FACULTY OF MECHANICAL AND POWER ENGINEERING

SUBJECT CARD

Name of subject in Polish: Energetyka wiatrowa
Name of subject in English: Wind Power Plants
Main field of study (if applicable): Power Engeenering
Specialization (if applicable): Renewable Sources of Energy
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: optional-specialization
Subject code: W09ENG-SM0045
Group of courses: No

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			15	
Number of hours of total student workload (CNPS)	60			30	
Form of crediting	crediting with grade			crediting with grade	
For group of courses mark final course with (X)					
Number of ECTS points	2			1	
including number of ECTS points for practical (P) classes				1	
including number of ECTS points for direct teacher-student contact (BK) classes	1			0.75	

*delete as applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basics of Fluid Mechanics

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SUBJECT OBJECTIVES

C1 – Familiarization of students with principles of operation and construction of wind turbines.
C2 – Introduction to wind and terrain characteristics and their influence of wind turbine design and operation.
C3 – Introduction to linear and angular momentum theory and actuation disc model.
C4 – Introduction to blade element theory and aerodynamics of wind turbine.
C5 – Developing skills to use blade element method to calculate trust force and power output of wind turbine.
C6 – Familiarization of students with economic and ecological aspects of wind turbines.
C7 – Providing basic knowledge about wind turbine farms and skills to select an optimal location for wind turbines.

SUBJECT LEARNING OUTCOMES

relating to knowledge:
PEU_W01 – knows and understands principles of wind turbine design, construction and operation,
PEU_W02 – knows and understands linear and angular momentum theory related to wind turbine,
PEU_W03 – knows and understands blade element theory and aerodynamics of wind turbine,

PEU_W04 – knows and understands blade element method to calculate trust force and power of wind turbine,
PEU_W05 – knows and understands how to select an optimal location for wind turbine and calculate annual energy production.

relating to skills:
PEU_U01 – is able to use principles of aerodynamics to design wind turbine,
PEU_U02 – is able to design wind turbine blade based on blade element method,
PEU_U03 – is able to use Qblade and ProPID software to calculate trust force, power of wind turbine and analyze aerodynamic properties of wind turbine,
PEU_U04 – is able to select an optimal location for wind turbine and to calculate annual energy production.

PROGRAM CONTENT

Lectures		**Number of hours**
Lec 1	Introduction to wind physics and mathematical description of main wind parameters related to wind power plants. Selection of a most optimal location for a wind turbine.	2
Lec 2	Linear momentum theory for wind turbines, actuation disc model, Betz limit and theoretical efficiency of wind turbine.	2
Lec 3	Angular momentum theory for wind turbine, introduction of tip speed ratio parameter and angular induction factor.	2
Lec 4	Aerodynamics of wind turbine and introduction to classical Blade Element Theory.	2
Lec 5	Introduction to Blade Element Method and computational algorithm.	2
Lec 6	Corrections of Blade Element Method and discussion of the corrected algorithm.	2
Lec 7	Introduction to Qblade and ProPID software for designing and calculation of wind turbines.	2
Lec 8	Control and regulation of wind turbine performance, passive and active control and regulation.	2
Lec 9	Non-standard control and regulation of wind turbine performance. Lecture based on own research.	2
Lec 10	Optimization of wind turbine: cost modeling and the NREL cost model.	2
Lec 11	Fixed speed and variable speed wind turbines.	2
Lec 12	Wind farms and mutual interaction of wind turbines.	2
Lec 13	More about wind turbine components: blades, rotor hub, gearbox, generator, mechanical brake, yaw drive, tower and foundations.	2
Lec 14	Offshore wind turbines and wind farms	2
Lec 15	Final test	2
	Total hours	30

Project		**Number of hours**
Proj 1	Discussion of the project goal and scope.	1
Proj 2	Introduction to Qblade and ProPID software used for wind turbine design. Preliminary assumptions of individual projects: rated power, rated wind velocity, rpm.	2

Proj 3	Design of wind turbine blade: determination of basic wind turbine parameters and selection of aerodynamic airfiols.	2
Proj 4	Wind turbine blade design: determination of the range of Reynolds numbers of the blade, calculation of an optimal twist angle of the blade.	2
Proj 5	Using Blade Element Method: calculation of the turbine power and aerodynamic forces, aerodynamic analysis of the designed blade.	2
Proj 6	Determination of an optimal location for the designed wind turbine, calculation of an annual production of the wind turbine based on the Weibull distribution.	2
Proj 7	Selection of other turbine components and basic stress and load analysis.	2
Proj 8	Optimization of the designed wind turbine based on simplified cost model and NERL cost model.	2
	Total hours	15

TEACHING TOOLS USED

N1. Lectures using multimedia presentation.
N2. Students own work - independent studies and preparation for final test.
N3. Qblade and ProPID software.
N4. Detailed list of things to do for the project with explanations.
N5. Partial presentations during each project class to show and discuss progress in the project.
N6. Individual consultations with the project tutor.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT – Lecture

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P	PEU_W01– PEU_W05	Final test

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT – Project

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P	PEU_U01 – PEU_U04	Grades for completed projects

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Ackermann T.: Wind Power in Power Systems, Wiley 2005
[2] Boczar T.: Wykorzystanie energii wiatru. PAK 2010
[3] Burton T.: Wind Energy Handbook, Wiley 2011
[4] Gasch R.: Twele J.: Windkraftanlagen. Grundlagen, Entwurf, Planung und Betrieb, Teubner 2009
[5] Heier S.: Grid Integration of Wind Energy Conversion Systems, Wiley 2006
[6] Hau E.: Windturbines: fundamentals, technologies, application, economics. Springer 2006

SECONDARY LITERATURE:

[1] Bianchi F., Battista H., Mantz R.: Wind Turbine Control Systems, Pronciples, Modelling and Gain Scheduling Design. Springer 2007
[2] Clark R.: A Modern Course in Aeroelasticity (Solid Mechanics and Its Applications), Springer 2004
[3] Gipe P.: Wind Power: Renewable Energy for Home, Farm, and Business. Chelsea Green Publishing Company 2004
[4] Lubośny Z. Farmy wiatrowe w systemie elektroenergetycznym. WNT 2009
[5] Nelson V.: Wind Energy, Renewable Energy and the Environment. CRC Press 2009
[6] Mathew Sathyajith: Wind Energy: Fundamentals, Resource Analysis and Economics. Springer 2006
[7] Wright J., Introduction to Aircraft Aeroelasticity and Loads, Wiley 2008.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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