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Stochastic Bilevel Waste-to-Energy pricing

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Waste-to-energy (WtE) plants offer a way of treating waste while converting it to energy. This provides a more sustainable way of treating waste than common landfills. A vital part of a well-functioning waste management environment is the right price setting of gate fees, i.e., treatment price per amount of waste, for the WtE plants. The price setting can be described as a non-cooperative game where each player (WtE plant) tries setting its gate fee to maximize revenue. The amount of waste flowing to some plants depends on the gate fees of competition and the transportation costs from the waste producers (municipalities) to the given plant. Thus, the payoff function of each WtE plant forms a bilevel structure in which the leader (WtE plant) tries to maximize revenue while considering the follower's reaction to the gate fee. All the municipalities that try to minimize their total waste processing costs cooperatively represent the follower. The best-response dynamics algorithm can find the Nash equilibrium of the considered game, but only when considering some limitations on feasible changes in gate fees. A more robust price setting, which can help to obtain a more realistic and stable outcome, can be provided if stochasticity is included in the problem. The most suitable parameter in the model that can be considered subject to stochastic influences is the amount of waste produced by the municipalities in the studied waste management network. Building on the heuristic proposed in the literature, the heuristic mathematical programs are enhanced to handle random variables. Each random variable corresponds to fluctuations of the waste production around the mean waste production of each municipality. After discussing possible reformulations of stochasticity in constraints and objective function, a corresponding deterministic equivalent to each stochastic program is presented. Then, the gate fees proposed by the novel stochastic-enhanced heuristics were tested against realizations solved by the original heuristics.

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