KTH Electrical Engineering

Partial exam 1 in EG2050 System Planning, 6 February 2014, 9:00-10:00, Q31, Q33, Q34, Q36

Instructions

Students must arrive to the partial exam within 45 minutes of the start time of the test. No students may leave the room until the end of the test.

Write all answers on the answer sheet provided. Motivations and calculations do not have to be presented. (Those who want may also submit complete solutions, but the answer sheet should be filled out nevertheless!)

Together, the three partial exams offered during the course correspond to part I in the final exam. A total score in the partial exams of at least 33 points is required to pass.

Allowed aids

In this partial exam you are allowed to use the following aids:

- Calculator without information relevant to the course.
- One **handwritten**, **single-sided** A4-page with **your own** notes (original, not a copy), which should be handed in together with the answer sheet.

Problem 1 (4 p)

Answer the following theoretical questions by choosing *one* alternative, which you find correct.

a) (1 p) Which of the following statements do you consider the best description of the function of the system operator in an electricity market?

1. The system operator buys electricity from producers, retailers or a power exchange and sells to consumers, retailers or an power exchange.
2. The system operator is responsible for safe operation of the power system.
3. The system operator is economically responsible that the system during each trading period (for example one hour) is supplied as much energy as consumed by the customers of the player.

b) (2 p) The following applies to a centralised electricity market: I) Producers are free to sell to any other producer, retailer or consumer, II) All electricity trading has to be performed at a power pool, III) The consumers are free to buy from any producer or retailer.

1. None of the statements is true.
2. Only I is true.
3. Only II is true.
4. Only III is true.
5. I and III are true but not II.

c) (1 p) Some power exchanges allow so-called block bids. What does that mean?

1. A block bid is a sell or purchase bid which is valid for one single trading period.
2. A block bid is a sell or purchase bid which is valid for several trading periods, and which can only be accepted as a whole.
3. A block bid is a sell or purchase bid which is valid for one single trading period, but which can only be accepted if the same player during that trading period is allowed to sell regulation power to the system operator.

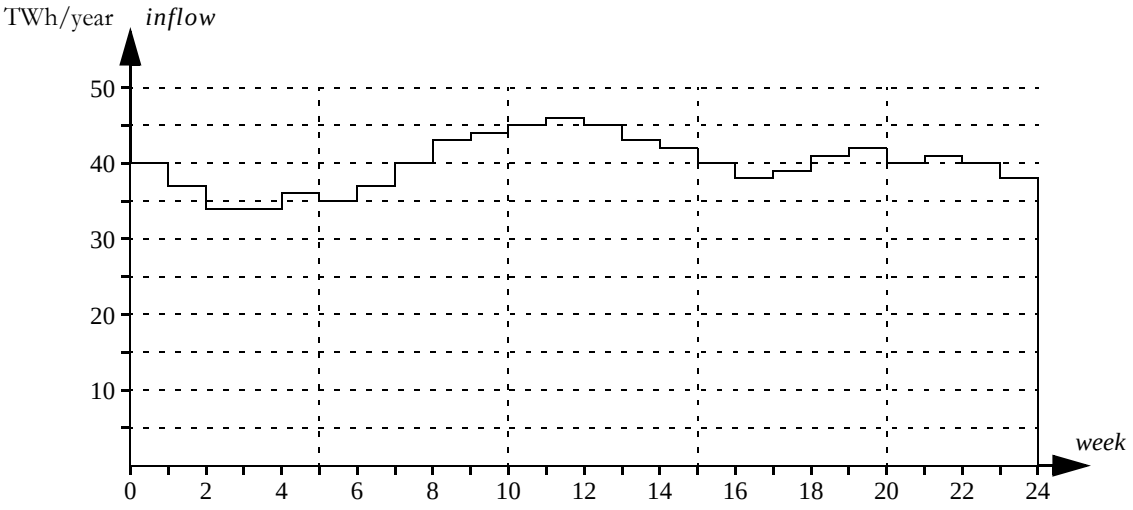
Problem 2 (6 p)

The electricity generation in Land comes from hydro power, nuclear power and coal condensing. Data for the electricity producers of Land are given in table 1. The variable costs of the coal condensing are assumed to be linear in the given interval; the production is zero if the price is on the lower price level and the production is maximal at the higher price level. The electricity consumption in Land is 100 TWh/year.

The hydro power production capability is depending on the inflow, which is varying from year to year. There is a new forecast each week on the inflow for the next 12 months. The figure below shows how this forecast is changing during some weeks. Assume that all players in the electricity market in Land use the same forecast for the hydro power inflow, and that there is perfect competition, all players have perfect information except for the inflow, and there are neither capacity, transmission nor reservoir limitations in the system.

Table 1 Data for the electricity producers in Land.

Power source	Production capability [TWh/year]	Variable costs [¤/MWh]
Hydro	Depends on inflow	10
Nuclear	50	100
Coal condensing	30	300–540



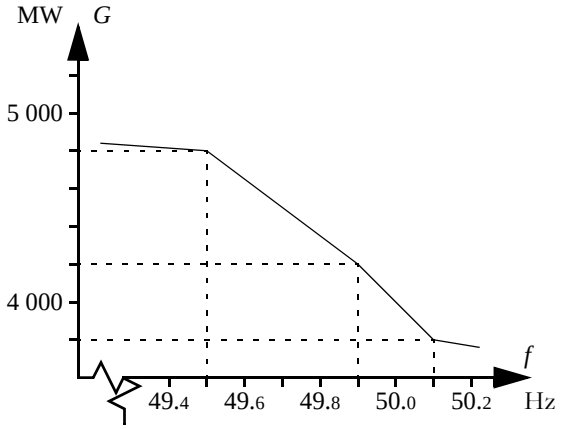
a) (2 p) Which electricity price will there be in Land during week 5?

b) (2 p) Which electricity price will there be in Land during week 10?

c) (2 p) Which electricity price will there be in Land during week 15?

Problem 3 (6 p)

The primary control in Land is divided in a normal operation reserve and a disturbance reserve, where the former is intended to manage normal variations in for example load and wind power generation, whereas the latter is intended to manage outages in larger power plants. The normal operation reserve is available in the frequency range 49.9–50.1 Hz and the disturbance reserve is available in the frequency range 49.5–49.9 Hz. The figure below shows the total generation in the power plants participating in the primary control as a function of the frequency.



a) (2 p) How large is the gain in the normal operation reserve?

b) (2 p) How large is the gain in the disturbance reserve?

c) (2 p) A fault occurs in a substation at the hydro power plant Språnget, which means that the hydro power plant is disconnected from the grid. As a consequence, the frequency of the system drops from 49.95 Hz to 49.7 Hz. How large was the electricity generation in Språnget at the time of the failure? (It can be assumed that the fault only affected the electricity generation in Språnget, i.e., the other power plants and the load did not change.)

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Answer sheet

Name: .....

Personal number: .....

Problem 1

a) Alternative ..... is correct.

b) Alternative ..... is correct.

c) Alternative ..... is correct.

Problem 2

a) ..... ¤/MWh **b)** ..... ¤/MWh

c) ..... ¤/MWh

Problem 3

a) ..... MW/Hz **b)** ..... MW/Hz

c) ..... MW

Suggested solution for partial exam i EG2050 System Planning, 6 February 2014.

Problem 1

a) 2, **b)** 3, **c)** 2.

Problem 2

a) During week 5 the players in the electricity market assume that there will be 35 TWh hydro power available the coming year. Hydro and nuclear can then provide 85 TWh, which means that it will be necessary to utilise 15/30 of the price interval for coal condensing, i.e., the electricity price will be 420 ¤/MWh.

b) During week 10 the players in the electricity market assume that there will be 45 TWh hydro power available the coming year. Hydro and nuclear can then provide 95 TWh, which means that it will be necessary to utilise 5/30 of the price interval for coal condensing, i.e., the electricity price will be 340 ¤/MWh.

c) During week 15 the players in the electricity market assume that there will be 40 TWh hydro power available the coming year. Hydro and nuclear can then provide 90 TWh, which means that it will be necessary to utilise 10/30 of the price interval for coal condensing, i.e., the electricity price will be 380 ¤/MWh.

Problem 3

a) For the normal operation reserve (i.e., in the interval 49.9–50.1 Hz) we get that $R = \Delta G/\Delta f = 400/0.2 = 2\,000$ MW/Hz.

b) For the disturbance reserve (i.e., in the interval 49.5–49.9 Hz) we get that $R = \Delta G/\Delta f = 600/0.4 = 1\,500$ MW/Hz.

c) The first response when Språnget is disconnected is that the normal operation reserve will increase the generation until the frequency has dropped to 49.9 Hz, i.e., these power plants will increase generation by $\Delta G_N = 2\,000 \cdot 0.05 = 100$ MW. Then it will be the disturbance reserve increasing generation, which yields $\Delta G_D = 1\,500 \cdot 0.2 = 300$ MW. In total the system has been supplied 400 MW and as everything else is considered constant, this must be equal to the lost generation in Språnget.