# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Energy storage in the power system [N2Elenerg1-ŹOiME>ME]

## Course

Field of study
Electrical Power Engineering

Year/Semester
2/4

Area of study (specialization)
Renewable Sources and Storage of Energy

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
part-time

Requirements
compulsory

## Number of hours

Lecture
10

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
10

## Number of credit points

2,00

## Coordinators

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## Lecturers

## Prerequisites

A student starting this subject should have basic knowledge of electrical power engineering. He should know the basic principles of the functioning of the electricity market in Poland and in the European Union. Additionally, he should have knowledge of the basics of electrical engineering and electronics at the level of first-cycle studies.

## Course objective

Familiarization with the principles of cooperation between energy storage and power system in term of legal and engineering. Understanding the impact of installing energy in the power system. Getting to know presentes in the classes methods of modeling energy storage, the power system and its components.

## Course-related learning outcomes

Knowledge:
1. student has a extended knowledge about the processing and transformation of electricity.
2. understands the importance and impact of energy storage technology on the problem of energy reliability in local and global terms.
3. learns the principle of cooperation between energy storage facilities in accordance with the polish

law and the principles of operation of the energy market

Skills:
1. he is able to evaluate and compare various solutions in the field of energy storage.
2. he is able to create ana analytical model of energy storage installation, analyze the cooperation of this installation with the power system and optimize its parameters.

Social competences:
1. he understands the importance of the power industry for the country and society.
2. he understands the need to develop new technologies in order to ensure energy supplies in line with the environmental protection requirements.

## 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 during the examination session. The exam consists of open questions scored depending on the level of difficulty. The passing threshold is 50% of all possible points. Exam topics are presented to students a few weeks before the exam and discussed during the last lecture.
The skills acquired during design classes are verified on the basis of a task to be completed independently during classes. The topic of the final task is a variation of the issues discussed during design classes.

## Programme content

Overview of current trends and technical problems in incorporating energy storage systems into the power system. Energy storage in the Energy Law in Poland and other EU countries. Description of the use strategies and related control algorithms of energy storage facilities cooperating with the power grid. Possibilities of using energy storage in prosumer installations to actively participate in the purchase and sale of energy. Modern energy storage technologies Power2Gas, Vehicle2Grid and their impact on the operation of the power system. Economic analysis of the use of energy storage in the power system. Using matlab and simulnik software for modelling energy storage and power systems.

## Course topics

The following topics are discussed during the lecture:
1) legal acts regarding the energy market in the Polish National Power System
2) electricity storage technologies: division and features important in the context of cooperation with the power system
3) benefits and applications for energy storage in the power system
4) the process of selecting energy storage units for specific applications
5) optimization methods used to determine the parameters of the energy storage installation
6) Power2Gas and Vehicle2Grid

The following issues are discussed during the laboratories:
1) introduction to matlab and simulink environment
2) creating dynamic models of energy storage
3) controlling the energy flow between the energy storage and the power system
4) qualitative assessment of the obtained results

## Teaching methods

Lecture: multimedia presentation supplemented with simulation and computational examples. Taking into account various aspects of the presented issues, including economic, ecological, legal and social. Encouraging students to participate in substantive discussions regarding aspects technical, social and environmental application of the solutions presented during classes. Additional materials, such as links to necessary literature, transcripts of lectures available on the university e-learning platform.
Project: multimedia presentations introducing the topics of individual classes. Design tasks performed together with the teacher during classes. Supporting materials available on the university e-learning platform. Tasks to be completed alone during classes.

## Bibliography

Basic
1. Instrukcja Pracy Systemów Połączonych UCTE: Część 1. Regulacja mocy i częstotliwości, 2004.
2. Komisja Europejska,: Energy storage - the role of electricity, February, 2017
3. Kim, H.T., Jin, Y.G., Yoon, Y.T., An Economic Analysis of Load Leveling with Battery Energy Storage Systems (BESS) in an Electricity Market Environment: The Korean Case. Energies 12, 2019. https://doi.org/10.3390/en12091608
4. Paska, J., Zasobniki energii elektrycznej w systemie elektroenergetycznym - zastosowania i rozwiązania. Przeglad Elektrotechniczny 2012, pp. 50-56
5. Swain, A., Salkuti, S.R., Swain, K., An Optimized and Decentralized Energy Provision System for Smart Cities. Energies 14, 2021. https://doi.org/10.3390/en14051451
6. Ustawa z dnia 10 kwietnia 1997 r. Prawo energetyczne tj. (Dz. U. z 2020 r. poz. 833, 843,471, 1086, 1378 i 1565, z 2021 r. poz. 234 i 255), 1997.
Additional
1. Bednarek, K., Kasprzyk, L., Hłasko, E., Modele funkcjonowania zasobników energii stosowanych w układach mobilnych. Electrical Engineering 277–289, 2016
2. Tomczewski, A., Kasprzyk, L., Optimisation of the Structure of a Wind Farm—Kinetic Energy Storage for Improving the Reliability of Electricity Supplies. Applied Sciences 8, 2018. https://doi.org/10.3390/app8091439
3. Yan, Z., Zhang, X.-P., General Energy Filters for Power Smoothing, Tracking and Processing Using Energy Storage. IEEE Access 5, 2017. https://doi.org/10.1109/ACCESS.2017.2737547

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 50 | 2,00 |
| Classes requiring direct contact with the teacher | 20 | 1,00 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 30 | 1,00 |