KTH Electrical Engineering

COURSE PM EI2455 Smart Electrical Networks and Systems, 7.5p. Per. 1-4, 2021/2022.

Welcome to the course in Smart Electrical Networks and Systems – a course on concepts of the evolution of the electric power grid into a 'smart grid'!

PREREQUIREMENTS

Basic courses in electrical engineering. Fundamental knowledge of power system analysis and power electronics is necessary, but as the courses are taught in parallel with these ones at KTH they are not mandatory, but you will need concepts from these courses later on. This is also one reason why more technically detailed projects in the course are coming later.

COURSE RESPONSIBLE

Examiner and lecturer: Professor Hans Edin, KTH, Teknikringen 31, 4th floor, room 1424, phone 08 - 790 7639, e-mail: edin@kth.se

OBJECTIVES AND LEARNING OUTCOMES

In the course Smart Electrical Networks and Systems you will apply your electrical engineering competence on projects that are of high relevance in the field what is called 'smart grids'. You will also get the basic concepts on evaluating the business potential of different technical innovations.

After being approved for all parts of this course the student should be able to

- describe the novelties, benefits and business opportunities that a smart grid will address (Module 1, Project 1)
- develop models for the impact of distributed renewable generation on different aspects of the grid as voltage limits and current overloading (Module 2, Project 2)
- describe the innovation process of a product, service, etc related to communication technologies within the smart grid (Module 1, Project 1)
- analyze the influence of fast measurements and (big) data acquisition on control and automation properties of the electric power network (Module 4, Project 4)
- present the recent findings about smart electrical networks (whole course)
- judge the needs and business opportunities from a system perspective that the future's electrical networks must have (whole course)
- understand the different methods with which local generation can be installed in the power system (Project 2, Module 2)

- be aware on where and how information control systems and monitoring/diagnostic systems can be implemented in the power grids; (Module 4, Project 4)
- be able to describe the design of an HVDC super grid and where the challenges are to realize such a grid (Module 3, Project 3)

COURSE ORGANISATION AND EXAMINATION

The course is organized around 4 modules or themes during the year.

Module 1 (Aug.- ~Oct.): Smart Grids overview and ICT technologies in the smart grid – need, drivers, vision, etc.
Module 2: (~Oct.-Nov.): Integration of renewable and distributed energy resources into the grid/Microgrids
Module 3 (Jan – March): HVDC supergrid technology
Module 4: (March - May): Data driven applications in the smart grid

The exact program will be decided from time-to-time, depending on the availability of guest lectures etc.

Lectures

The lectures are to some extent provided by invited speakers from different segments of the electric power industry, i.e. manufacturing industries, power utilities, small companies and grid operators. The lectures have been selected to provide different view on different technologies and business opportunities in the field of electric power engineering in general. Some lectures are related to the technology developments, some to the experiences of people that have started own companies and may be called entrepreneurs and some given by project managers of large projects.

Assignments and Projects

Assignment/Project #	Topic	Release	Deadline for written report
Project 1	Smart Grids overview + ICT Technologies in the smart grid	210916	211111 (Report and poster uploaded in Canvas). Poster presentation 211118
Project 2	Integration of renewable and distributed energy resources into	211104	211206 Oral presentations by each group, TBD

	the power grid / Microgrids		
Project 3	HVDC supergrids	Jan 2022 (Exact time to be decided)	March 2022 (Exact time TBD)
Project 4	Data driven applications in the smart grid	March 2022 (Exact time TBD)	May 2022 (Exact TBD)

The projects are organised in such a way that the end-user of the product differ between the projects:

1. Could be anything from producer to consumer or prosumers,
2. Distribution system operator (DSO)
3. Could be anything from producer to consumer or prosumers,
4. Transmission system operator (TSO)

In relation to each project release about 6 hours of lectures are provided and background material is handed out. (2-4 hours from academic staff and 2-4 hours by lecturers from industry

Evaluation and grading

The projects and assignments are evaluated and graded in a scale F, Fx, E, D, C, B, A.

Three parts will generally be judged on a scale 0 - 5:

1. Overall quality of report concerning structure, language and clarity
2. Technical correctness and degree of advanced levels in models and assumptions. As an example: the correct analysis of a situation with a simple model may give a D, but including more complicated situations such as transient behaviour (just an example) will give the higher grades. For the highest grade it should be obvious that one have consulted the scientific literature and also a quantitative analysis is needed.
3. How the market needs and business potential/value are reflected upon is evaluated.

Project 1 (Individual project), 1.0 credits: (PRO A) Grade FX-A.
Project 2 (Group project), 2.7 credits: (PRO B) Grade FX-A.
Project 3 (Individual project) (PRO C) , 1,0 credits: Grade FX-A.
Project 4 (Group project) (PRO D), 2,8 credits: Grade FX-A.

The total grades are converted to a numerical grade according to: E=3, D=3.5, C=4, B=4.5, A=5

Final course grade (grade on PRO 1 as well) is numerically calculated according to the credit weighted sum:

(1.0*Numgrade(Project1)+ 2.7*Numgrade(Project 2)+ 2,8*Numgrade(Project 4)+ 1,0*Numgrade(Project 3))/7.5

Final grades are converted from the sum above according to:
E≥3, D≥3.25, C≥3.75, B≥4.25, A≥4.75

Code of honour:

Each student has to read and understand the Code of honour:

https://www.kth.se/polopoly_fs/1.919802.1566304651!/Code%20of%20honour%20for%20students%20and%20teachers%20EECS.pdf

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COURSE SCHEDULE

*) The time for guest lectures may be rescheduled depending on their ability

Type	Subject	Day	Hour	Place	Teacher
Lec. 1	Course introduction. Overview of smart grids Literature: Borlase Chapter 1 & 2	Thu Sep 2	13 – 15	E2 and Zoom	HE
Lec. 2	Smart grids overview cont'd. Smart grid projects over the world. Literature: Borlase Chapter 1 & 2	Thu Sep 16	13 – 15	E2 and Zoom	HE
Lec. 3	Communication in Smart Grids + Tentative Guest lecture Carlo Fischione, KTH (15-17) Literature: Borlase Chapter: 4	Thu Sep 23	13 - 17	E2 and Zoom	HE
Lec. 4	Tentative Guest lecture	Thu Oct 7	13-15	Q31 and Zoom	
Lec. 4	Guest lecture: Prof. Sonja Berlijn, KTH, Previously Vice President R&D Statnett, Norway: "The future power grid from a TSO perspective"	Thu Oct 14	10 - 12	Q26 and Zoom	HE
Lec. 5	Integrating renewable and distributed generation. Literature: Jenkins, Chapter 1-3,5	Thu Nov 4	13 - 15	Q17 and Zoom	HE
Lec. 6	Voltage regulation in the distribution grid. OLTCs etc, Literature: To be updated	Thu Nov 11	14 - 16	Q26 and Zoom	HE
Sem. 1	Poster session on Project1 : Smart grids overview (Mandatory)	Thu Nov 18	12 – 15 (Lunch offered)	Q17 (alternative room may come)	HE
Lec. 7	Direct load control, demand response, customer interaction Literature:	Thu Nov 25	13 - 15	Q17 and Zoom	HE
Lec. 8	Energy storage solutions, V2G, etc.	Thu Dec 2	13-15	V11 and Zoom	HE

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Sem. 2	Group oral presentations of Project 2. 10 minutes per group	To be scheduled	To be scheduled	Sten Velander and Zoom	HE
	Schedule for P3 and P4 will come later				
	Schedule for spring semester to be delivered later				

COURSE LITERATURE

The course literature consists of material that you find useful,
In particular the following Books/e-books are of interest:

A.B.M. Shawkat Ali (Ed.), Smart Grids: Opportunities, Developments and Trends,, Springer Verlag, 2013 (Available as E-book)

Bernd M. Buchholz, Zbigniew Styczynski, *Smart Grids – Fundamentals and Technologies in Electricity Networks*, Springer Verlag, 2014 (Available as E-book)

J. Ekanayake, *Smart grid : technology and applications* (Available as E-book).

Stuart Borlase (ed) *Smart grids : infrastructure, technology, and solutions*, Wiley 2018, Available as E-book:
https://www.taylorfrancis.com/books/edit/10.1201/9781351228480/smart-grids-stuart-borlase

N. Jenkins, J.B. Ekanayake and G. Strbac, Distributed Generation, IET, 2010, (Available as E-book)

Kabalci, Ersan : From Smart Grid to Internet of Energy, Academic Press, 2020
https://www-sciencedirect-com.focus.lib.kth.se/book/9780128197103/from-smart-grid-to-internet-of-energy

Handbook of Distributed Generation Electric Power Technologies, Economics and Environmental Impacts / edited by Ramesh Bansal. SpringerLink (Online service) ISBN 978-3-319-51343-0 Publicerad: Cham : Springer International Publishing : 2017.Engelska IX, 819 p. 466 illus., 229 illus. in color.

Sioshansi, Fereidoon P, “Smart Grid, Integrating Renewable, Distributed & Efficient Energy”

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Distributed materials for each lecture/project:

- Distributed lecture notes/slides
- Articles from scientific papers

COURSE EVALUATION

In the end the course. Course evaluation committee members to be selected early in the course (three persons).

Stockholm 2021-09-01

Hans Edin