



KTH Electrical Engineering

Electric Power Systems Lab  
**EG2050 SYSTEM PLANNING**  
17 January 2013

# Syllabus spring 2013

The latest news can be found on KTH Social ([www.kth.se/social/course/EG2050](http://www.kth.se/social/course/EG2050)). It is also possible to contact the involved teachers:

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## Objectives

The aim of the course is that the students learn methods and models for planning, operation and analysis of electric power systems. The course comprises background information about possible ways to design an electricity market, computation methods (for example applied optimisation theory and reliability analysis) as well as examples from reality.

To pass the course, the students should show that they are able to

- describe the principles of how an electricity market can be organised,
- perform rough estimations of electricity prices,
- explain how the balance between production and consumption is maintained in an electric power system, and calculate how the frequency is affected by various events in the power system,
- formulate short-term planning problems of hydro-thermal power systems,
- apply both probabilistic production cost simulation and Monte Carlo simulation to calculate expected operation cost and risk of power deficit in an electricity market.

To receive a higher grade (A, B, C, D) the students should also show that they are able to

- identify factors that have a large importance for the electricity pricing, and to indicate how these factors affect for example producers and consumers,
- determine if the frequency control of an electric power system has sufficient margins, and if necessary be able to choose between various measures to increase the margins,
- create specialised models for short-term planning problems,
- create specialised models both for probabilistic production cost simulation and Monte Carlo simulation, and to use the results of an electricity market simulation to judge the consequences of various actions in the electricity market.

## Course Registration

The course includes mandatory home assignments as well as home assignments which yield bonus points for the exam. In order for us to keep record of student results, we need to register all active students. Go to the course web page on KTH Social, choose “Course registration” in the menu to the right and follow the instructions.

## Learning Activities

As a student some work is required to fulfil the objectives of the course. You can to a large extent decide yourself how to organise your studies, but it is of course important that you plan your work so that you can complete the lab course and the exam on the available times (see *Examination* below).

The following learning activities are offered in the course:

- **Lectures.** There are 19 lectures in the course (see the schedule). The lectures present the most important theory as well as practical examples. There are ready-made lecture notes for most of the lectures. Before the lectures you should preferably prepare yourself by reading these lecture notes (which are available on the course web pages).
- **Lecture assignments.** The lecture assignments are small problems that are solved during the lecture. The idea behind these assignments are that you should get an opportunity to master the basic definitions and calculation methods that are required to pass the course. What is important is therefore not to answer these questions correctly, but to learn something from them (preferably in cooperation with your fellow students).
- **Self-study.** The most important literature in this course is the compendium “*Efficient Operation and Planning of Power Systems*”, which is sold by the student office STEX (Osqudas väg 10 in the entrance hall, open Monday-Friday 11:00-14:00) for the nice price of 200 SEK. The compendium covers the same contents as the lectures. In addition to that there are solved examples and exercises, so that the compendium can be used for self-study. Reading instructions for the course compendium can be found in the table above.  
Besides the exercises in the compendium, there are also old exams published on the course web pages.
- **Home assignments.** There are in total 25 home assignments in the course divided into four parts, which cover electricity pricing, frequency control, short-term planning and simulation of electricity markets. The objective of the home assignment is that you should train to solve problems related to reality. The home assignments will also

### Reading instructions for the course compendium

Section	Moment	Weight	Exercises
1	Introduction	*	
2	The structure of an electricity market	**	2.1–2.15
3	Electricity pricing	***	3.1–3.8
4	Frequency control	***	4.1–4.11
5	Short-term planning		
5.1	Objective	**	
5.2	Hydro power	***	5.1–5.13
5.3	Thermal power	***	
5.4	Dual variables	**	
6	Simulation of electricity markets		
6.1	Problem description	**	6.1–6.10
	Probabilistic production cost simulation		
6.2.1–6.2.3	Basic model	***	
6.2.4	Multi-state model of power plants	***	
6.2.4	Wind power model	*	
6.2.5	Dispatchable hydro power	**	
6.2.6	Normal approximation	–	
6.3	Monte Carlo simulation	***	6.12–6.18
A-E	Appendices	**	
<p>*** Central part of the course. Calculation methods should be well-known. Generally included in the exam as a calculation problem.</p> <p>** Important part of the course. The principles should be known. Generally included in the exam as a minor part of a problem or as a theory question.</p> <p>* General part of the course. Can be skimmed through.</p> <p>– Not included in the course.</p>			

give you the opportunity to try using different kinds of software to solve larger problems.

You can ask questions to the lecturers in connection with the lectures. It is also acceptable to discuss with other students how to solve the home assignments. However, the home assignments are to be presented individually (see *Examination* below). Some of the home assignments are part of the laboratory course and are mandatory. The other assignments are voluntary.

## Examination

The examination of this course is divided in two parts: a lab course and a written exam. Students must first pass the lab course and can then write the exam. Once a student has passed the lab course, it is not necessary to repeat it even if the students fails the exam.

### *Laboratory course*

The home assignments that are part of the laboratory course can give in total 50 lab points. To pass the laboratory course, the student must have at least 45 lab points. To get lab points, the student should prepare an oral presentation of the solution to the assignment. The lab points are valid until the re-exam in June. If you have not completed the laboratory course by then, you will have to redo the laboratory course from the beginning next academic year.

The oral presentations are given at special seminars. The schedule for the seminars are shown in the table below. The number of seats is limited in each seminar; therefore, you have to sign up in

advance. Go to the course web page on KTH Social, choose “Course registration” in the menu to the right and follow the instructions.

#### Schedule for home assignment seminars

Seminar	Assignments	Time and venue	Language
Ordinary	Part I	Monday 28 January, 10:15–11:30, the seminar room Wednesday 30 January, 13:15–14:30, the seminar room Thursday 31 January, 10:15–11:30, the seminar room Friday 1 February, 13:15–14:30, the seminar room	English
Ordinary	Part I	Tuesday 29 January, 15:15–16:30, the seminar room Thursday 31 January, 13:15–14:30, the seminar room	Swedish
Ordinary	Part II	Monday 4 February, 8:15–9:30, the seminar room Wednesday 6 February, 13:15–14:30, the seminar room Thursday 7 February, 10:15–11:30, the seminar room Friday 8 February, 15:15–17:30, the conference room	English
Ordinary	Part II	Tuesday 5 February, 13:15–14:30, the seminar room Thursday 7 February, 13:15–14:30, the seminar room	Swedish
Ordinary	Part III	Wednesday 13 February, 13:15–15:00, the seminar room Thursday 14 February, 10:15–12:00, the seminar room Thursday 21 February, 10:15–12:00, the seminar room Monday 25 February, 10:15–12:00, the seminar room	English
Ordinary	Part III	Monday 18 February, 10:15–12:00, the seminar room Friday 22 February, 13:15–15:00, the conference room	Swedish
Ordinary	Part IV	Thursday 28 February, 10:15–12:00, the seminar room Monday 4 March, 8:15–10:00, the seminar room Tuesday 5 March, 13:15–15:00, the seminar room Wednesday 6 March, 15:15–17:00, the seminar room	English
Ordinary	Part IV	Friday 1 March, 13:15–15:00, the seminar room Wednesday 6 March, 13:15–15:00, the seminar room	Swedish
Repetition	All	Thursday 7 March, 10:15–12:00, the seminar room Friday 31 May, 10:15–12:00, the seminar room	English

The seminar room is located at Teknikringen 33, 1st floor (former H21).

The conference room is located at Teknikringen 33, 1st floor (room 3424). To enter the conference room, you have to pass the Electric Power Systems Lab, which is locked. The course assistant will let in students until the start of the seminar; hence, do not come late!

At the beginning of the seminar each student states which assignments he or she is ready to present. In connection with this the student should hand in a copy of the presentation (it could for example be hand-written notes if the presentation is given using the blackboard or a print-out of the slides in a computer presentation). The ordinary seminars comprises a given selection of assignments, as shown in the schedule above. For each assignment, the course assistant chooses<sup>1</sup> which student that is giving his or her presentation. If there is time left, several students may present the same assignment. The repetition occasions can be used to present those assignments that the student has been skipped earlier or have failed to present. For each student, the course assistant then chooses<sup>2</sup> one or more assignments to present.

If a student has passed all presentations during a seminar (or if the student is not selected to present) then lab points will be rewarded for all assignment that the student has prepared. However, if a student fails at least one oral presentation, no lab points at all will be rewarded for this seminar, regardless of which other assignments that the student have been prepared to present!

1. The selection is done almost, but not quite entirely, randomly.

2. This selection is also done almost, but not quite entirely, randomly.

To pass a presentation the following requirements must be fulfilled:

- **The presentation must be completed within the time limit.** The student is given three minutes per lab point.
- **The presentation must be performed independently.** This means that the student must be able to give the presentation without turning to fellow students or the course assistant to ask for help.
- **The presentation must be clear.** All details in the calculations do not have to be shown, but the presentation must provide sufficient details so that a fellow student who have not done the assignment should know what to do in order to solve the problem.
- **The solution must be reasonable.** The solution method that is presented must be appropriate for the problem. However, the student will not fail if some minor computation error has slipped into the presentation.
- **The student must be able to answer questions after the presentation.** The other participants and the course assistant should have the opportunity to ask questions about the solution after the presentation. During this questioning the student must be able to explain all details in the solution, such as for example how input values have been chosen or why a particular formula has been used.

The idea is that the laboratory course should be performed during period 3. There will also be repetition occasions before the exams in March and June. If you are at the end your studies and want to get your degree later this year then it is important that you plan your studies so that you can pass the laboratory course during this time.

### **Exam**

In order to attend the exam, the student must have passed the lab course. The student must also register in advance using KTH My pages, which can be accessed from the student web (<http://www.kth.se/student/minasidor>). The premises of the exam can be changed depending on the number of examinees. Check the course notice board or the course web page for detailed information before the exam! (The central KTH exam schedule is not updated in time.)

The home assignments which are not part of the lab course can give bonus points for the exams in March 2013 and June 2013 respectively. These home assignments are presented in a written report. It is not possible for the one marking the home assignments to print out reports sent by e-mail and it is therefore only possible to submit the assignments in the mailbox marked “*System planning*”, which is found in the stairwell at Teknikringen 33, first floor. Home assignments that are submitted in any other way will not be marked.

To receive bonus points for a home assignment, the following requirements must be fulfilled:

- **The report must be submitted in time.** The deadlines for the home assignments are shown in the table below. Reports that are handed in too late will not be marked.
- **The report must be an individual work.** It is not allowed to copy neither parts nor the entire report of another student! If several submitted reports are much the same in essential parts then neither report will receive any bonus points.
- **The solution must be clear and correct.** All introduced symbols must be defined. Solutions should include sufficient detail that the argument and calculations can be easily followed. The score will be reduced if there are computation errors, insufficient motivations or incorrect conclusions.

The exam itself is divided in two parts. The first part of the exam decides whether or not the grade will be failed or passed. Bonus points from the home assignments are not counted in part I. To pass it is necessary to score at least 33 points out of 40. Examinees who have failed the exam but are close to the requirement for passing (i.e., 31 or 32 points) may write a supplementary test. If the result of this test is approved, the student will get the grade E. The date of the extra test is

### Deadlines for bonus points

Home assignments	Maximal bonus	Last day to hand in written report
Part I	3	Monday 28 January, 12:00 noon
Part III	5	Monday 25 February, 12:00 noon
Part IV	5	Thursday 7 March, 12:00 noon

### Grading in the exam

Score from part I	Total score (part I + part II + bonus)	Grade
0–29	–	F
31–32	–	Fx
33–40	33–59	E
33–40	60–69	D
33–40	70–79	C
33–40	80–89	B
33–40	90–115	A

decided by the course coordinator after consulting the concerned students. However, the student must notify his or her intention to write the supplementary test no later than one month after the exam.

The second part of the exam will only be marked if the student has passed part I. Part II gives a total of 60 points. Then the results of parts I and II and the bonus points will be added together and the sum determines the examination grade (A–E).

The following aids are allowed at the exams and extra tests:

- 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 exam.

Notice that the exam is given only twice a year (in March and June respectively). If you are at the end your studies and want to get your degree later this year then it is important that you plan your studies so that you can pass the exam at one of these occasions. However, according to the KTH rules (available at [http://intra.kth.se/regelverk/utbildning-forskning/grundutbildning/prestationer?l=en\\_UK](http://intra.kth.se/regelverk/utbildning-forskning/grundutbildning/prestationer?l=en_UK)), students have the right to demand an extra exam if there is a proper cause.<sup>3</sup> If you are granted an extra exam, you will agree upon a date for the exam with the course coordinator. If you for some reason cannot prepare to the extent that you would desire (for example due to a new employment) then it is important that you contact the course coordinator and reschedule the exam, because if you fail an exam that you have requested yourself then you will have to wait for the next scheduled exam in order to make another attempt.

## Computer Account

Those who wants to use the computers in the ETS Students room for solving the home assignments will need a computer account at the department. The accounts are managed by Peter Lönn (Teknikringen 33, room 3337), which usually will be at his office after 13:00.

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3. It is in short required that you have made an attempt at all scheduled exams (or had a reasonable excuse not to attend) and that this course is the only course that is left for you before you can get your degree.

## Course Evaluation Committee

To evaluate and improve the course, we need a few students who are willing to participate in the course evaluation committee. The committee is meeting shortly after the ordinary exam. In connection with this meeting, the Electric Power Systems Lab will treat the participants to lunch. Students who are interested in participating can contact the course coordinator by e-mail or in connection to a lecture.

## Preliminary Schedule

The lectures will be given in English. The preliminary schedule is listed below. The notion **3:4** refers to the fourth teaching occasion in period 3. The notion C: 4.1 means section 4.1 in the course compendium. Teaching occasions marked “Reserve” will not be used unless another occasion has been cancelled. Information about changes in the schedule can be found on the course web page.

- 3:1**     *Monday 14 January, 13–15, V1*  
L1: Introduction. The structure of an electricity market. C: 2
- 3:2**     *Tuesday 15 January, 8–10, V1*  
L2: The structure of an electricity market. C: 2.
- 3:3**     *Wednesday 16 January, 10–12, V1*  
L3: Electricity pricing. C: 3.
- 3:4**     *Friday 18 January, 10–12, V1*  
L4: Electricity pricing. Home assignments part I, presentation techniques. C: 3.
- 3:5**     *Monday 21 January, 13–15, V1*  
L5: Frequency control: Synchronous grid, primary control. C: 4.1.
- 3:6**     *Tuesday 22 January, 8–10*  
Reserve.
- 3:7**     *Wednesday 23 January, 10–12, V1*  
L6: Frequency control: Primary control, secondary control. Home assignments part II. C: 4.1–4.2.
- 3:8**     *Friday 25 January, 10–12, V1*  
L7: Linear programming. C: Appendix A.
- 3:9**     *Monday 28 January, 13–15, V1*  
L8: Short-term planning: LP model of hydro power plants. C: 5.2.1–5.2.4.
- 3:10**    *Tuesday 29 January, 8–10*  
Reserve.
- 3:11**    *Wednesday 30 January, 10–12, V1*  
L9: Short-term planning: LP model of thermal power plants. C: 5.3.1–5.3.3.
- 3:12**    *Friday 1 February, 10–12, V1*  
L10: Short-term planning: Examples of planning problems, dual variables. Home assignments part III. C: 5.2.5, 5.3.4, 5.4, appendix B.
- 3:13**    *Monday 4 February, 13–15*  
Reserve.
- 3:14**    *Wednesday 6 February, 10–12*  
Reserve.

- 3:15** *Friday 8 February, 10–12, V1*  
L11: Electricity market simulation: Objective, repetition of random variables. C: 6.1, appendix C.
- 3:16** *Monday 11 February, 13–15, V1*  
L12: Probabilistic production cost simulation: Model of load and power plants, equivalent load and calculation of system indices. C: 6.2.1–6.2.3.
- 3:17** *Wednesday 13 February, 10–12, V1*  
L13: Probabilistic production cost simulation: Equivalent load and calculation of system indices. C: 6.2.1–6.2.3.
- 3:18** *Friday 15 February, 10–12, V1*  
L14: Probabilistic production cost simulation: Model of wind power (and maybe also model of dispatchable hydro power). Home assignments part IV. C: 6.2.4.
- 3:19** *Monday 18 February, 13–15*  
Reserve.
- 3:20** *Wednesday 20 February, 10–12, V1*  
L15: Monte Carlo simulation: Simple sampling, random number generation. C: 6.3.1, appendix E.
- 3:21** *Friday 22 February, 10–12, V1*  
L16: Monte Carlo simulation: Electricity market model, sampling of electricity markets. C: 6.1, 6.3.1.
- 3:22** *Monday 25 February, 13–15, V1*  
L17: Monte Carlo simulation: Complementary random numbers, control variates. C: 6.3.2, 6.3.3.
- 3:23** *Wednesday 27 February, 10–12, V1*  
L18: Monte Carlo simulation: Stratified sampling. Home assignments part IV. C: 6.3.4, 6.3.5.
- 3:24** *Friday 1 March, 10–12*  
Reserve.
- 3:25** *Monday 4 March, 13–15*  
Reserve.
- 3:26** *Wednesday 6 March, 10–12*  
Reserve.
- 3:27** *Friday 8 March, 10–12, V1*  
L19: Repetition. Hints for the exam. (No lecture notes will be supplied for this lecture.)  
*Thursday 14 March, 8–13*  
Exam. Last day for sign-up: *Thursday 28 February*. The premises of the exam will be posted on the course web page about a week before the exam.