Local MORE master basic syllabus

Title:
Marine Renewable Energy Converters

Credit value:
4,5 ECTS

Mandatory/Optional:
Mandatory

Semester:
3

Lecturers:
Antoine Ducoin, Jean-Christophe Gilloteaux, Aurélien Babarit, Derrick Holliday and Max Parker

University:
Ecole Centrale Nantes
University of Strathclyde

Department:
Fluid Mechanics and Thermodynamics
Department of Electronics and Electrical Engineering

Rationale:
Offshore renewable energy technologies have gone through significant developments and improvements. This subject will deal with the marine renewable energy resources, markets and conversion technologies that enable the integration of these generation sources to the power grid. Building on other courses, it will focus on energy performance, efficiency and their assessment and the fundamentals of operation of both typical generator and converter types.

Objectives:
To provide students with (i) good understanding of the fundamentals of wind turbines, tidal turbines and wave energy converters performances, (ii) a first experience with the assessment of the performance of these technologies, (iii) understanding the operating principles of common AC machines and (iv) knowledge on the fundamentals of common power electronic converters used in renewable energy sources

Skills:

Subject skills	More Master Skills						
	L2.1	**L2.2**	**L2.3**	**L2.4**	**L2.5**	**L2.6**	**L2.7**
L3.1. Explain and demonstrate knowledge and understanding of the resource and market for offshore wind, tidal energy and wave energy	X		X				
L3.2. Explain and demonstrate knowledge and understanding of offshore wind turbine technologies, tidal turbines and wave energy converters	X		X				
L3.3. Have knowledge of numerical and experimental methods and tools for the performance assessment of offshore wind turbines, tidal turbines and wave energy converters	X	X	X	X			
L3.4. Students learn basic techniques to analyse magnetic circuits		X	X			X	X
L3.5. Students get familiarise with AC machines components, operation and modelling in the dq frame		X	X			X	X
L3.6. Students are able to explain components and	X	X	X			X	X

principles of operation of two-level and three-level power converters typically used to interface renewable energy sources							

Teaching and learning methods:

Teaching and learning methods include lectures dealing with theory, which will be applied through tutorials and computer lab in small groups of students. To support the learning process part of the modules covers tutorial-like sessions where the students are put to the challenge of working together and addressing problems of slight higher technical complexity.

Allocation of student time:

	Attendance (classroom, lab,…)	**Non attendance (lecture preparation, self study…)**
Lectures	26 hours	31,5 hours
Lab (computer)	16 hours	30 hours
Tutorial-like session	3hours	6 hours

Assessment:

Knowledge of the students acquired during the lectures and tutorials will be assessed through exams. The computer lab work will be assessed through reports followed sometimes with presentations.

Assessment Matrix:

Subject skills	Assessment method		
	Exam	**Presentation**	**Report**
L3.1.	100%	0 %	0 %
L3.2.	0%	0 %	100 %
L3.3.	0%	0%	100%
L3.4	100%		
L3.5	100%		
L3.6	100%		

Programme:

Lesson 1	***Fundamental of turbine performances (Antoine Ducoin)*** *This course is an introduction to the "offshore wind turbines" and "tidal turbine" classes. The objective is to understand the fundamentals turbines performances, focusing on the specificity marine applications. We will focus on the main operating principle of turbines, followed by the understanding of flow physics around the blades occuring in the marine environment, including cavitation.* *2h theory*
Lesson 2	***Tidal turbines (Antoine Ducoin)*** *This part of the course will describe, the resource,market and technologies. Experimental and numerical methods for studying tidal turbines will be outlined. Through guest lectures, an overview of current activities in the field of tidalturbines will be given.* *4h theory + 4h Lab (computer)*
Lesson 3	***Offshore wind turbines (Jean-Christophe Gilloteaux)*** *Firstly, this part of the course will describe the wind resource at sea. Then, the components of a wind turbine will be detailed. Rotor technologies, drive-train and generators, control as well as bottom fixed and floating foundations will be addressed.. Experimental methods will be outlined as well as park effects. Numerical exercises will be carried out in order to investigate the dynamic behaviour of floating offshore wind turbines* *4h theory + 6h Lab (computer)*
Lesson 4	***Wave energy converters (Aurélien Babarit)*** *The objective of this part of the course is (i) to give to the student a good understanding of the current status of wave energy conversion technologies in terms of potential and actual performance and (ii) to give them a first experience in the numerical assessment of the energy performance of wave energy converters.* *Thus, it will address first the wave energy resource and market. An historical perspective of wave energy conversion will be given and state-of-the art of the technology will be described. Fundamentals of wave energy conversion and energy performance will be highlighted. Energy performance of current technologies will be discussed as well as project development methodologies. Then, the course will focus on the numerical modelling of wave energy converters. It will include a description of current Power Take-Off technologies. Numerical exercises will be carried out in order to give the students a first experience in the assessment of the energy performance of a generic WEC at typical deployment sites.* *4h theory + 6h Lab (computer)*
Lesson 5	*Electrical machines* *Revision of basics on AC machines components and behaviour (torque production and derivation of equivalent circuits)* *Distribution (3h theory + 1 h tutorial-like session)*
Lesson 6	*Electrical machine modelling* *Dynamic models of induction and synchronous machines* *Distribution (3 h theory + 1h tutorial-like session)*
Lesson 7	*Power electronic converters* *Basics of power electronic converters, components and main topologies*

	Distribution (3h theory + 1h tutorial-like session)
Lesson 8	*Operation and control of power electronic converters* *Fundamentals of converters operation and control* *Distribution (3h theory)*

Resources:

Lectures, seminars and presentations require blackboard and projector in lecture hall.
Lab works are carried out in computer room.

Bibliography:

- J. Falnes (2002) *Ocean Waves and Oscillating Systems: Linear Interactions Including Wave-Energy Extraction*. Cambridge University Press.
- J. Cruz (2008) *Ocean Wave Energy: Current Status and Future Perspectives*. Springer.
- B. Multon (2011) *Marine Renewable Energy Handbook*. Wiley.
- J.J. Newman; *Marine Hydrodynamics*, MIT press, 1977.
- I.H. Abbott, A.E.VonDoenhoff, *Theory of wing section*, Courier Corporation, 1959.
- J.F. Manwell, J.G. MCGowan& A.L. Rogers (2009) *Wind energy explained – Theory, Design and Application*. Wiley.
- M. C. Brower (2012) *Wind resource assessment – A practical guide to developing a wind project*. Wiley.
- ‘Power Electronics’, 3rd Ed, C W Lander (McGraw-Hill), ISBN 0-07-084162-4
- ‘Principles of Electric Machines and Power Electronics’, P.C. Sen (Wiley), ISBN 0-471-61717-2
- ‘Electrical Machines, Drives and Power Systems’, T. Wildi (Prentice-Hall), ISBN 0-13-082460-7
- 'Power Electronics: Converters, Applications and Design', N Mohan et.al. (Wiley), 0-471-22693-9

Further comments: