Course memo 2020

This course i prioritised for classroom teaching at KTH during the covid-19 outbreak. However, many activities (lectures, seminars and project assignment presentations) will also be available online. Please also notice that the teaching might be subject to changes depending on the development. The latest news can be found on Canvas (kth.instructure.com). It is also possible to contact the involved teachers:

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Assistance with administrative matters, such as course and exam registration are managed by the student service desk:

- **Web**: KTH | EECS | Contact | Student service desk
  https://www.kth.se/en/eecs/studentsupport
- **Service Center Borggården:** Lindstedtsvägen 3, floor 4
  (open Mo-Th 8:00–16:00, Fr 8:00–14:00)
- **Service Center Q:** Malvinas väg 10, entrance hall
  (open Mo-Th 8:00–16:00, Fr 8:00–14:00)

Learning Outcomes

The aim of the course is that the students learn methods and models for operation, planning and analysis of electric power generation. 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 as well as analyse factors that have a large importance for the electricity pricing, and to indicate how these factors affect for example producers and consumers,
- explain how the balance between production and consumption is maintained in an electric power system, calculate how the frequency is affected by various events in the power system and design the frequency control so that there are sufficient margins in the power system,
- formulate short-term planning problems of hydro-thermal power systems,
- apply probabilistic production cost simulation to calculate the expected operation cost and risk

of power deficit in an electricity market, and to use the results of an electricity market simulation to judge the consequences of various actions in the electricity market,

- give a short oral presentation of the solution to a problem within operation and planning of power generation.

Course Registration

In order to access the course on Canvas you need to be registered on the course. Most students can register themselves through KTH My pages. Contact student service desk if there is any problem.

Learning Activities

In order to fulfil the learning objectives of the course, students will have to put some effort into their studies. 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 examination (see below) on the available times.

The following learning activities are offered in the course:

- **Lectures.** 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 in table 1). There are also ready-made lecture notes for most of the lectures, which will be made available on the course web page). There are also recorded lectures on the course web page.

  Please notice that lectures 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.
- **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"*. The compendium includes theory and solved examples and covers the same contents as the lectures; hence, the compendium can be used for self-studies. In addition to the textbook, there is also an exercise booklet. Both the textbook and exercise booklet are available on the course web page.

Examination

The examination of this course is divided in two parts: exam (TEN1) and project assignments (PRO1). Students have to complete both these parts to receive their final grade. The grading scale of the exam is just pass or fail and the final grade of the course is therefore equal to the grade of the project assignments. There are several ways to complete each of the two parts of the examination. Further details are provided below.

The examination includes two types of problems:

- **Basic problems.** The problem text is relatively short and there is a direct question. The problems may include calculations, short theoretical questions and multiple choice questions.
- **Advanced problems.** The problem text is relatively long. The student will have to identify the problem from the text, choose an appropriate solution method and be able to discuss the conclusion of the results.

The grading criteria are shown in table 2. Familiar problems refers to problems that have been explained in lectures, course literature or seminars. New problems refers to problems that can be solved using methods explained in the course, but which have not yet appeared in the course. Moreover, new advanced problem may require that the students have to adjust models and methods to the new problem and that they can see the connection between the different topics of the course, for example by for-

Table 1 Schedule for the lectures.

Lecture	Time and place	Topics	Compendium	
			11th edition (2011)	New edition/ exercise book
Introduction	Monday 24 August, 8–10, H1	Course organisation		
L1	Monday 24 August, 13–15, U41	Overview of electricity markets	2	2
L2	Wednesday 26 August, 8–10, V3	Overview of electricity markets	2	2
Reserve	Monday 31 August, 8–10, D3			
L3	Tuesday 1 September, 10–12, M33	Electricity pricing	3	3
L4	Thursday 3 September, 10–12, L52	Electricity pricing. Presentation techniques.	3	3
L5	Monday 7 September, 10–12, L52	Synchronous grids, primary control.	4	5.1
L6	Monday 14 September, 10–12, L51	Primary, secondary and tertiary control.	4	5.1–5.2
L7	Tuesday 22 September, 10–12, Q31	Linear programming.	5.1, appendix A	Appendix A.1–3
L8	Thursday 24 September, 10–12, U1	LP model of hydro power plants.	5.2	6.1, 6.2
L9	Monday 28 September, 10–12, L51	LP model of thermal power plants.	5.3	6.3
L10	Thursday 1 October, 10–12, U1	Additional modelling. Dual variables. Short-term planning problems in GAMS.	5.4, appendix B, 5.2, 5.3	6.4, appendix A.4, 6.2, 6.3
Reserve	Monday 5 October, 10–12, L51		–	–
Exercise	Tuesday 6 October, 10–12	GAMS tutorial	Appendix C, 6.1	8, appendix B.1
L11	Monday 26 October, 10–12, U21	Objective of electricity market simulations. Repetition of random variables.	6.2.1–3	9.1, 9.2.1
L12	Wednesday 28 October, 10–12, W42	Model of load and power plants, equivalent load and calculation of system indices.	6.2.1	9.1, 9.2.2
L13	Monday 2 November, 13–15, L52	Equivalent load and calculation of system indices.	6.2.4	9.2.3
L14	Wednesday 4 November, 14–16, Q31	Model of wind power.	–	–

mulating an optimisation problem to solve a problem on frequency control. Advanced problems may also intentionally be formulated so that there are more than one possible solution; thus, not only the solution itself but also the motivation for the chosen solution will be evaluated.

Exam

The exam can be completed either by participating in partial exams during the course or by writing the final exam. In both cases the students will be given a mix of familiar and new basic problems on electricity markets, electricity pricing, frequency control, short-term planning and simulation of electricity markets.

In order to attend partial exams and the final exam, students must register in advance. Please contact student service if you have difficulties registering.

Table 2 Grading criteria.

Grade	Requirement	Examination
E	• Ability to determine if statements on electricity markets are true or false. • Ability to solve basic problems on electricity pricing, frequency control, short-term planning and electricity market simulation. • Ability to give a short oral presentation of problems in power generation operation and planning and to discuss the solutions with other students.	Exam Exam Project assignments
D	As for E, as well as *ability to solve advanced but **familiar** problems* on electricity pricing, frequency control, short-term planning and electricity market simulation.	Project assignment CD
C	As for E, as well as ***very good** ability to solve advanced but **familiar** problems* on electricity pricing, frequency control, short-term planning and electricity market simulation.	Project assignment CD
B	As for E, as well as *ability to solve **new** advanced problems* on electricity pricing, frequency control, short-term planning and electricity market simulation.	Project assignment AB
A	As for E, as well as ***very good** ability to solve **new** advanced problems* on electricity pricing, frequency control, short-term planning and electricity market simulation.	Project assignment AB

The following aids are allowed at the exams and partial exams:

- 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.

Please notice that if you are about to finalise your studies and want to get your degree then it is important that you plan your studies so that you can pass the exam during the course (partial exams) or in one of the two occasions for the final exam that are offered. However, according to KTH rules (available at http://intra.kth.se/en//styrning/regelverk/utbildning-pa-grund-och-avancerad-niva-1.660818) students have the right to demand an extra exam if there is a proper cause.[1] If you are granted an extra exam, you will agree upon a date for the exam with the examiner. 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 examiner 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.

Partial exams

There will be three partial exams during the course, which together correspond to the final exam. The schedule of the partial exams is shown in table 3. The maximal score of the three partial exams is 50 points, and you need to have at least 40 points to pass.

Table 3 Schedule for partial exams.

Partial exam	Time and place	Problems
KS1	Monday 21 September, 8–9, M23, M24, M3, M38	Electricity markets Electricity pricing Frequency control
KS2	Friday 9 October, 8–9, W25, W43	Short-term planning
KS3	Friday 20 November, 8–9, W25, W43	Electricity market simulation

The partial exams are one hour each and the same rules applies as for an exam. This means that students must arrive no later than 30 minutes after the start of the partial exam and nobody may leave the room until 60 minutes have passed (i.e., all students have to remain in the room until the end of the

1. In short, it is 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 before you can get your degree.

partial exam).

Final exam

The final exam is four hours long. The maximal score is 50 points, and you need to have at least 40 points to pass. Examinees who have failed the exam but are close to the requirement for passing (i.e., 38 or 39 points) may write a complementary test. If the result of this test is approved, the student will pass the exam. 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 complementary test no later than one month after the exam.

Project Assignments

The project assignments are divided in three parts: AB, CD and E. Only project assignment E is mandatory. Students who participate in the other assignments have the possibility to improve their grade to A–D. Each assignment includes several problems, which are to be solved individually or in a small group. Students may choose who to work with themselves. It is not necessary to work with the same students for each problem, i.e., students may work in one group for problem E1 and in another for problem E2, etc.

Project assignment E

This assignment is mandatory for all students. The problems are a mix of familiar basic and advanced problems on electricity pricing, frequency control, short-term planning and simulation of electricity markets.

The total score of the project assignment E is 44 and you need at least 40 points to pass. The points are valid until the re-exam. If you have not completed the project assignment E by then, you will have to redo them from the beginning next academic year. Hence, if you are at the end your studies and want to get your degree later this academic year then it is important that you plan your studies so that you can complete all assignments in time.

The rules for project assignment E are as follows:

- **Group.** The problems may be solved in groups of up to four students. Students may choose themselves who to work with and you do not need to register your group in Canvas.
- **Solution.** The problems should be solved according to the EECS code of honour (see https://www.kth.se/en/eecs/utbildning/hederskodex).
- **Preparation.** The solution should be explained in slides. The slides do not need to be submitted in advance. The front page of the solution should state the name of all group members, the course code (EG2200) and the date when the report was prepared. The text, figures and table in the slides must include sufficient detail that the argument and calculations can be easily followed also for someone who is not attending the presentation. The principles of calculations that are performed in Matlab, GAMS, Excel or any other software must be described in the slides.
- **Presentation.** The solutions are presented in seminars. The schedule for the seminars are shown in table 4. The number of seats is limited in each seminar; therefore, each student has to sign up for the seminars in advance using the calendar function in Canvas. All group members do not need to attend the same seminar.
- **Score.** Students get points for the questions which they are prepared to present in the seminar. 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.

At the beginning of the seminar each student states which questions he or she is ready to present. The ordinary seminars comprises a given selection of questions, as shown in the schedule above. For each

Table 4 Schedule for the seminars

Seminar	Assignment	Time and place
Ordinary	E1	Monday 7 September, 13:15–14:30, E34 Tuesday 8 September, 13:15–14:30, B21 Tuesday 8 September, 15:15–16:30, B21 Wednesday 9 September, 8:15–9:30, D35
Ordinary	E2	Tuesday 15 September, 13:15–14:30, E33 Tuesday 15 September, 15:15–16:30, E33 Thursday 17 September, 13:15–14:30, Q13 Friday 18 September, 8:15–9:30, L42
Ordinary	E3	Wednesday 7 October, 8:15–10:00, Q11 Wednesday 7 October, 13:15–15:00, D33 Thursday 8 October, 8:15–10:00, B23 Thursday 8 October, 10:15–12:00, B23
Ordinary	E4	Tuesday 17 November, 13:15–15:00, D33 Tuesday 17 November, 15:15–17:00, D33 Wednesday 18 November, 8:15–10:00, D33 Wednesday 18 November, 10:15–12:00, D33
Repetition	E1–4	To be decided

question, the course assistant chooses[2] 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[3] 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 points will be rewarded for all questions that the student was prepared to present. However, if a student fails at least one oral presentation, no points at all will be rewarded for this seminar, regardless of which other assignments that the student have been prepared to present!

Project assignment CD

This assignment is voluntary and can yield a higher final grade in the course. The problems are familiar advanced problems on electricity pricing, frequency control, short-term planning and simulation of electricity markets.

The total score of the project assignment CD is 44. The points are valid until the re-exam. If you have not completed the project assignment by then, you will have to redo them from the beginning next academic year. Students who receive at least 36 points will get the grade C and students who receive at least 27 points will receive the grade D. The score for project assignment CD may include results from project assignment AB, if that score should be higher than the score of the corresponding problem in project assignment CD, i.e., a student's score from problem AB1 can replace the score from problem CD1, the score of AB2 can replace CD2, etc.

The rules for project assignment CD are as follows:

- **Group.** The problems may be solved individually or by a group of two students. Students may choose themselves who to work with, but students are requested to set up their group in Canvas using the "People" section.
- **Solution.** The problems should be solved according to the EECS code of honour (see https://www.kth.se/en/eecs/utbildning/hederskodex).
- **Preparation.** The solution should be explained in slides. The slides should be uploaded in Canvas using the "Assignments" section. There are two Canvas assignments for each problem: one for the slides themselves and one for additional program code. The deadlines for submission are shown in table 5.

  The front page of the solution should state the name of all group members, the course code (EG2200) and the date when the report was prepared. The text, figures and table in the slides must include sufficient detail that the argument and calculations can be easily followed *without*

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

an oral explanation. The principles of calculations that are performed in Matlab, GAMS, Excel or any other software must be described in the slides.

- **Defence.** Each group member must orally defend the group's solution. Sign up for a defence time using the calendar function in Canvas. Notice that you sign up as a group, but that each group member will have to explain the solution individually (while the other group member is waiting).
- **Score.** The solutions will be marked in Canvas. There will be a score reduction for errors in the presented solutions. However, students will not receive any score for a problem if they did not attend the defence or if they cannot respond well enough to the course assistant's questions about how they have solved the problem.

Table 5 Schedule for project assignment CD.

Problems	Release date	Deadline for submission
1–2	Monday 21 September	Tuesday 29 September, 8:00 am.
3	Friday 9 October	Tuesday 20 October, 8:00 am.
4	Friday 20 November	Friday 27 November, 8:00 am.

Project assignment AB

This assignment is voluntary and can yield a higher final grade in the course. The problems are new advanced problems on electricity pricing, frequency control, short-term planning and simulation of electricity markets. The problems are published 27 November and should be submitted no later than Monday 14 December, 8:00 am.

The total score of the project assignment AB is 44. The points are valid until the re-exam. If you have not completed the seminar assignments by then, you will have to redo them from the beginning next academic year. Students who receive at least 36 points will get the grade A and students who receive at least 27 points will receive the grade B.

The rules for project assignment AB are as follows:

- **Group.** The problems may be solved individually or by a group of two students. Students may choose themselves who to work with, but students are requested to set up their group in Canvas using the "People" section.
- **Solution.** The problems should be solved according to the EECS code of honour (see https://www.kth.se/en/eecs/utbildning/hederskodex).
- **Preparation.** The solution should be explained in slides. The slides should be uploaded in Canvas using the "Assignments" section. There are two Canvas assignments for each problem: one for the slides themselves and one for additional program code. The deadline for submission is Monday 16 December.

  The front page of the solution should state the name of all group members, the course code (EG2200) and the date when the report was prepared. The text, figures and table in the slides must include sufficient detail that the argument and calculations can be easily followed *without an oral explanation*. The principles of calculations that are performed in Matlab, GAMS, Excel or any other software must be described in the slides.
- **Defence.** Each group member must orally defend the group's solution. Sign up for a defence time using the calendar function in Canvas. Notice that you sign up as a group, but that each group member will have to explain the solution individually (while the other group member is waiting).
- **Score.** The solutions will be marked in Canvas. There will be a score reduction for errors in the presented solutions. However, students will not receive any score for a problem if they did not attend the defence or if they cannot respond well enough to the course assistant's questions about how they have solved the problem.

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 Division of Electric Power and Energy Systems 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.