Fellow of INFORMS in 2017.

Shabbir enjoyed traveling with his family; running; he was a skilled table-tennis player; and he was an extremely-talented heavy-metal musician. Most of all, Shabbir was a staggering intellect, an encouraging and energetic force for the optimization community, a devoted husband, a loving father, and a wonderful colleague and friend. We all miss him very deeply, but we are consoled by our memories of him and the lasting legacy he left behind for our community.

REFERENCES

[1] S. Ahmed, M. Tawarmalani, and N. Sahinidis. A finite branch and bound algorithm for two-stage stochastic integer programs, *Mathematical Programming*, 100, 355–377, 2004.

[2] Y. Guan, S. Ahmed, and G. Nemhauser. Cutting planes for multistage stochastic integer programs, *Operations Research*, 57(2), 287–298, 2009.

[3] J. Zou, S. Ahmed, and X.A. Sun. Stochastic dual dynamic integer programming, *Mathematical Programming*, 175, 461–502, 2019.

[4] J. Luedtke and S. Ahmed. A sample approximation approach for optimization with probabilistic constraints, *SIAM Journal on Optimization*, 19, 674–699, 2008.

[5] J. Luedtke, S. Ahmed, and G.L. Nemhauser. An integer programming approach for linear programs with probabilistic constraints, *Mathematical Programming*, 122, 247–272, 2010.

[6] W. Xie and S. Ahmed. On quantile cuts and their closure for chance constrained optimization problems, *Mathematical Programming*, 172, 621–646, 2018.

[7] W. Xie and S. Ahmed. Bicriteria approximation of chance constrained covering problems, *Operations Research*, 2020.

[8] A. Shapiro and S. Ahmed. On a class of minimax stochastic programs, *SIAM Journal on Optimization*, 14, 1237–1249, 2004.

[9] S. Ahmed. Convexity and decomposition of mean-risk stochastic programs, *Mathematical Programming*, 106, 433–446, 2006.

[10] S. Ahmed and A. Atamtürk. Maximizing a class of submodular utility functions, *Mathematical Programming*, 128, 149–169, 2011.

[11] T. Santoso, S. Ahmed, M. Goetschalckx, and A. Shapiro. A stochastic programming approach for supply chain network design under uncertainty, *European Journal of Operational Research*, 167, 96–115, 2005.

[12] B. Verweij, S. Ahmed, A. Kleywegt, G. Nemhauser, and A. Shapiro. The sample average approximation method applied to stochastic routing problems: A computational study, *Computational Optimization and Applications*, 24, 289–333, 2003.

[13] J. Zou, S. Ahmed, and X. A.Sun. Partially adaptive stochastic optimization for electric power generation expansion planning, *INFORMS Journal on Computing*, 30(2), 217–240, 2018.

Real World Impact of Stochastic Programming in Pension Funds: An Example from Chile

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Impact Summary: *How to measure risk in a defined contribution pension system? In Chile, the oldest of such systems, the regulator recently announced that risk measures will replace portfolio constraints as a way of defining investment alternatives. The decision was based on results from a paper that uses Stochastic Programming techniques. The Chilean system manages around 80% of the country's GDP, and it is a blueprint for many systems around the world.*

At some point in our lives, most of us need to stop working, and we all hope to have a good pension plan to cover our expenses during retirement. Governments and private companies around the world offer different alternatives to achieve that. In all cases, there is an accumulation phase where active workers contribute towards retirement (which ends after working a certain number of years, and if workers are past some age), and a decumulation period where retirees are eligible to receive their benefits.

The most basic retirement schemes are defined benefit (DB) and defined contribution (DC). In DB systems, the worker is guaranteed to have a fixed benefit after retirement, and the contribution during the active phase may vary. In DC systems, the contribution to retirement is a fixed percentage of the salary, but the annuity that will be received during retirement depends on how well the money was invested and on the returns of the assets in the active phase. Many countries use hybrid schemes, combining elements from both systems. However, it is undeniable that in recent decades there has been a shift to DC systems [1, 2]. The reasons for this trend include a sharp decrease in fertility ratios, longevity risk and a future with extremely low interest rates. I am going to discuss two issues that appear in all DC systems, and I will use the Chilean case to illustrate the discussion since it is the oldest (and purest) DC system in the world. Moreover, deflated data is publicly available, which makes it a natural candidate for experiments [3].

The first aspect I want to address is how to specify the financial instruments that will be available to workers during the active phase. In Chile, a DC system was imposed in 1980, and in 2002 it reached its more mature phase with the creation of five different funds, A, B, C, D and E. Fund A is supposed to be the riskiest, and fund E the safest, and each fund is defined by upper and lower bounds on some financial instruments (see Table 1 for a sample of the constraints imposed by the regulator). We claim that such a system is based on proxies for risk: it is expected that, by allowing a higher exposure to stocks, fund A will have higher returns—and higher risk—which will decrease gradually until fund E (lower returns, lower risk). As an example, a portfolio composed of 80% of US stocks and 20% of treasury bonds does not have the same risk as a portfolio consisting of 80% of stocks from a more volatile emerging market (and the same 20% of treasury bonds), and they would both be eligible as investments for fund A. By analyzing Chilean data, we noticed that the cumulative returns of the funds were not properly ordered (i.e. the supposed higher returns for A, and then B, C, D, and E), even for extended periods of time. That is problematic, since the funds were designed to have such profile, and workers that choose a particular fund (say, fund A) expect to have higher returns in the long run.

In [4] we proposed to measure risk directly, that is, we suggest to remove all portfolio constraints (aside from nonnegativity, and that investments must sum to one) and include a risk measure for each fund. In our approach, a fund will be defined by the right-hand side of a risk constraint on returns: smaller values will correspond to fund E (tighter constraint), higher val-

	Limits on stocks		Limits on foreign instr.	
	Max %	Min%	Max %	Min%
A	80	40	100	45
B	60	25	90	40
C	40	15	75	30
D	20	5	45	20
E	5	0	35	15

Table 1: Limits in % based on the market value of the portfolio for funds A, B, C, D and E

ues to fund A, and values in between will define funds B, C, and D. Our out-of-sample results indicated that had such strategy been adopted the funds would have been correctly ordered in terms of risk and return according to the original intention of the regulator. Moreover, our results showed that higher returns would have been obtained in the risk-controlled framework even if the investment universe was drastically reduced to include only six index funds instead of thousands of individual assets. It is worth mentioning that the Mexican pension system includes risk measures in the fund's definitions, and they have exhibited ordered returns since their inception.

I presented, with one of the study's co-authors (A. Cifuentes), our findings to the technical committee that defines the investment rules for pension funds in Chile. Our conclusions were well-received, and in October 2019, the Pension Superintendent (the ultimate authority in pensions in the country) announced that in 2020 the funds would not be defined by portfolio constraints anymore [5]. He mentioned that using risk to define the different funds will "generate a regulatory context that facilitates the construction of efficient portfolios".

The second topic is related to default strategies in DC pension funds. It is a well-known fact that financial illiteracy prevents a large percentage of workers from adequately managing their portfolio. Lack of time and even interest (!) have also been pointed out as factors explaining why workers do not manage their pension fund accounts. Several polls done in Chile in the last 10 years show that 65% of the respondents do not know in which fund they are at the moment, and only 22% know how much they have accumulated in their pension account [6].

Due to those facts, all DC pension fund systems need to have a default strategy for workers that do not manage their savings. A standard approach is to follow life-cycle strategies: in the first years, the worker should be in a riskier fund (to boost returns), and then move gradually to safer funds as retirement approaches. The popular target funds follow this strategy, which only takes into account the time to retirement. The default strategy in Chile is described in Table 2. A fundamental question is whether the default strategy is a good one and if other strategies dominate it in some sense. The default strategy is like a "Waze-less driver": no matter the driving conditions (snow, traffic), I will follow the path that I defined when I left home.

		A	B	C	D	E
Men $\leq$ 35	Women $\leq$ 35		■			
Men 36-55	Women 36-50			■		
Men $\geq$ 56	Women $\geq$ 51				■	

Table 2: The default strategy in Chile per gender and age bracket

In a recent work [7], we propose to include wealth as a state variable. In other words, the investment strategy will depend on how much money was accumulated so far. We use stochastic dynamic programming to obtain an investment strategy that (stochastically) dominates the default strategy. In the Chilean case, we showed that although the default strategy has an adequate performance overall, our proposed approach had a higher probability of meeting retirement goals, and had a smaller shortfall on average. Additionally, the optimal solution includes only funds A and E, calling into question the need for five funds.

Constructing, managing, and regulating pension funds are complex problems, and we will probably continue to see fierce discussions around the world in the coming years on how to build a system that offers the best benefits to workers. DC systems are an excellent opportunity for optimizers (in particular stochastic ones!) because the problems involve meaningful

Figure 1: The challenges of retirement

and clear decisions and the need to measure risk in a context that is related (but different) from pure portfolio allocation problems. I believe the optimization community should be part of this discussion, working closely with policymakers.

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REFERENCES

[1] J. Broadbent, M. Palumbo, and E. Woodman. The shift from defined benefit to defined contribution pension plans-implications for asset allocation and risk management, *Reserve Bank of Australia, Board of Governors of the Federal Reserve System and Bank of Canada*, 1–54, 2006.

[2] The trouble with pensions: Falling short. The Economist, June 12th 2008.

[3] Superintendencia de Pensiones Chile. Monthly returns. https://www.spensiones.cl/portal/institucional/594/w3-propertyvalue-10089.html.

[4] T. Gutierrez, B. Pagnoncelli, D. Valladão, and A. Cifuentes. Can asset allocation limits determine portfolio risk–return profiles in dc pension schemes? *Insurance: Mathematics and Economics*, 86, 134–144, 2019.

[5] Oro y más: anuncian cambios en las inversiones de los fondos de pensiones. https://www.elmercurio.com/Inversiones/Noticias/Analisis/2019/09/10/Invertir-en-oro-y-mas-anuncian-cambios-\a-las-inversiones-de-\los-fondos-de-pensiones.aspx.

[6] La encuesta de protección social y la reforma al sistema de pensiones: el caso de chile. https://www.previsionsocial.gob.cl/sps/download/estudios-previsionales/encuesta-de-proteccion-social/estudios-relacionados-eps/2009/24-la-eps-y-la-reforma-al-sistema-de-\pensiones_el-caso-de-chile.pdf.

[7] D. Duque, D. Morton, and B. Pagnoncelli. How good are default investment policies in defined contribution pension plans? *Available at SSRN 3471428*, 2019.

Real World Impact of Stochastic Programming in Energy: An Example from Europe

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Impact Summary: *Energy, in particular electricity, as a fundamental resource, impacts society at large. The electricity system in Western Europe*[1]*, for instance, impacts more than 150 million people. The trend to increase the share of wind and solar generation and thus intermittent generation creates a need to asses and improve flexibility of the system. Assessing the need for such flexibility arises as a result of uncertainty. The tools from stochastic programming are required for a proper evaluation of this flexibility. The result of these tools will lead to updated policy and to changes in the physical system.*

Energy management is about the efficient handling and decision making around "assets" that produce or consume "energy" in one form or another. Since "energy" is a vital resource for

[1]Western Europe is composed of France, Germany, Netherlands, Belgium, Austria, Switzerland, Luxembourg, Monaco, Liechtenstein

the economy, and basically any aspect of society, it is indeed reasonable to desire some efficiency in its handling. Although we will mainly discuss electrical energy, one can also think of gas, oil and heat networks. In the electrical sector, assets involve thermal generation units (nuclear, coal, gas,...), hydro-electrical installations (cascading systems, pump storage units, run-of-the river,...), intermittent renewable generation (wind turbines, solar panels,...) and also demand-side management programs. Decisions to consider are investment choices (generation assets, network), strategic planification of resources with long cycles (e.g., water), how to operate a set of given generation assets, how and when to deploy/activate demand-side management, but also how to handle uncertainty. Uncertainty has always been an important aspect of energy management. Indeed, vital underlying aspects are subject to uncertainty, and actually weather related. This is for instance the case with load, which depends not only on the economic cycle, but also on weather through the demand in heating / cooling. Likewise, the management of hydro-electric installations depends on water, which has unknown inflows (melting of snow, rain,...), but may also have unknown outtake for agriculture. Modern systems are further dependent on weather as a result of unknown generation in wind and solar.

The use of optimization, as a support for decision making, was recognized already as early as in the 1940s, when Pierre Massé laid the foundations of many principles of optimization, in particular to hydroelectric reservoir management [1]. Contemporaneously with Dantzig and Kantorovitch, Massé realized the importance of dual variables, and their economic interpretation, and he also laid the foundations of dynamic programming through the recognition of an optimal value function. Optimization has ever since remained a vital building block of decision making support tools/software. This is for instance the case in unit-commitment and its great many variants. Optimization contributes to energy applications as a tool, but also the practically relevant aspects of the problem stimulate the development of new theoretical insights and better algorithms.

Optimization should be understood here in a broader scope. Indeed, uncertainty has always been accounted for, in one way or another in all of these problems. First of all, by putting in place a series of failsafe mechanisms through organizational measures, such as spinning reserve requirements. Second, by carefully studying and modelling uncertainty with the techniques of statistics. Finally, by incorporating uncertainty itself within the optimization model: the use of stochastic programming. This too, takes various forms, from the incorporation of additional safety margins (derived through considerations involving individual probability constraints or robustness arguments), the incorporation of forecasts, operationally rerunning the software with sliding windows, whenever new information is available, all the way to the consideration of more involved and larger models from stochastic programming itself.

As we have thus seen, these models can be large in a variety of ways: spatially, temporally, detailed and possibly explicitly accounting for uncertainty. We will illustrate the practical relevance of stochastic programming in two "extremal situations": the context of centrally planning the European energy sector; the context of an energy management system on a distribution grid, providing services to the system, dealing with uncertainty on wind generation and having access to a storage device.

1. Large-Scale System

The EU H2020 funded project[2] plan4res focusses on delivering an end-to-end planning tool which will help examine the trade-off between the share of integrated renewable energy into the European Energy System and system reliability. The model will account for the Pan-European interconnected electricity system, synergies with other energy systems, emerging technologies, flexibility resources and provide a fully integrated modelling environment. As a first point we should emphasize what is meant with "real-world impact" in this particular situation.

[2] grant 773897, http://plan4res.eu

Indeed, in this case, it is not meant in the sense that some particular new asset will be constructed in a specific location as a result of the outcomes of the model, but rather that the latter outcomes will serve to enlighten policy. This is the fairly general case, and only rarely will the results of an optimization problem lead to direct decisions. The policy, enlightened by the results of various studies with the optimization tool, will make better use of resources. One should thus see real-world impact in this light.

Now immediately comes the question of how to properly tackle the study of reliability in conjunction with high intermittent renewable energy insertions. What would be the origin of "unreliability"? It is clear that this results on one hand from the presence of the physical constraints of the system (e.g., on classic generators) and on the other from the presence of unpredictable quantities, i.e., uncertainty. It is thus only when both features are modelled, that one can properly address the question. Next, one has to distinguish that uncertainties impact the system at different scales of time, and both are relevant. Most intermittent generation has a short term impact, e.g., within the day, whereas hydro inflows are naturally measured across the four seasons, i.e., on a yearly basis. Hydro-electric energy plays an important role in the system, since it is generally a fast, flexible means of generation, that moreover is cheap. The vital issue is thus to properly place this energy with a yearly cycle, thus attributing it a cost of use (a substitution cost), since otherwise the resource would be prematurely depleted. While doing so, one should evidently account for constraints implied by other uses of water, such as agriculture or touristic applications. The thus computed value of water is typically transmitted, in one way or another, to shorter time span applications such as unit-commitment. The vital place that water valuation has, was recognized a long time ago, e.g., [2], and the typical operationally used approaches are stochastic dynamic programming. These approaches usually involve some form of aggregation, but are what were/is used in practice. Recently, SDDP (e.g., [3]) has moved to the foreground. This approach will also be used in plan4res (we also refer to e.g., [4]), where moreover the transition problem will be formed by a full-scale European unit-commitment problem.

2. Small-Scale System

Accounting for uncertainty is not only important at the larger scale, but also matters at a reduced scale. This is for instance the case in the demonstrator built within the EU-Sysflex H2020 project [3]. Figure 1 below shows the physical installation of the demonstrator.

Figure 1: Facilities of the multi-resources multi-services demonstrator

The purpose of this demonstrator is to acquire insights and conduct complex testing campaigns that can not be conducted on a real system (without potentially compromising safety), as a result of handling intermittency and storage systems. One of the objectives is to examine to what extent batteries can provide frequency support services to the system. Announcing such services (or selling them) is typically something done ahead of real time. Subsequently, the difficulty resides in being able to honour the engagement as a result of real time deviations. The latter being themselves, the result of uncertainty. For this purpose a stochastic programming based energy management system is embedded within the scheme shown in Figure 2. A stochastic programming based scheduler is what leads to better profits than when considering a scheduler based

[3] grant 773505, http://https://eu-sysflex.com/

only on forecasts. This results also from having to pay less penalties in case of discrepancies between engagements and real time capabilities. Contrary to the usual situation, the actual output of the planning tool is this time, taken into account immediately. There are of course some failsafe mechanisms in so much that the decisions are actually adapted to account for real time information coming from the actual equipment. Moreover, the planning tool is rerun intradaily to adjust for new forecasts and information such as the state of charge of the battery. Still, the decisions mostly get implemented. For further details on the equipment, we refer to [5].

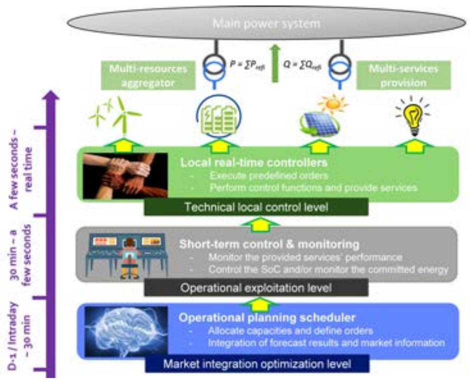

Figure 2: General control layers of the demonstrator

3. Concluding observations

As we have thus seen in both contexts, which are illustrative, stochastic programming is a vital building block in the analysis and operation of energy systems and has been so for a significant amount of time. Stochastic programming is not only vital at larger scales of time / space, as was traditionally the case, but tends also to become significantly more important for smaller scales. At these smaller scales, the non-convexity of the underlying physics (e.g., powerflow equations) have a real impact and are hard to neglect or simplify. There is thus lots of room for new modelling, theory and algorithms in stochastic programming within these applications – and – most importantly, real impact of one's research if the entire path, from application to theory and back, is taken.

REFERENCES

[1] P. Massé and R. Boutteville. *Les réserves et la régulation de l'avenir dans la vie économique*, Hermann & Cie., 1946.

[2] A. Turgeon. Optimal operation of multi-reservoir power systems with stochastic inflows, *Water Resources Research*, 16(2), 275–283, 1980.

[3] M.V.F. Pereira and L.M.V.G. Pinto. Multi-stage stochastic optimization applied to energy planning, *Mathematical Programming*, 52(2), 359–375, 1991.

[4] D. Beulertz, S. Charousset, D. Most, S. Giannelos, and I. Yueksel-Erguen. Development of a modular framework for future energy system analysis, In *54th International Universities Power Engineering Conference (UPEC)*, 2019.

[5] Y. Wang, H. Morais, B. Lenz, V. Gomes, T. Godlewski, and H. Baraffe. The eu-sysflex french industrial-scale demonstrator: Coordinating distributed resources for multi-services provision, In *25th International Conference on Electricity Distribution, Madrid*, 2019.

Stochastic Programming Events in 2020

Below please find a list of events related to Stochastic Programming in 2020. **The situation due to COVID-19 is rapidly changing. Therefore, please check the provided links for the latest information.**

- Workshop title: *Optimization under Uncertainty*
  Where/when: Montréal, March 23–27, 2020. **Postponed to 2021. Please check the website for updates:** https://lnkd.in/gdHHVgW

- Workshop title: *JuMP-dev 2020*
  Where/when: Louvain-la-Neuve, Belgium, June 15–17, 2020
  More information: https://jump.dev/meetings/louvain2020/

- School title: *5th DTU CEE Summer School: Advanced Optimization, Learning, and Game-Theoretic Models in Energy*
  Where/when: Lyngby campus of the Technical University of Denmark (DTU), Copenhagen, June 21–26 2020
  More information: https://lnkd.in/gMsisxC

- Conference title: *ECSO-CMS-2020 Conference*
  Where/when: Ca' Foscari University of Venice, July 1–3, 2020, **Postponed to 2021. Updates will be published in the website:** https://lnkd.in/gG987EP

- Conference title: *Latin-American Conference on Operations Research (CLAIO2020)*
  Where/when: Madrid, Aug. 31–Sept. 2, 2020
  Stream and sessions devoted to stochastic optimization (organizers: Laureano Escudero and Antonio Alonso Ayuso)
  More information: www.claio2020.com.

- Conference title: *International Conference on Optimization and Decision Science (ODS2020)*
  Stream: Optimization under uncertainty (organizers: P. Beraldi and F. Maggioni)
  Where/when: Rome, September 8–11, 2020
  More information: http://www.airoconference.it/ods2020/

- Conference Title: *INFORMS Annual Meeting 2020*
  Stream: Optimization under uncertainty (organizer: Ruiwei Jiang)
  Where/When: Washington DC, USA, November 8–11, 2020
  More information: Contribute or view sessions and talks at https://tinyurl.com/OptUncertainty2020

ICSP XVI

July 25-29, 2022 Davis, California, USA

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Mark your calendars! We are going to hold the sixteenth International Conference on Stochastic Programming (ICSP) during the last week of July 2022: **July 25–29, 2022**. If you are on the program committee for any other conferences, please try to avoid that week.

We are starting work on the website:

https://gsm.ucdavis.edu/xvi-international-conference-stochastic-programming-2022

If you want to organize a session or a track, please let us know at DLWoodruff@UCDavis.edu

Figure 1: UC Davis campus

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