REM master basic syllabus

Title:
ELK12 Wind power in electric power systems

Credit value:
3.75 ECTS

Mandatory/Optional:
Optional

Semester:
3

Lecturer/s:
Prof. Kjetil Uhlen

University:
NTNU- Norwegian University of Science and Technology

Department:
Department of Electric Power Engineering

Rationale:
The course will discuss how the offshore and onshore wind power resources might be utilized and integrated into the energy and power systems in an economic efficient, technical robust and reliable way. Different wind turbine technologies, use of power electronics, design of wind parks, grid integration and network interface and principles for control and system operation are the topics that will be covered to aid in the exploitation of the potential of wind power. The differences between offshore and onshore wind power will be discussed. Further, the course will present and discuss economy and market issues related to large-scale integration of wind power.

Objectives:
The overarching objective of the course is to give a thorough introduction to different topics related to integration of onshore and offshore wind power in electric power systems. After completing this course the candidate shall understand and have insight into:

- *some rules and regulations related to wind power development, grid codes*
- *main types of modern wind turbines*
- *wind characteristics and resources*
- *wind variations, influence of terrain*
- *wind measurements and instrumentation*
- *wind data analysis*
- *wind turbine and wind farm siting, production estimation*
- *basic wind turbine aerodynamics, Betz law*
- *wind turbine and wind farm control*
- *electrical aspects of wind turbines*
- *power system integration*
- *grid solutions for wind farms*
- *reactive power management*
- *HVAC transmission (cables for offshore wind power installations)*
- *power markets*
- *current research activities on wind power (Norway)*

Skills: *(according to the list of skills provided)*

Subject skills	REM Master Skills						
	L2.1	**L2.2**	**L2.3**	**L2.4**	**L2.5**	**L2.6**	**L2.7**
L3.1. Identify important rules and regulations related to wind power development	X				X		
L3.2. Understand the main characteristics of and differences between electrical machines used in wind turbines; assess typical efficiencies for different types of wind turbines	X		X				

L3.3. Understand the main principles of control of modern wind turbines; identify the main challenges related to siting of wind turbines and wind farms	X		X				
L3.4 Perform simplified power and energy calculations	X		X				
L3.5 Identify the main characteristics of power markets and the influence of wind power in these markets	X		X				X
L3.6 Define challenges related to grid integration of wind turbines/farms, onshore and offshore and propose various solutions	X	X				X	X

Teaching and learning methods:

The course methodology includes:

1. Lecture format with oral and audiovisual presentations.

2. Exercises.

3. Seminars of invited speakers.

Allocation of student time:

	Attendance (classroom, lab,…)	**Non attendance (lecture preparation, self study…)**
Regular Lectures	14 hours	24 hours
Classroom practice	0 hours	22 hours
Guest lectures	10 hours	14 hours

Assessment:

Procedures for assessment of the course:

- *There will be a final exam, with 100% weightage.*
- *Students must get their assignments approved.*

Note: The Assessment rules might vary from year to year. The students will be notified at the beginning of the semester of such changes.

Assessment Matrix:

Subject skills	**Assessment method**				
	Exam	**Presentation**	**Paper**	**…**	**…**
L3.1.	100%				
L3.2.	100%				
L3.3.	100%				
L3.4.	100%				
L3.5.	100%				
L3.6.	100%				

Programme: *Distribution (2 h theory per lesson)*

Topic 1	Course Introduction ● About the course, lectures, the textbook, etc. ● Why wind energy? ● Challenges and Possibilities ● Wind Power Production in Europe (on- and offshore) ● Some important rules and regulations (if time permits)
Topic 2	Wind turbines- Part I and II ● Basic Design ● Vertical vs. horizontal turbines ● Pitch and stall regulated turbines ● Mechanical design ● Generator types - basic introduction
Topic 3	Electrical system and grid integration – Part I ● Generator types ● Power electronics (briefly) ● Reactive power and compensation
Topic 4	Electrical system and grid integration – Part II ● Connection and grid codes ● Grid integration, grid solutions (examples)
Topic 5	Wind power integration into the Norwegian and Nordic system ● Power system analysis ● Power flow and stability analysis ● Voltage stability ● Examples – results from case studies
Topic 6	Power Markets involving wind energy generation ● Market design ● Influence of wind power ● Market integration ● Examples
Topic 7	Wind Power modeling ● Wind flow principles and models ● Numerical Weather Prediction Models (NWPM) ● Wind turbine/farm siting ● Production estimation/simulations ● Wind speed monitoring (briefly) ● Real-life examples
Topic 8	Wind turbine and wind farm control and system integration ● Wind turbine and wind farm control ● Modelling and control of wind turbine systems (an introduction) ● Connection of large-scale onshore and offshore wind farms ● Dynamic interaction between wind power and conventional generation. ● Examples – results from case studies
Topic 9	Wind power activities in Statkraft, Norway
Topic 10	Aerodynamics ● Betz law ● Energy calculations (wind turbine power production) ● Statistical distributions: Weibull, Raleigh
Topic 11	Research activities on wind energy in Norway
Topic 12	Course Summary

Resources:

Classroom, Blackboard, laptop, projector, audio, computer room.

All the material necessary to follow the course is facilitated by the course instructors during the course, through 'eLS' (e-Learning System) platform (known as 'Blackboard).

Bibliography:

The written material used in the course include the following:

- J. F. Manwell, J. G. McGowan and A. L. Rogers, "Wind Energy Explained," 2nd Edition, Wiley, 2009.
- Select few scientific papers and reports (state-of-art) will be uploaded as supplementary and background literature during the semester, as and when required.
- Handouts of power point presentations.

Further comments:

Deviations: Since the teaching and learning processes are adaptive, there may arise minor deviations in the course schedule and content.