



KTH Electrical Engineering

EG2340 Wind Power Systems Course Syllabus 2015

The latest news related to the course is announced on the course webpage
<https://www.kth.se/social/course/EG2040/>.

You can also contact the course staff at the department for Electric Power Systems, Teknikringen 33:

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Mehrdad Ghandhari (lecturer)
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External Experts:

Thomas Ackermann	Energynautics GmbH
Hans Bergström	Department of Earth Sciences, Uppsala University
Karl Bolin	Department of Aeronautical and Vehicle Engineering, KTH
Mikael Ekhangen	Vattenfall AB
Katherine Elkington	Svenska Kraftnät
Staffan Engström	Ägir konsult
Kjell Grip	Vindval, which is financed by Naturvårdsverket
Stefan Ivanell	Department of Mechanics, KTH
Richard Ogiewa	Enercon GmbH
Sven Ruin	TEROC AB

Course schedule

The detailed course schedule can be found on KTH Social, or directly accessed through
<https://www.kth.se/social/course/EG2340/calendar/>

Objectives

The course Wind Power Systems aims at providing knowledge about the wide area of technology that is needed for persons working in the wind energy industry or related industry, such as generation or network companies.

At the end of the course you should be able to:

- give some basic definitions (power curve, overall efficiency, Betz limit, stall and pitch regulation, etc.),
- understand basic concepts, such as power in the wind, vertical distribution of wind speeds, power production and efficiency of a wind turbine, energy yield of a wind turbine from a site,
- calculate energy yield of a wind turbine using actual wind speed measurements or approximate data,
- describe the main wind turbine design concepts, main differences, advantages, disadvantages,
- understand basic concepts from grid integration of wind turbines (voltage at the connection point, active, reactive power, strength of the grid, power quality of a wind turbine),
- describe some effects that wind power has on power system operation and grid investments,
- describe operation of hybrid systems (wind/diesel, wind/battery/diesel),
- describe effects that wind power has on environment,
- describe different economical support schemes for wind power.

In order to receive a higher grade (A-D), you will also need to show that you are able to

- derive the important formulas studied during the course (power in the wind, Betz limit, etc.),
- analyse and compare characteristics of different wind turbines,
- present some control possibilities of wind turbines,
- analyse wind conditions, and wind farm layout possibilities of the particular site,
- perform basic calculations and analysis for grid connection of a wind turbine,
- describe main aspects treated in the Grid Codes for connection of wind turbines and explain why those aspects are important.

Prerequisites

60 HP (basic mechanics, basic physics, complex numbers, numerical methods), and documented proficiency in English B or equivalent. Basic knowledge in Matlab programming is recommended.

Course Registration

You must register for this course through KTH's web registration system. You must also register here se page: (<https://www.kth.se/social/course/EG2340/page/course-information-course-syllabus/>) for internal usage.

Course Structure

The course includes 24 lectures, 5 exercise sessions and a five-hour examination. It is taught in English. Reading suggestions related to each lecture are given in the schedule on KTH Social and at the end of this document. During the course assistance hours, the teaching assistant will be available to assist the students with the assignments and/or project work, and review the completed home assignments.

Student Office

STEX – Studerandeexpeditionen
Osquldas väg 10
Phone 08-790 9086/7

Course Literature

The following book is highly recommended for this course: J.F. Manwell, J.G. McGowan, A.L. Rogers, *Wind Energy Explained: Theory, Design and Application, Second edition*. It can be bought from STEX for 500 SEK. In addition, overhead and online material can be found on the course webpage.

Home Assignments

You can work on five facultative assignments that should give you a better understanding. All assignments will be marked, but only the best four can give up to 2.5 bonus points each for the exam (for a maximum of 10 extra points in total). The bonus points are valid for the exam in May and the re-exam in August this year.

The assignments should be completed individually and a written report has to be submitted thru the WEB system: <https://www.kth.se/social/course/EG2340/page/course-information-course-syllabus/> If Matlab is used for completing the assignments the code should be included with the report. Solutions to the assignments must be well motivated and explained in detail. All equations used must be written clearly and all variables clarified. Figures and tables must be properly scaled and have labels and captions. Write your name and personal number on the front page of the assignments.

The assignments will be uploaded on KTH Social. The teaching assistant (see table below) will be available to answer questions during the scheduled course assistance hours.

Assignment	Due date	Teaching assistant
1. Wind Data Analysis	Monday 21 September, 09.00	Ilias Dimoukias
2. Power Generation Technology	Monday 12 October, 09.00	Wei Li
3. Grid Integration of Wind Power Systems	Thursday 22 October, 18.00	Wei Li
4. Wind Turbine Design Concepts	Monday 30 November, 09.00	Ekaterina Moiseva
5. Small Scale Wind Power Systems	Monday 14 December, 09.00	Ekaterina Moiseva

Project

There is also a course project, where a group of 3 or 4 students makes a technical and economical pre-feasibility study for an imaginary wind farm project given real wind data, location, electrical network topology etc.

The project description and data will be uploaded on KTH Social.

Each project group will also receive a project report from another group to read. They should then act as an opponent by preparing some questions to ask about the report.

Upon completing of the project, the students are rewarded 1.5 hp (ECTS credits).

The reports summarizing the results of the project should be submitted has to be submitted thru the WEB system: <https://www.kth.se/social/course/EG2340/page/course-information-course-syllabus/>

All presentations will be on Monday December 14, 10-12 in the rooms: L42, L43, L44, B22 and B23. The presentations should be around 15 minute long.

Examination

Rules regulating written examinations at the Royal Institute of Technology (KTH) can be found on [KTH Intranet](#).

The examination is a single-part examination. Upon completing the course work and passing the final exam, which is given twice a year, the students are awarded 6 hp (ECTS credits). The regular exam is on Friday 24 May and a re-examination will take place in August (details to be announced).

At KTH it is compulsory to register for examinations. In order to be eligible for a seat during the exam, the examinee must file this registration in advance. Bookings must be made in advance through <https://www.kth.se/student/minasidor/>.

The final grade of the course is given according to the table below.

Total score: Exam (max 100 points) +Assignments (max 10 points)	Grade
0–57	F
58–60	FX*
61–68	E
69–76	D
77–84	C
85–92	B
93–110	A

FX*: conditional fail.

Study Trip

We plan to organize a 2-day study trip involving a visit to a wind farm and a visit to a company, e.g. a wind turbine manufacturer or a system operator. For the study trip in 2012 we went to Germany.

Participation in the study trip is not compulsory. Costs for the study trip are shared between the students and the department. Typically the costs for each student are around 500–700 SEK = mainly cost for flight ticket.

The study trip will preliminary take place on Monday–Tuesday, 23-24 November, Germany. Information about registration will be given during the lectures.

Course Evaluation

Your feedback is important for continuously improving of the course. Any feedback you have during the course can be sent to Lennart or Yalin and evaluation forms will be available at the middle and the end of the course.

LIST OF LECTURES AND ASSOCIATED READING SUGGESTIONS

Lennart Söder: Intro – Wednesday 150902 15-16, Q2

Thomas Ackermann: Crash course I and II – Friday 150904 13-17, H1

Chapter 1.

Chapter 11: 11.1, 11.2, 11.3.3.1, 11.3.3.3, 11.3.4, 11.4, 11.5.1 – 11.5.3, 11.5.4.3, 11.5.4.4, 11.7.

Ilias Dimoulkas: Wind measurement – Wednesday 150909 15-17, H1

Chapter 2: 2.2.1, 2.2.3, 2.3.4, 2.3.5, 2.4 – 2.6, 2.8.

Chapter 9: 9.3, 9.4.1 – 9.4.2.5.

Chapter 11: 11.5.2.2.

Hans Bergström: Meteorology – Monday 150914 10-12, L4

Chapter 2: 2.1, 2.2, 2.3 (skip 2.3.3), 2.4.3, 2.4.4, 2.6.

Chapter 9: 9.1, 9.2.

Mehrdad Ghandhari: Power generation technology I and II – We 150916 15-17, H1 + Mo 150921 10-12, L1

Chapter 5: 5.1 – 5.7.

Stefan Ivanell: Aerodynamics I and II – We 150923 15-17, B3 + Mo 150928 10-12, H1

Chapter 2: 2.2.3, 2.3.5.

Chapter 3: 3.1, 3.2, 3.3, 3.4.1 – 3.4.6, 3.6.3, 3.7, 3.9, 3.10, 3.12.

Lennart Söder: Electric power systems I and II – We 150930 15-17, B3 + Mo 151012 Q2

Chapter 5: 5.1 – 5.3.

Chapter 9: 9.5.1.

Staffan Engström: Design of a wind turbine – Monday 151005 10-12, B3

Chapter 3: 3.14.1.

Chapter 6: 6.3.2, 6.3.3 (skip 6.3.3.5).

Chapter 7: 7.1 – 7.4.

Richard Ogiewa: Enercon: Wind farm control – Wednesday 151007 15-17, H1

Chapter 3: 3.1, 3.2, 3.3, 3.4.1 – 3.4.6, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.12, 3.14.1.

Chapter 4: 4.1, 4.2.

Chapter 5: 5.6.

Chapter 6: 6.5.2, 6.5.4, 6.5.5.

Chapter 7: 7.3.1, 7.7. Chapter 8: 8.1 – 8.3.

Lennart Söder: Electric network integration and balancing – We 151014 15-17, Q2 + Mo 151109 10-12, Q36

Chapter 9: 9.5.4, 9.5.5.

Chapter 11: 11.5.

Katherine Elkington: Planning for wind power at Svenska Kraftnät – 151102 10-12, Q36

Sven Ruin: Stand-alone and hybrid systems – Monday 151116, D3

Chapter 10: 10.1 – 10.3 (skip 10.3.4).

Karl Bolin: Noise – Wednesday 151118, 15-17, H1

Chapter 12: 12.4.1 – 12.4.3, 12.4.5, 12.4.6, 12.7.

Thomas Ackermann: Offshore wind power – Monday 151130 10-12, D3

Chapter 1: 1.2.5.

Chapter 3: 3.14.1.

Chapter 7: 7.3.1.

Chapter 10: 10.4 (skip 10.4.4).

Chapter 12: 12.1.

Thomas Ackermann: Wind pumps and small turbines – Wednesday 151202 15-17, H1

Chapter 10: 10.1 – 10.3, 10.6.1.

Kjell Grip: Wind power and the environment – 151209 15-17, D3

Chapter 12: 12.1, 12.2 (skip 12.2.4), 12.3.1, 12.3.2, 12.4.1, 12.5.1, 12.7.2.

