Wind Energy Systems
Albert-Ludwigs-Universität Freiburg – Summer Semester 2018

Exercise Sheet 0 SOLUTION: Course Organization

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Deadline: 25 April, 2018 (or the next exercise session)
`https://goo.gl/forms/GiQEWYS2ZuNFDqRz1`

The Wind Energy Systems (WES) course has two modes of instruction: lectures and exercises. For this purpose, there are two time slots scheduled every week: Tuesdays 14-16h and Wednesdays 14-16h. The lectures are given by Moritz Diehl. One biweekly time slot is dedicated to an 'exercise session' that will be coordinated by Rachel Leuthold (rachel.colette.leuthold@imtek.uni-freiburg.de).

Current information about the course can be found at: `https://www.syscop.de/teaching/ss2018/wind-energy-systems`.

The biweekly exercises will be posted before the first time slot of the week, as well as an online form where you can report which exercises you finished. The online form must be submitted on the midnight before the presenting exercise session. Please note, that those reporting completed exercises may be volunteered to present their solutions during the following exercise sessions. To encourage honest self-reporting, presenters that are unable to demonstrate their exercise solutions satisfactorily will lose ALL points for the sheet. As the exercises are self-corrected, the solution to the preceding exercise will be posted when the new exercise is given out. The exercises consist of both analytical and computer-programming (language as desired) problems. (Exercise teams of up to three people are encouraged, though presentations of results must be done individually.)

Additionally, we'd like to offer an optional weekly 'Fluid Mechanics Film Series' on Wednesday evenings at 17:00 in room 01-012 of building 102. Information about the film series can be found at: `https://www.syscop.de/event/fluid-mechanics-film-series`.

The grade for the course corresponds to the grade of the final exam. The total earned exercise score must be at least half of the total exercise points in order to qualify for the final exam. This final exam is 'closed-book,' which means that ONLY pens, a calculator, and one A4 page (that is, two sides) of notes can be used. The questions will be partially multiple-choice and partially short-answer.

In this exercise sheet, we want to do two things simultaneously: first, to practice using the reporting forms, by considering the difference between the rated power and delivered power of a turbine.

1. **Capacity Factors** **[*1 pt*]**

   (a) The the five wind turbines on Freiburg's ground (on Rosskopf and Schauinsland) have each a height of 133 m and a nominal capacity of 1.8 MW. They deliver together 10.2 GWh per year. What is their capacity factor? [*1 pt*]

   The capacity factor f of power plant is the ratio of between the average power the power plant actually produces to how much the plant should produce under the nominal or rated conditions. That is:

$$f = \frac{\bar{P}_{\text{actual}}}{P_{\text{rated}}}.$$

   Here, the power plant is the combination of all five turbines. Then, the power plant's rated power is:

$$P_{\text{rated}} = (5)(1.8\text{ MW}) = 9\text{ MW} = 9 \cdot 10^6\text{ W}.$$

   We can find the average power delivered by the wind turbines by dividing the total energy they produce per year (in Joules) by the number of seconds in that year.

$$\bar{P}_{\text{actual}} = \frac{E_{\text{total}}}{(1\text{ year})(365.25\text{ days/year})(24\text{ hours/day})(60\text{ min/hour})(60\text{ sec/min})}$$

   So, now we need to know how much energy the wind turbines produce in Joules over one year.

$$E_{\text{total}} = (10.2\text{ GWh})(3600\text{ J/Whr}) = 36.72 \cdot 10^{12}\text{ J}$$

   This then gives that:

$$\bar{P}_{\text{actual}} = \frac{36.72 \cdot 10^{12}\text{ J}}{31.56 \cdot 10^6\text{ s}} = 1.16 \cdot 10^6\text{ W}$$

   So, we finish by saying that:

$$f = \frac{1.16 \cdot 10^6\text{ W}}{9 \cdot 10^6\text{ W}} = 0.13$$

   That is, the capacity factor of the power plant comprising Freiburg's five wind turbines is 0.13.