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Special issue on: Nonlinear and Combinatorial Methods for Energy Optimization

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Energy management is of fundamental importance nowadays in Europe, and it will be more and more so in the future. Many EU countries are radically reconsidering their energy infrastructure due to several factors, ranging from evolution of energy generation (e.g., wind, solar, ...) and distribution (e.g., smart grids, storage ...) systems to economical, socio-politic, and legislative changes. Energy management includes both energy production and distribution, that are nowadays tightly interconnected. Energy networks are already, and will be more and more, large-scale, valuable and sophisticated systems requiring complex decision-making in all phases, from design to management to operations. Dealing with that is intrinsically challenging because of its dramatic impact in so many economical and ethical aspects of the society, from environmental protection, to people health, to responsible use of resources and fair energy distribution. Software tools based on mathematical optimization techniques have a long tradition in supporting planning and operational decisions in the energy sector. However, the current challenges call for a new generation of solutions that efficiently and robustly integrate different sources and technologies. In particular, the difficulties for mathematical optimization in this new context are clearly associated with the size of the addressed problems, and, even more challengingly, with the need of simultaneously considering discrete (combinatorial) decisions, modelling nonlinear processes, and tackling uncertainty. Discrete decisions occur everywhere in the context of energy production and distribution, such as when generators have to be dynamically switched on and off like in the classical Unit Commitment problem, and when compressors or valves have to be operated in gas distribution networks. Furthermore, energy systems have many nonlinear aspects, such as the intrinsic nonlinearities of water, gas, and power flows net-

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works, and the nonlinear cost function of energy generators. Separate scientific communities, namely Discrete Optimization (DO) and Non Linear Programming (NLP), have traditionally studied the different nonconvexities associated with discrete decisions and nonlinear systems, but recently the attempts of putting those aspects together flourished. This is due to the maturity achieved by both the DO and NLP fields, which in turn led to the recognition that only through unified methodology and software tools one can model a wider range of complex structures, much closer to nowadays industrial, technological, and social needs. This is the case in many applied areas, among which energy networks. The COST Action TD1207 "Mathematical Optimization in the Decision Support Systems for Efficient and Robust Energy Networks" (`www.energy-opt.eu`), started in 2013 and now nearing completion, has been gathering many researchers and industry practitioners from all across Europe, with rather different backgrounds, trying to serve as an aggregation point and to allow sharing of experiences. This Special Issue on "Nonlinear and Combinatorial Methods for Energy Optimization" follows on the COST Workshop on Mathematical Models and Methods for Energy Optimization (CWM^{3}EO) held on 25–26 September 2014 at Budapest University of Technology and Economics, where researchers have presented both methodological advances of interest for energy optimization problems and applications to mathematical optimization techniques in the energy sector. The Special Issue was not restricted to participants at the conference, but shared the aim of presenting a good balance between methodological contributions and challenging applications. Accordingly, the contributions in this volume are:

- In "Uncontrolled inexact information within bundle methods", J. Malick et al. study convex nonsmooth optimization problems for which additional information with uncontrolled accuracy is available and propose two inexact bundle algorithms that incorporate uncontrolled linearizations.
- In "A multiplicative weights update algorithm for MINLP", L. Mencarelli et al. propose to adapt the well-known multiplicative weights update algorithm to general mixed integer nonlinear programming problems and test it computationally on three applications.
- In "A bounded degree SOS hierarchy for polynomial optimization", J.B. Lasserre et al. propose a new hierarchy of semidefinite relaxations, showing a good tradeoff between the advantages of standard LP-relaxations with Krivine's positivity certificate and those of the standard SOS-hierarchy, for the general polynomial optimization problem on a compact basic semi-algebraic set.
- In "A comparison of four approaches from stochastic programming for large-scale unit-commitment", W. van Ackooij analyzes the stochastic nature of the unit commitment problem and compare four different approaches, namely chance-constrained programming, robust optimization, and 2-stage stochastic and robust programming.
- In "Tighter MIP formulations for the discretized unit commitment problem with min-stop ramping constraints", N. Dupin compares solvers' performance on compact MIP formulations for a discrete unit commitment problem with minimum stop and ramping constraints.
- In "A Tight MIP Formulation of the Unit Commitment Problem with Start-up and Shut-down Constraints", C. Gentile et al. focus on the single thermal Unit Commitment problem with generation limits, start-up and shut-down capabilities, and minimum up and down times and propose its convex hull description.
- In "The Summed Start-up Costs in a Unit Commitment Problem", R. Brandenberg et al. focus on the sum of the incurred start-up costs of a single unit in a Unit Commitment problem and derive binary tree inequalities that strengthen the continuous relaxation.
- In "Sufficient Pruning Conditions for MINLP in Gas Network Design", J. Humpola and F. Serrano introduce new sufficient conditions for proving the infeasibility of the active transmission problem, arising in topology optimization for gas networks, and show how to certify this infeasibility by solving a mixed integer linear program.
- In "A MIP framework for non-convex uniform price day-ahead electricity auctions", M. Madani and M. Van Vyve consider a difficult day-ahead electricity market problem with non-convexities and propose a new primal-dual framework, useful both for economic analysis and algorithm design.
- In "Multi-machine energy-aware scheduling", D. Van Den Dooren et al. propose a method composed of a constructive heuristic and a late acceptance hill climbing algorithm to find good-quality solutions for the multi-machine energy-aware scheduling problem.

The variety of topics, algorithmic techniques, and applications that are presented in this Special Issue is a great snapshot on the impressive activity characterizing this research area. It is exciting to see academics, practitioners, policy makers, and industrial players from different communities exchanging around the topic of energy and its effective production, distribution and use. We believe that the COST Action TD1207 "Mathematical Optimization in the Decision Support Systems for Efficient and Robust Energy Networks" has provided a very suitable venue for such an exchange and we are looking forward to further initiatives of this type.

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