

FACULTY OF ELECTRICAL  
ENGINEERING**SUBJECT CARD**

Name in Polish: **Integracja zasobów rozproszonych w systemach elektroenergetycznych**  
 Name in English: **Integration of Distributed Resources in Power Systems**  
 Main field of study (if applicable): **Electrical Engineering**  
 Specialization (if applicable): **Renewable Energy Systems**  
 Level and form of studies: **2nd level, full-time**  
 Kind of subject: **obligatory**  
 Subject code: **ELR042536**  
 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:	examination		crediting with grade		
For group of courses mark (X) final course:					
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:	1.40		0.70		

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Has a basic knowledge of electricity systems operation
2. Has basic knowledge concerning a three-phase and single-phase electric circuits analysis in phase coordinates A, B, C and symmetrical components 0, 1, 2

**SUBJECT OBJECTIVES**

- C1. Adoption of theoretical knowledge concerning an integration of distributed resources in power systems
- C2. Development and progress of practical ability to analysis and design and modeling of a power system under normal and abnormal states

**SUBJECT EDUCATIONAL EFFECTS***relating to knowledge:*

- PEK\_W01 Explains the standards in practice of wind farms electrical connection to the power system
- PEK\_W02 Has knowledge concerning the impact of distributed generation on a power system and on a smart grid operation

*relating to skills:*

- PEK\_U01 Is able to model and examine an electric power system with embedded generation
- PEK\_U02 Is able to model and make analysis of a power systems

*relating to social competences:*

- PEK\_K01 Is able to prepare complex the electric power calculations in a competent way

## PROGRAMME CONTENT

Form of classes - lecture		Number of hours:
Lec 1	Introduction. Structures of modern power system.	2
Lec 2	Definitions and classification of distributed energy resources (DER)	2
Lec 3	Technical requirements for wind generation	2
Lec 4	Diagrams of connection of dispersed generators into electric power system	2
Lec 5	Technical requisites for dispersed generators connection to the public electric power grids	2
Lec 6	Modeling of dispersed generators in power system analysis	2
Lec 7	Impact of dispersed generators on power load flow and voltage changes in electrical power network	2
Lec 8	Impact of dispersed generators on short-circuit currents in electrical power network	2
Lec 9	Dispersed generator contribution to voltage regulation in electrical power system	2
Lec 10	Dispersed generator contribution to frequency regulation in electrical power system	2
Lec 11	Impact of dispersed generators on relay protection of electrical power network	2
Lec 12	The effect of dispersed generators on power quality and reliability of electrical power network.	2
Lec 13	Autonomous generation of DER	2
Lec 14	Microgrids	2
Lec 15	Practical analysis of the impact of wind farms on transmission or distribution network	2
Total hours:		<b>30</b>

Form of classes - laboratory		Number of hours:
Lab 1	Regulations in the laboratory and conditions and regulations to pass	2
Lab 2	Static and short circuit models of DER	2
Lab 3	Modeling of distribution network with dispersed generation for computer simulation	2
Lab 4	Load flow simulation in distribution network with DER	2
Lab 5	Examination of the effect of dispersed generation on power load flow and voltage changes in distribution network	2
Lab 6	Short circuit simulation and analysis in distributed network with DER	2
Lab 7	Examination of effect of dispersed generation on power quality of distribution network	2
Lab 8	Reserve	1
Total hours:		<b>15</b>

## TEACHING TOOLS USED

- N1. Academic lecture using AV facilities and multimedia presentations  
 N2. Matlab program  
 N3. Reports from assignments

## EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation <i>F – forming (during semester) P – concluding (at semester end)</i>	Educational effect number	Way of evaluating educational effect achievement
F1(W)	PEK_W01 PEK_W02	Exam
P(W)	P=F1	
F1(L)	PEK_U01 PEK_U02	Activity during labs
F2(L)	PEK_U01 PEK_U02	Assessment of individual lab project
P(L)	P = 0.3F1 + 0.7F2	

## PRIMARY AND SECONDARY LITERATURE

### PRIMARY LITERATURE:

- [1] Robert Lis, Marian Sobierajski: Integration of distributed resources in power systems, Wydawnictwo Politechniki Wrocławskiej, Wrocław 2011.  
 [2] Piotr Kacejko.: Generacja rozproszona w systemie elektroenergetycznym. Wydawnictwo Politechniki Lubelskiej, Lublin 2004.  
 [3] Jenkins N., Allan R., Crossley P., Kirschen D., Strbac G.: Embedded Generation. Power & Energy 2000.

### SECONDARY LITERATURE:

- [1] Sobierajski M., Łabuzek M., Lis R., Electrical Power System Analysis In Matlab, Oficyna Wydawnicza Politechniki Wrocławskiej, 2006.  
 [2] Bergen A. R., Power Systems Analysis, Prentice-Hall, 2000.  
 [3] IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.  
 [4] Selected articles published in refereed or reputable academic journals.

**SUBJECT SUPERVISOR**

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**MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT  
ELR042536 - Integration of Distributed Resources in Power Systems  
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **Electrical Engineering**  
AND SPECIALIZATION **Renewable Energy Systems****

<b>Subject educational effect</b>	<b>Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)</b>	<b>Subject objectives</b>	<b>Programme content</b>	<b>Teaching tool number</b>
PEK_W01	S2RES_W06	C.1	Lec1 Lec2 Lec3 Lec4 Lec5 Lec13 Lec14 Lec15	N.1
PEK_W02	S2RES_W06	C.1 C.2	Lec6 Lec7 Lec8 Lec9 Lec10 Lec11 Lec12	N.1 N.2
PEK_U01	S2RES_U06	C.2	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7	N.2 N.3
PEK_U02	S2RES_U06	C.1 C.2	Lab2 Lab3 Lab4 Lab5 Lab6 Lab7	N.3
PEK_K01	K2ETK_K06	C.1 C.2	Lec1 Lab1 Lab2 Lab7	N.1 N.2