

PSE2015 and ESCAPE25 Plenary Lecture:

Recent Advances in Mathematical Programming Techniques for the Optimization of Process Systems under Uncertainty

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Optimization under uncertainty has been an active and challenging area of research for many years. However, its application in Process Synthesis has faced a number of important barriers that have prevented its effective application. Barriers include availability of information on the uncertainty of the data (ad-hoc or historical), determination of the nature of the uncertainties (exogenous vs. endogenous), selection of an appropriate strategy for hedging against uncertainty (robust optimization vs. stochastic programming), handling of nonlinearities (most work addresses linear problems), large computational expense (orders of magnitude larger than deterministic models), and difficulty in the interpretation of the results by non-expert users. In this paper, we describe recent advances that address some of these barriers. We first describe the basic concepts of robust optimization [1], including the robust counterpart, showing its connections with semi-infinite programming. We next consider two-stage and multi-stage stochastic programming in the case of exogenous parameters [2], for which we describe acceleration techniques for Benders decomposition, hybrid sub-gradient/cutting plane methods for Lagrangean decomposition, and sampling techniques. We then address the generalization to the case of both exogenous and endogenous parameters [3], which gives rise to conditional scenario trees for which theoretical properties are described to reduce the problem size. To avoid ad-hoc approaches for setting up the data for these problems, we describe approaches for handling of historical data for generating scenario trees [4]. Finally, we illustrate the application of each of these formulations in demand-side management optimization, chemical supply chains under disruptions, planning of oil and gas fields, and optimization of process networks, all of them under some type of uncertainty.