KTH Electrical Engineering

# Partial exam 3 in EG2050 System Planning, 6 March 2014, 9:00-10:00, D32, D33, 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 5 (12 p)

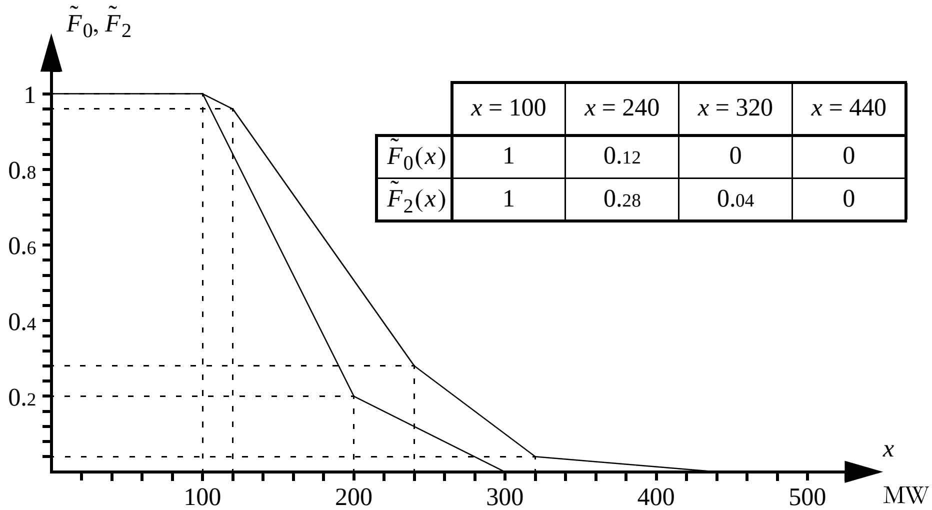
**a) (2 p)** Assume that the electricity market in Land has been simulated with data for next year (i.e., the availabilities and operation costs of the power plants, and the load duration curve) and that the resulting *LOLP* is equal to 0.1%. How many hours of power deficit will there be in Land next year?

1. There will be power deficit during exactly 1 hour.
2. There will be power deficit during at most 8.76 hours.
3. There will be power deficit during exactly 8.76 hours.
4. There will be power deficit during at least 8.76 hours.
5. None of the alternatives 1–4 above is correct.

**b) (2 p)** The national grid in Nchi is supplied by a wind farm, three hydro power plants and a thermal power plant (see table 1). The figure below shows the duration curve of the total load in Nchi, $\tilde{F}_0(x)$, as well as the equivalent load duration curve when including outages in the hydro power plants and the wind farm, $\tilde{F}_2(x)$.

Use probabilistic production cost simulation to calculate the probability that there is a need for generation from the thermal power plant.

*Hint:* If the thermal power plant did not exist then there would be power deficit whenever the available generation capacity in wind power and hydro power is fully utilised.




| | $x = 100$ | $x = 240$ | $x = 320$ | $x = 440$ |
|---|---|---|---|---|
| $\tilde{F}_0(x)$ | 1 | 0.12 | 0 | 0 |
| $\tilde{F}_2(x)$ | 1 | 0.28 | 0.04 | 0 |

**Table 1** Data for the power plants in Nchi.

| Power plants | Total installed capacity [MW] | Variable costs [¤/MWh] | Availability [%] |
|---|---|---|---|
| Mlima wind farm | 20 | 0 | 97* |
| Hydro power in River Mto | 220 | 0 | 99* |
| Oil condensing power plant in Jiji | 60 | 500 | 90 |

* Refers to the technical availability; the available generation capacity is also depending on the present weather conditions.

**c) (3 p)** The expected energy not served when considering all power plants in Nchi is 4.94 MWh/h. Calculate the expected total operation cost per hour for the system in Nchi.

**d) (3 p)** Assume that a Monte Carlo simulation of the power system in Nchi is requested. Use the inverse transform method to randomise a value of the available generation capacity of the oil condensing power plant, $\overline{G}$. Start with the random number 0.4711 from a $U(0,1)$-distribution. What is the corresponding complementary random number, $\overline{G}^*$?

**e) (2 p)** The expectation value $E[X]$ is to be determined using a combination of a control variate and stratified sampling. Assume that $L$ strata have been defined and let $\omega_h$ denote the stratum weight of stratum $h$. Introduce the symbol $x_{h,\,i}$ for the $i$:th observation of $X$ from stratum $h$ and let $z_{h,\,i}$ denote the $i$:th observation from stratum $h$ of the control variate, $Z$. The total number of observations is $n$, and we use the symbol $n_h$ to denote the number of observations from stratum $h$. How is the estimate $m_X$ calculated

1. $m_X = \frac{1}{n}\sum_{h=1}^{L}\sum_{i=1}^{n_h}\omega_h x_{h,\,i} + E[Z]$.
2. $m_X = \frac{1}{n}\sum_{h=1}^{L}\sum_{i=1}^{n_h}\omega_h z_{h,\,i} + E[Z]$.
3. $m_X = \sum_{h=1}^{L}\frac{\omega_h}{n_h}\sum_{i=1}^{n_h} z_{h,\,i} + E[Z]$.
4. $m_X = \sum_{h=1}^{L}\frac{\omega_h}{n_h}\sum_{i=1}^{n_h} (x_{h,\,i} - z_{h,\,i}) + E[Z]$.
5. $m_X = \sum_{h=1}^{L}\frac{1}{n_h}\sum_{i=1}^{n_h} \omega_h x_{h,\,i} z_{h,\,i} + E[Z]$.

## Problem 5

**a)** 5.

**b)** The equivalent load duration curve including outages in wind and hydro power states the probability that the load exceeds the available generation capacity (which means that there will be a need for generation in the thermal power plant):

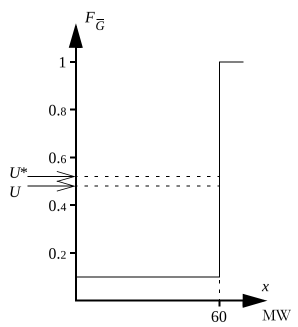
$$\tilde{F}_2(240) = 28\%.$$

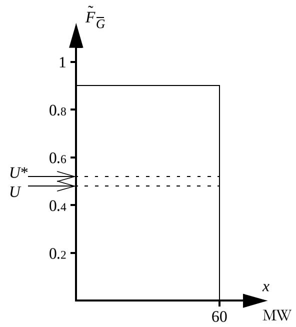
**c)** The expected generation in the oil condensing power plant is

$$EG_3 = EENS_2 - EENS_3 = \int_{240}^{\infty} \tilde{F}_2(x)dx - 4.94 = \frac{0{,}28 + 0{,}04}{2}80 + \frac{0{,}04}{2}120 - 4.94 =$$
$$= 10.26 \text{ MWh/h}.$$

Hence, the expected operation cost is $ETOC = 500EG_3 = 5\,130$ ¤/h.

**d)** If we draw the distribution function or the duration curve of $\overline{G}$ it is easy to see that $U = 0.4711$ and $U^* = 1 - U$ are both transformed to 60, i.e., $\overline{G} = 60$ and $\overline{G}^* = 60$.




**e)** 4.