Technical University of Denmark

46750 - Optimization in Modern Power Systems

Assignment 1: Demand-Side Flexibility in Active Distribution Grids (Bonus Question)

This bonus assignment corresponds to Question 2.(a) of Assignment 1. and should be carried out in **the same groups as Assignment 1**.

All data provided, problem statement and learning objectives provided in Assignment 1, Questions 1.(a) - 1.(c) are still valid.

Each group should submit a single **report** using the recommended Latex Template in DTU Learn, including concise answers to each question (rigorous and compact mathematical formulations, with definition of all notations and description of all equations - including those introduced in the main report of Assignment 1 and reused in this question, description of modeling steps, relevant insights, adequate visual aids and tables), and an **individual participation table**, summarizing the contribution (in %) of each student in Question 2.(a).

Grading: Each group will receive a grade between **0-15 points**. These points will be adjusted individually based on each student's contribution to Question 2.(a), as reported in the participation table, and the adjustment rules illustrated in Figure 1, and will be added (as a bonus) to their individual grade for Assignment 1. The resulting individual grade for assignment 1 will count towards **40%** of the final grade.

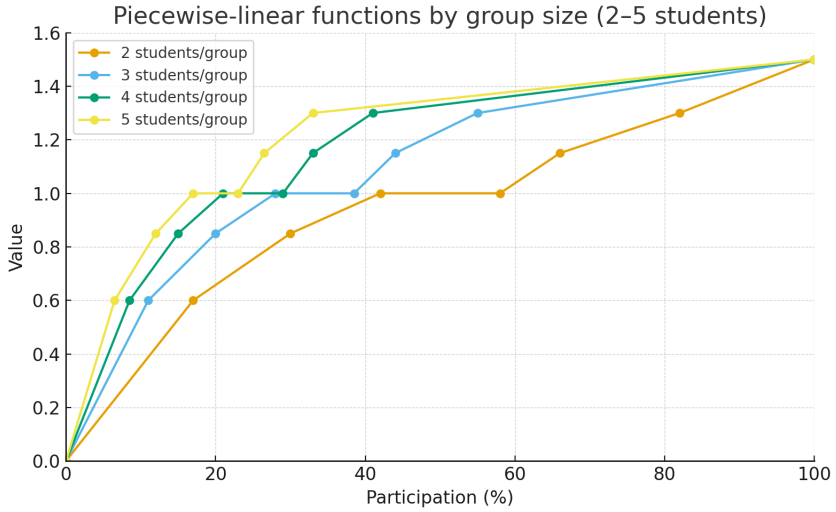

Figure 1: Individual grade adjustment ratios, depending on % of total participation and number of students/group

2. **Value of demand-side flexibility**

Building on the individual models derived in Question 1, we further analyze the value of demand-side flexibility for various types of consumers, and derive actionable operational and investment insights.

(a) **This question is now optional, and all points have been redistributed between questions 1.(a)-1.(c). All bonus points scored in this question will be added to your grade for assignment 1. Please submit your answers for Question 2.(a) separately (no deadline).**

We consider the flexible consumer described in Question 1.(b), and conduct a techno-economic analysis of the value of flexibility, through duality.

i. (7 points) Describe in your own words the techno-economic meaning of the dual formulation of the cost-minimization optimization problem of this consumer, derived in Question 1.(b), including the dual variables associated with key constraints, and the Lagrange function. What economic signal does the value at optimality of these dual variables provide?

ii. (8 points) Considering that this consumer wants to participate in the day-ahead electricity market, derive their hourly demand (or supply) curve, representing their marginal willingness to pay (or marginal opportunity cost) for purchasing (selling) 1 additional MWh of electricity in the market. *Tip: you can use the KKT conditions derived in Question 1.(b) to find conditions linking the optimal quantity purchased/sold on the market for varying electricity prices.*