COURSE DESCRIPTION CARD - SYLLABUS

Course name
Renewable Sources and Energy Storage [S2AiR2-SIiB>PO1-ŹOME]

Course

Field of study
Automatic Control and Robotics

Year/Semester
1/2

Area of study (specialization)
Intelligent and Unmanned Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
15

Number of credit points

3,00

Coordinators

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Lecturers

Prerequisites

A student starting this subject should have basic knowledge of mathematics, technical statistics, physics, circuit theory and numerical methods. Should have the ability to work in a group and obtain information from indicated sources, including catalog cards. A student should be aware of the dynamic changes in modern technology and the significant importance of ecological issues.

Course objective

To familiarize students with the structure, principles of operation and modeling methods of renewable energy sources (mainly photovoltaic and wind) and energy storage systems. Acquiring practical skills in designing effective RES generation systems, including hybrid ones containing energy storage. Developing teamwork skills in students during laboratories and design classes.

Course-related learning outcomes

Knowledge:

1. Has knowledge of the construction, principles of operation and modeling of photovoltaic and wind sources and selected types of energy storage facilities. (K2_W5, K2_W12)
2. Has knowledge of the design of hybrid generation systems using renewable sources and energy storage. (K2_W5, K2_W12)

Skills:
1. Is able to apply an appropriate mathematical description to the analysis of RES and energy storage systems. (K2_U1)
2. Is able to design highly efficient RES generation systems, taking into account their location. geographical location and the nature of the receiver using software designed to analyze wind and solar energy resources or your own applications. (K2_U2, K2_U18)

Social competences:
1. Is aware of the growing energy problem in the world. (K2_K4)
2. understands non-technical aspects, including economic and ecological ones, of the use of renewable sources and energy storage. (K2_K4)

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The knowledge acquired during the lecture is verified during a written exam. The exam consists of 5-8 open questions scored depending on the level of difficulty. Exam issues are sent to the group head by e-mail using the university e-mail system 2-3 weeks before the exam date.
The skills acquired during laboratory classes are verified on the basis of ongoing progress monitoring and evaluation of the prepared reports.
The skills acquired during project classes are verified on the basis of ongoing monitoring of progress, activity during classes and the implementation of the final project carried out in subgroups.
The following grading scale is used for all forms of classes: <0;50%) possible points - insufficient (2.0), <50;60%) - satisfactory (3.0), <60;70%) - satisfactory plus (3.5) , <70;80%) - good (4.0), <80;90%) - good plus (4.5), <90;100%> - very good (5.0).

Programme content

Characteristics and use of renewable energy sources (RES), energy storage and hybrid power systems with RES.

Course topics

Lecture: Definition and general characteristics of renewable sources, legal aspects of the use of RES. Wind and solar energy, measurements of wind speed and irradiance, statistical description of wind energy - Weibull distribution, vertical profile of wind speed, use of data from IMWM, time series and their properties. Photovoltaics: characteristics of components, parameters and operating conditions, review of design solutions, substitute models of PV cells and their numerical implementation, on-grid and off-grid system configurations, energy storage in the PV system. Wind energy: construction and principle of operation of selected types of wind turbines, operating parameters, methods and methods of power regulation, a simple model of a wind turbine - interpolation of the power curve. Hybrid systems with RES: definition and types, advantages and disadvantages, examples, simplified models of hybrid systems. Estimation of energy yields from RES for wind, solar and hybrid sources, characteristics of prosumer installations with renewable sources and energy storage. Classification of electricity storage. Parameters characterizing electricity storage (power and energy density, SOC, SOP, standby time, durability, etc.). Characteristics and application of electrochemical storages, operation of energy storages in packages, BMS (active and passive balancers, etc.). Characteristics of mechanical warehouses (rotating masses, compressed air systems). Chemical warehouses - fuel cells and the use of hydrogen. Thermoelectric warehouses - principle of operation, application, cooperation with solar thermal power plants.

Project: Development of a design for a hybrid on-grid generation system using PV modules, wind turbines and energy storage.

Laboratories: To familiarize students with the structure, principle of operation and characteristics of

selected types of photovoltaic modules, wind turbines, electrochemical storage facilities and fuel cells. Planning measurement methodology, measurements and calculations of characteristic parameters of the above-mentioned devices.

Teaching methods

Lecture: multimedia presentation (including drawings, photos, animations, videos) supplemented with examples given on the board. Taking into account various aspects of the presented issues, including: economic, ecological, legal and social. Presenting a new topic preceded by a reminder of related content known to students from other subjects.

Project: working in teams, using catalog data and tools enabling students to perform tasks at home (e.g. open source software), developing project documentation.

Laboratory: team work (measurements) at physical stations modeling the operation of renewable energy sources in the area of photovoltaics, wind energy and hydrogen cells in cooperation with e.g. energy storage facilities and charging controllers.

Bibliography

Basic:
Jastrzębska G., Ogniwa słoneczne. Budowa, technologia i zastosowanie, Wydawnictwa Komunikacji i Łączności, Warszawa, 2013.
2. Wolańczyk F., Elektrownie wiatrowe, Wydawnictwo KaBe, Krosno, 2009.
3. Andrzej Czerwiński, Akumulatory, baterie, ogniwa. Wydawnictwa Komunikacji i Łączności, Warszawa, 2012.

Additional:
1. Burzyński D., Pietracho R., Kasprzyk L., Tomczewski A., Analysis and Modeling of the Wear-Out Process of a Lithium-Nickel-Manganese-Cobalt Cell during Cycling Operation under Constant Load Conditions, Energies 2019, 12(20), 3899; https://doi.org/10.3390/en12203899
2. Głuchy D., Kurz D., Trzmiel G., The impact of shading on the exploitation of photovoltaic installations,Renewable Energy, vol. 153, p. 480-498, June 2020, DOI: https://doi.org/10.1016/j.renene.2020.02.010.
3. Trzmiel G., Analiza metod regulacji mocy w elektrowniach wiatrowych, Computer applications inelectrical engineering vol. 89/2017, Poznan University of Technology Academic Journals Electrical Engineering, Poznań, 2017, str. 395-404

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00