Subject (course) name: **Photovoltaic systems**		
Programme: **Electrical Engineering** Specialty:		Subject code: **02S_EMEO1NS_OZE**
		Title graduate: **Engineer**
Type of course: **optional**	Course level: **First-cycle studies**	Year: **III** Semester: **V** Semester: **autumn**
Form of classes: **Lectures, Classes, Labs, Seminar, Project**	Number of hours per week: **2L, 0C, 1Lab, S, 1P**	Credit points: **4 ECTS**

GUIDE TO SUBJECT

SUBJECT OBJECTIVES

C1. Providing students with knowledge of the types, construction and operation of photovoltaic systems
C2. Familiarizing students with the possibilities of using photovoltaic systems
C3. Familiarizing students with software for designing photovoltaic systems

SUBJECT REQUIREMENTS

1. Knowledge of basic laws and concepts in the field of electrical engineering, mathematics and physics.

2. Ability to formulate conclusions based on the completed project.

3. Ability to operate a computer and use literature and Internet resources.

LERNING OUTCOMES

EK 1 - The student distinguishes the basic photovoltaic systems.
EK 2 - The student is able to describe the photovoltaic system, its operation and components.
EK 3 - The student is able to use software for designing photovoltaic systems.

SUBJECT CONTENT
Form of classes - lectures

Topic	Hours
W 1 – Properties of solar radiation	2
W 2 – Basic information about systems using solar energy	2
W 3 – Basic information about photovoltaics	2
W 4.5 - Photovoltaic systems (concepts, application possibilities, types).	4
W 6,7,8 - Elements of the photovoltaic system (modules, batteries, inverters, controllers, etc.).	6
W 9 – Energy production in the PV system.	2
W 10,11 - Hybrid Systems.	4
W 12 – Distributed energy production systems	2
W 13 – Building-integrated photovoltaic systems (BIPV)	2
W 14 – Solar heating systems	2
Final test	**2**
Total	**30**

Form of classes - lectures

Topic	Hours
L 1 – Modeling the distribution of the solar radiation spectrum	2
L 2 – Modeling of basic characteristics of PV cells	2
L 3 - Basics of MATLAB	2
L 4 – Elements of the PV system (basic parameters and modeling)	2
L 5 - Analysis of data from an example PV station	2
L 6 – Model of an example PV system (standalone system)	2
L 7 – Model of an example PV system (grid-connected system)	2

L 8 – Passing and making up missed exercises	1
Total	**15**

Form of classes – Seminar

Topic	Hours
P 1 – Introduction to programs supporting the design of PV systems	5
P 2 – Designing an example PV system (standalone system)	5
P 3 – Designing a sample PV system (grid-connected system)	5
Total	**15**

EDUCATIONAL TOOLS

1. Lecture with multimedia presentation
2. Classic or interactive whiteboard
3. MATLAB-Simulink and PVSyst software
4. Computer lab

METHODS OF ASSESMENT (F – Forming, P – Summary)

F1. Project - assessment of the correct and timely preparation of individual stages of the project
F2. Evaluation of laboratory exercises and reports
P1. Final test

STUDENT WORKLOAD

Form of activity		Averaged workload (hours)		
		[h]	$\sum$ [h]	ECTS
Participation in class activities	lecture	30		
	laboratory	15	60	2
	project	15		
Preparation (reading literature)		15		
Preparation for test from lectures		15	40	2
Preparation of reports		10		
Total			**100**	**4**

A. BASIC READING

[1] Handbook of Photovoltaic Science and Engineering, Editors: A. Luque and S. Hegedus, Jon Wiley & Sons 2003.
[2] Photovoltaic Systems Engineering, Editors: R. Messenger and J. Ventre, CRC Press, 2000.
[3] Luis Castaner; Santiago Silvestre: Modelling Photovoltaic Systems Using PSpice, ISBN-13: 9780470845271, 2002.
[4] Yaman Abou Jieb, Eklas Hossain: Photovoltaic Systems: Fundamentals and Applications, Springer 2021.
[5] James P. Dunlop: Photovoltaic Systems, ISBN-13: 978-0826913081, 2009.

B. FURTHER READING

[6] Photovoltaic Systems, Larsen and Keller Education, 2022.
[7] Deploying Renewables 2011, International Energy Agency.
[8] Papadopoulou Elena: Photovoltaic Industrial Systems: An Environmental Approach. Springer, 2011.

Learning objectives	In relation to the learning outcomes specified for the field of study	Subject objectives	Study methods	Methods of assessment
EK1	KEMEO1_W13, KEMEO1_W14 KEMEO1_U01	C1,C2,C3	lecture laboratory project	F1, F2, P1
EK2	KEMEO1_W13, KEMEO1_W14 KEMEO1_U01	C1,C2,C3	lecture laboratory project	F1, F2, P1
EK3	KEMEO1_W13,	C1,C2,C3	project	F1

	KEMEO1_W14 KEMEO1_U01, KEMEO1_U04 KEMEO1_U12			

II. EVALUATION

Grade	Outcome
EK1	The student distinguishes the basic photovoltaic systems
2 (F)	The student does not distinguish the basic photovoltaic systems, nor can he name an example
3 (E)	The student does not distinguish between the basic photovoltaic systems, but is able to list examples
4 (C)	The student distinguishes the basic photovoltaic systems and is able to give examples
5 (A)	The student distinguishes the basic photovoltaic systems, is able to give examples and describe the differences between individual systems
EK2	The student is able to describe the photovoltaic system, its operation and components
2 (F)	The student is unable to describe the photovoltaic system, its operation and components
3 (E)	The student is able to describe the photovoltaic system, but not its operation and components
4 (C)	The student is able to describe the photovoltaic system, its operation and components
5 (A)	The student is able to describe the photovoltaic system, its operation and components and explain the relationships between them
EK3	The student is able to use software for designing photovoltaic systems
2 (F)	The student is not able to use software for designing photovoltaic systems
3 (E)	The student is able to use software for designing photovoltaic systems, but errors occur
4 (C)	The student is able to use software for designing photovoltaic systems
5 (A)	The student is able to use software for designing photovoltaic systems and briefly explain their principle of operation

III. OTHER USEFUL INFORMATION

1. All information for students on the schedule are available on the notice board and on the website: https://we.pcz.pl/
2. Information on the consultation shall be provided to students during the first lecture and will be placed on the website https://we.pcz.pl/
3. Terms and conditions of credit courses will be provided to students during the first lecture