POZNAN UNIVERSITY OF TECHNOLOGY
EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)
pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Elective course B: Energy storage and hybrid systems

Course

Field of study
Power engineering

Year/Semester
3/6

Area of study (specialization)

Profile of study
general academic

Level of study
First-cycle studies

Course offered in
polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
15

Other (e.g. online)
0

Tutorials
0

Projects/seminars
15

Number of credit points

3

Lecturers

Responsible for the course/lecturer:
D.Sc Ph.D. Andrzej Tomczewski

email: andrzej.tomczewski@put.poznan.pl

tel. 61 665 23 89

Instytut Elektrotechniki i Elektroniki Przemysłowej

ul. Piotrowo 3A 60-965 Poznań

Responsible for the course/lecturer:
D.Sc. Leszek Kasprzyk

email: Leszek.Kasprzyk@put.poznan.pl

tel. 61 665 23 89

Instytut Elektrotechniki i Elektroniki Przemysłowej

ul. Piotrowo 3A 60-965 Poznań

Prerequisites

Basic knowledge in the field of electrical engineering, electric machines and the form and method of energy management. Ability to interpret transmitted messages and effective education in the field of relationships with energy storage and hybrid modules, as well as teamwork.

Course objective

Providing students with trade union knowledge regarding the construction, application and modeling of energy storage systems. Taken into account the skills to solve engineering problems require the selection of types and parameters of energy storage in issues related to the direction of energy.

Course-related learning outcomes

Knowledge

Has ordered knowledge of energy storage technology and types and principles of operation of various storage groups. Has knowledge of modeling techniques for selected electricity storage. Has knowledge of hybrid generational systems, including updated sources.

Skills

Is able to classify and analyze the work of energy storage and selected hybrid systems. Is able to select the type and parameters of energy balance data to the indicated engineering problem with a summary of the end of the field of study. Can be covered by basic electrochemical and kinetic energy storage studies.

Social competences

Is aware of the growing energy problem in the world.Understand various aspects and effects of electrical engineer activities, including environmental impact.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Knowledge acquired as part of the lecture is verified during the written test, which takes place during the last lecture. The exam consists of open-ended points depending on the level of difficulty. Passing threshold: 50% of points. Final issues are sent by e-mail to the group staroste using the university e-mail system 2-3 weeks before the date of passing.

Completion of project classes is based on ongoing control of progress, class participation and implementation of the final project.

Completion of laboratory exercises is based on the assessment of theoretical and practical knowledge necessary to complete the task being carried out, verified on an ongoing basis during classes with students and on the basis of written reports on the task.

Programme content

Lecture:

History and introduction to electricity storage. Classification of electricity storage. Parameters characterizing electricity storage (power, energy density, SOC, SOP, standby time, etc.). Operating principles of electrochemical batteries. Selection and analysis of the work of selected energy storage (modeling of lead-acid, lithium-ion batteries, supercapacitors). Analysis of the profitability of using energy storage. Methods and modeling of electrochemical (PbO_2, Li-Ion) and electrical energy storage (supercapacitors). Durability of electrochemical electricity storage. Work of energy storage in packages, BMS (active and passive balancers, etc.). Overview of UPS solutions. The use and tasks of energy storage in the power system, including the significant share of turbulent sources. Characteristics of mechanical warehouses (rotating masses, compressed air systems, pumped storage power plants). Chemical storage - fuel cells and the use of hydrogen. Thermoelectric warehouses - operating principle, application, cooperation with solar thermal power plants. Hybrid systems - definition, properties, types, generational hybrid systems from renewable energy sources. Integrating energy storage into hybrid systems. Characteristics of the work of example hybrid systems: solar-wind, photovoltaic with energy storage, wind with kinetic storage. Technical and economic analysis of hybrid solutions.

Projects:

Design classes deal with the following issues:

- modling of batteries and supercapacitors,

- electrochemical impedance spectroscopy,

- the selection and design of installations containing energy storage,

- kinetic and thermal modeling of energy storage,

- simulation of hybrid wind turbine

- kinetic energy storage system operation.

Laboratory:

1. Investigation of the process of charging and discharging lead-acid batteries (charging and discharging characteristics, determination of capacity, internal resistance, power and energy density).

2. Tests of the charging and discharging process (charging and discharging characteristics, determination of capacity, internal resistance, power and energy density)

3. Analysis of the work of the lithium-ion battery pack (voltage balancers, thermal tests, including thermovision ones)

4. Identification of lithium-ion battery model parameters

5. Identification of parameters of the supercapacitors model. Cooperation of lithium-ion battery with supercapacitor

6. Kinetic magazine. Hybrid system - PV with energy storage

Teaching methods

Lecture: multimedia presentation, illustrated with examples given on the board, initiating discussions during the lecture. Additional materials placed in the Moodle system.

Project: teamwork, computational experiments, use of tools enabling students to perform tasks at home (e.g. open source software)

Laboratory: detailed review of reports by the laboratory leader and discussions on comments, demonstrations, teamwork.

Bibliography

Basic

1. Leszek Kasprzyk, Wybrane zagadnienia modelowania ogniw elektrochemicznych i superkondensatorów w pojazdach elektrycznych, Poznan University of Technology Academic Journals. Electrical Engineering - 2019, Issue 101, s. 3-55.

2. Jastrzębska G.: Odnawialne źródła energii i pojazdy proekologiczne, WNT, Warszawa 2009.

3. Fuchs G., Lunz B., Leuthold M., Sauer D. U.: Technology Overview on Electricity Storage, RWTH Aachen, 2012.

Additional

1. Akumulatory elektryczne - Terminologia PN-88/E-01004 Polski Komitet Normalizacji Miar i Jakości.

2. Andrzej Czerwiński, Akumulatory, baterie, ogniwa. Wydawnictwa Komunikacji i Łączności, Warszawa, 2012.

3. Hariharan Krishnan S., Piyush Tagade, Sanoop Ramachandran. Mathematical Modeling of Lithium Batteries: From Electrochemical Models to State Estimator Algorithms. Springer, 2017

4. Akumulatory do napędu pojazdów elektrycznych drogowych - Część 3: Badania dotyczące działania i trwałości (kompatybilne w ruchu kołowym pojazdy do ruchu miejskiego) PN-EN 61982-3 / Polski Komitet Normalizacyjny

Breakdown of average student's workload

	Hours	ECTS
Total workload	80	3,0
Classes requiring direct contact with the teacher	68	2,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests, project preparation) [1]	12	1,0

[1] delete or add other activities as appropriate