Large-Scale Optimization Problem in Energy Systems: Applications of Decomposition Techniques

Assignment 2: Strategic Offering under Uncertainty

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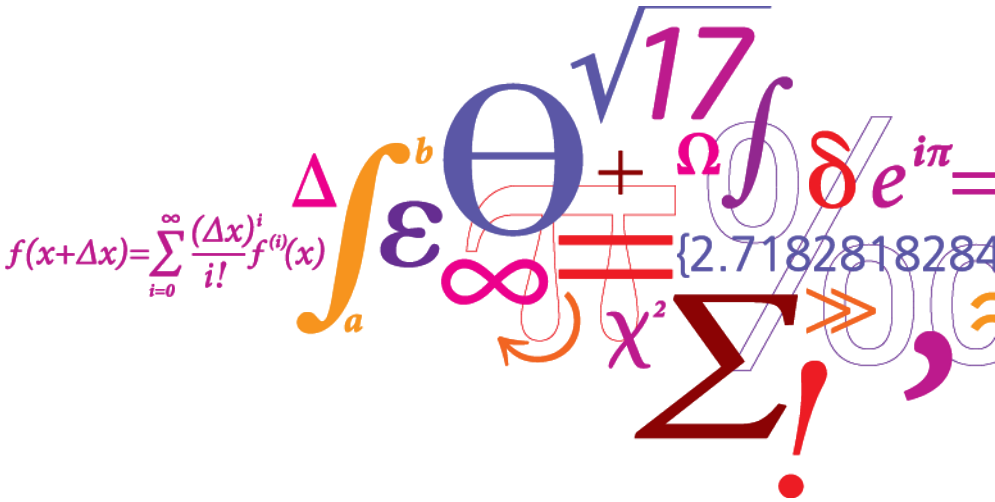

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Assignment 2: Description

Context

We consider a large producer (G1) participating in the electricity market. This producer can exercise market power, i.e. modify the market equilibrium, through strategic offering, in order to increase its own profit. For a strategic producer, modelling the behavior of rival participants and the competition in the electricity market is essential. Bilevel programming is a powerful tool, allowing this producer to devise an optimal offering strategy while anticipating on its impact on the market clearing. However, information on rival participants and loads is often uncertain. As a result, stochastic optimization can help the strategic producer make an informed decision, while accounting for all possible market outcomes scenarios.

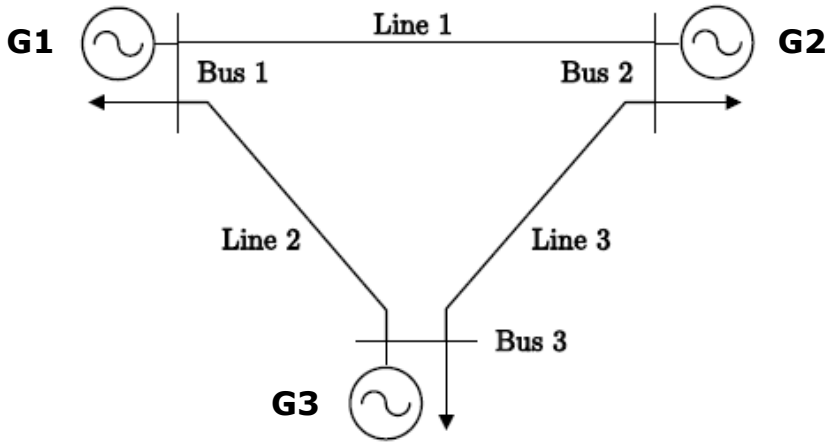

Figure 1: Three-bus power system

Assignment 2: Description

1) **Market clearing:** Formulate the market clearing problem (optimization problem), assuming no producer is strategic, including elastic demand and DC power flow.
2) **Strategic offering:** Formulate the strategic offering problem of producer G1, including elastic demand (tip: linearize the objective function using the KKT conditions and strong duality theorem of the lower level problem [1]). Compare the results with the market clearing outcomes in 1) (profit, social welfare).
3) **Stochastic bilevel programming:** We now consider the demand utility uncertain. Formulate and solve the stochastic bilevel optimization problem using the scenarios provided in Table 3. How does uncertainty influence the producer's strategic behavior?
4) **Decomposition:** Is this optimization problem decomposable? With complicating variables and/or constraints ? In how many subproblems can it be decomposed?

Please provide a report for this assignment, including mathematical formulations for all steps, results and codes (GAMS, Python)

[1] GABRIEL, Steven A., CONEJO, Antonio J., FULLER, J. David, *et al. Complementarity modeling in energy markets*. Springer Science & Business Media, 2012.

Assignment 2: Data

Line #	From	To	Susceptance (S)	Capacity (MW)
l1	n1	n2	100	5
l2	n1	n3	125	10
l3	n2	n3	150	10

Table 1: Transmission system data

Bus #	Capacity (MW)	Production cost ($/MWh)	Demand (MW)	Demand utility ($/MWh)
n1	20	16	5	18
n2	10	19	20	20
n3	15	15	15	21

Table 2: Generation and load data

Assignment 2: Data

scenario	d1 ($/MWh)	d2 ($/MWh)	d3 ($/MWh)	Probability
s1	18	17	21	0.5
s2	18	23	21	0.5

Table 3: Scenarios on demand curve