Syllabus spring 2014

The latest news can be found on KTH Social (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. It is also necessary to become registered on the course in order to get access to the computers in the Student room, Teknikringen 33. Go to the course web page, choose "Course registration" in the menu to the left 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. Before the lectures you should preferably prepare yourself by reading the corresponding sections in the course compendium (see the schedule at the end of this syllabus). There are also ready-made lecture notes for most of the lectures, which will be made 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 *"Effi-*

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
5.1
5.2
5.3
5.4
	Short-term planning
	  Objective
	  Hydro power
	  Thermal power
	  Dual variables
		
		∗∗
		∗∗∗
		∗∗∗
		∗∗
			5.1–5.13

6
6.1
 	
6.2.1–6.2.3
6.2.4
6.2.4
6.2.5
6.2.6
6.3
	Simulation of electricity markets
	  Problem description
	  Probabilistic production cost simulation
	    Basic model
	    Multi-state model of power plants
	    Wind power model
	    Dispatchable hydro power
	    Normal approximation
	  Monte Carlo simulation
		
		∗∗
		
		∗∗∗
		∗∗∗
		∗
		∗∗
		−
		∗∗∗
			
			6.1–6.10
			
			6.12–6.18

A-E	Appendices	∗∗	
∗∗∗ Central part of the course. Calculation methods should be well-known. Generally included in the exam as a calculation problem. ∗∗ 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. ∗ General part of the course. Can be skimmed through. − Not included in the course.			

cient Operation and Planning of Power Systems", which is sold by the student office STEX (Osquldas 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 26 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 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, 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	Thursday 30 January, 8:15–9:30, the seminar room Friday 31 January, 8:15–9:30, the seminar room Monday 3 February, 13:15–14:30, the seminar room	English
Ordinary	Part I	Thursday 30 January, 10:15–11:30, the seminar room Friday 31 January, 10:15–11:30, the seminar room Monday 3 February, 15:15–16:30, the seminar room	Swedish
Ordinary	Part II	Tuesday 4 February, 15:15–16:30, the seminar room Wednesday 5 February, 10:15–11:30, the seminar room Monday 10 February, 15:15–16:30, the seminar room	English
Ordinary	Part II	Wednesday 5 February, 8:15–9:30, the seminar room Monday 10 February, 13:15–14:30, the seminar room Tuesday 11 February, 15:15–16:30, the seminar room	Swedish
Ordinary	Part III	Monday 17 February, 13:15–15:00, the seminar room Tuesday 18 February, 15:15–17:00, the seminar room Tuesday 25 February, 13:15–15:00, the seminar room	English
Ordinary	Part III	Monday 17 February, 15:15–17:00, the seminar room Tuesday 18 February, 13:15–15:00, the seminar room Tuesday 25 February, 15:15–17:00, the seminar room	Swedish
Ordinary	Part IV	Monday 3 March, 13:15–15:00, the conference room Tuesday 4 March, 13:15–15:00, the conference room Wednesday 5 March, 8:15–10:00, the conference room	English
Ordinary	Part IV	Monday 3 March, 15:15–17:00, the conference room Tuesday 4 March, 15:15–17:00, the conference room Wednesday 5 March, 10:15–12:00, the conference room	Swedish
Repetition	All	Thursday 11 March, 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 be able to 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[1] 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 participating student, the course assistant then chooses[2] 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 assignments 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!

It should be noted that the presented solution does not have to be completely correct. To pass a presentation it is sufficient that the student shows that he or she is able to discuss the solution with other students and the teaching assistant. This means that the student must be able to explain why he or she decided to solve the problem in a particular way and 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 student should also be able to compare his or her solution to alternative solution methods suggested by the other participants and discuss which method that should be 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 2014 and June 2014 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 report must be submitted in time (see the table below). Reports submitted after the deadline will not be marked. The reports are individual, which means that is acceptable to ask a friend for advice on how to solve the problem, but it is considered as plagiarism to use—either directly or slightly modified—text, program code, tables or figures that you have not written yourself. No bonus points will be awarded to students involved in plagiarism (this includes the student who originally wrote the solution). Severe cases will also be reported to the President of KTH, and might be examined in the Disciplinary Board.

The reports should clearly present both the solution method and the answer to the problem. All introduced symbols must be explained, and the solution must include sufficient detail that the argument and calculations can be easily followed.

There will be three partial exams during the course. Together these partial exams correspond to part I of the exam (see below). A student who collects at least 33 points in the partial exams can skip the first part of the exam. Students may of course still choose to rewrite part I of the exam in order to improve their score; in the final score of the exam, the best result will be used of the par-

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

Deadlines for bonus points

Home assignments	Maximal bonus	Last day to hand in written report
Part I	3	Tuesday 4 February, 12:00 noon
Part III	5	Wednesday 26 February, 12:00 noon
Part IV	5	Thursday 6 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

tial exams or part I of the actual exam. The partial exams are one hour each and the same rules applies as for an exam. This means that students must sign up for the partial exam using KTH My pages. Moreover, students must arrive no later than 45 minutes after the start of the partial exam and nobody may leave the room until 60 minutes have passed (which means that all students have to remain in the room until the end of the partial exam).

The exam itself is divided in two parts, where 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 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), students have the right to demand an extra exam if there is a proper cause.[3] If you are granted an extra exam, you will agree upon a date for the exam with the course

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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.

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.

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.

Teaching premises

Room	Address
H1	Teknikringen 33, 2nd floor
V1	Teknikringen 76, 1st floor
Q31–Q36	Osquldas väg 6, entrance floor

3:1   *Monday 20 January, 15–17, V1*
Introduction.

3:2   *Tuesday 21 January, 13–15, H1*
L1: The structure of an electricity market. C: 2

3:3   *Wednesday 22 January, 8–10, H1*
L2: The structure of an electricity market. C: 2.

3:4   *Thursday 23 January, 10–12, V1*
L3: Electricity pricing. C: 3.

3:5   *Friday 24 January, 8–10, H1*
L4: Electricity pricing. Home assignments part I, presentation techniques. C: 3.

3:6   *Monday 27 January, 15–17, V1*
L5: Frequency control: Synchronous grid, primary control. C: 4.1.

3:7   *Tuesday 28 January, 15–17, H1*
L6: Frequency control: Primary control, secondary control. Home assignments part II. C: 4.1–4.2.

3:8   *Wednesday 29 January, 8–10*
Reserve.

Thursday 6 February, 9–10, Q31, Q32, Q34
Partial exam 1 (The structure of an electricity market, electricity pricing and frequency control).

3:9 *Thursday 6 February, 10–12, H1*
L7: Linear programming. C: Appendix A.

3:10 *Friday 7 February, 8–10, H1*
L8: Short-term planning: LP model of hydro power plants. C: 5.2.1–5.2.4.

3:11 *Wednesday 12 February, 8–10, H1*
L9: Short-term planning: LP model of thermal power plants. C: 5.3.1–5.3.3.

3:12 *Thursday 13 February, 10–12, H1*
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 *Thursday 13 February, 15–17*
Reserve

3:14 *Friday 14 February, 8–10*
Reserve.

3:15 *Wednesday 19 February, 10–12, H1*
L11: Electricity market simulation: Objective, repetition of random variables. C: 6.1, appendix C.

3:16 *Thursday 20 February, 10–12, H1*
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 *Thursday 20 February, 15–17, H1*
L13: Probabilistic production cost simulation: Model of wind power (and maybe also model of dispatchable hydro power). Home assignments part IV. C: 6.2.4.

3:18 *Friday 21 February, 8–10, V1*
L14: Probabilistic production cost simulation: Equivalent load and calculation of system indices. C: 6.2.1–6.2.3.

3:19 *Monday 24 February, 15–17, H1*
L15: Monte Carlo simulation: Simple sampling, random number generation. C: 6.3.1, appendix E.

3:20 *Wednesday 26 February, 8–10, H1*
L16: Monte Carlo simulation: Electricity market model, sampling of electricity markets. C: 6.1, 6.3.1.

Wednesday 26 February, 13–14, Q33, Q34, Q36
Partial exam 2 (Short-term planning).

3:21 *Thursday 27 February, 10–12, H1*
L17: Monte Carlo simulation: Complementary random numbers, control variates. C: 6.3.2, 6.3.3.

3:22 *Thursday 27 February, 13–15, H1*
L18: Monte Carlo simulation: Stratified sampling. Home assignments part IV. C: 6.3.4, 6.3.5.

3:23 *Friday 28 February, 8–10*
Reserve.

Thursday 6 March, 9–10, Q33, Q34, Q36
Partial exam 3 (Simulation of electricity markets).

3:24   *Friday 7 March, 10–12, H1*
L19: Repetition. Hints for the exam. (No lecture notes will be supplied for this lecture.)

Monday 17 March, 14–19, Q33, Q34, Q36
Exam. Last day for sign-up: *Monday 3 March*.