Uncertainties in early-stage capital cost estimation of process design – a case study on biorefinery design

Capital investment, next to the product demand, sales, and production costs, is one of the key metrics commonly used for project evaluation and feasibility assessment. Estimating the investment costs of a new product/process alternative during early-stage design is a challenging task, which is especially relevant in biorefinery research where information about new technologies and experience with new technologies is limited. A systematic methodology for uncertainty analysis of cost data is proposed that employs: (a) bootstrapping as a regression method when cost data are available; and, (b) the Monte Carlo technique as an error propagation method based on expert input when cost data are not available. Four well-known models for early-stage cost estimation are reviewed and analyzed using the methodology. The significance of uncertainties of cost data for early-stage process design is highlighted using the synthesis and design of a biorefinery as a case study. The impact of uncertainties in cost estimation on the identification of optimal processing paths is indeed found to be profound. To tackle this challenge, a comprehensive techno-economic risk analysis framework is presented to enable robust decision-making under uncertainties. One of the results using order-of-magnitude estimates shows that the production of diethyl ether and 1,3-butadiene are the most promising with the lowest economic risks (among the alternatives considered) of 0.24 MM$/a and 4.6 MM$/a, respectively.

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