



## COURSE DESCRIPTION CARD - SYLLABUS

Course name

Electromobility and energy storage [N1Eltech1>E-EiME]

### Course

Field of study

Electrical Engineering

Year/Semester

5/9

Area of study (specialization)

–

Profile of study

general academic

Level of study

first-cycle

Course offered in

Polish

Form of study

part-time

Requirements

elective

### Number of hours

Lecture

20

Laboratory classes

10

Other

0

Tutorials

0

Projects/seminars

10

### Number of credit points

4,00

### Coordinators

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### Lecturers

### Prerequisites

Basic knowledge of electrical engineering, electrical machines, and forms and methods of energy conversion. Ability to interpret transmitted messages and effective education in the field related to energy storage and hybrid systems as well as teamwork.

### Course objective

To familiarize students with the current state and directions of electromobility development in Poland and in the world. Presentation of the classification and general characteristics of electric energy storage facilities and presentation of selected methods of testing and fastening them.

### Course-related learning outcomes

Knowledge:

Structured knowledge in the field of electromobility.  
hybrid vehicles.

Skills:

Able to classify and analyze the operation of the propulsion system and energy storage in electric and

hybrid vehicles.

Able to research, analyze and model the work of selected electricity storage facilities used in mobile systems.

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 during the lecture is verified during the crediting, which takes place during the last lecture in the form of a test in the eKursy system.

Crediting threshold: 50% of points. Crediting problems are sent to the group's head electronically 2 weeks before the crediting date.

Crediting of project classes is based on ongoing progress monitoring, activity during classes and implementation of the final project.

Crediting of laboratory exercises is based on an assessment of theoretical and practical knowledge necessary to perform the task being performed, verified on an ongoing basis during classes with students and on the basis of written reports on the completed task.

### Programme content

Electromobility in Poland and the world.

Construction, principle of operation, classification and operating parameters of electrochemical energy storage devices.

Determination of energy consumption of vehicles and issues of selecting an energy storage device for electric vehicles.

### Course topics

The lecture:

History of vehicles, current statistics on transport and motorization worldwide. Worldwide electromobility including Poland. Methods of improving efficiency of motor vehicles. Technical parameters of electric and hybrid vehicles. Determining the power and energy requirements of a conventional vehicle. Selection and analysis of energy storage operation in a vehicle. Energy storage charging systems in electric and plug-in hybrid vehicles.

Introduction to electrical storage. Classification of energy storage facilities. Parameters characterizing electrical storages (power density, energy, SOC, SOP, SOH, ready time).

Principles of operation of electrochemical batteries. Selection and analysis of operation of selected energy storages (modelling of lead-acid, lithium-ion and supercapacitors).

Operation of energy storage in packages, BMS (active and passive balancers, etc.).

The usage and tasks of energy storage facilities in the power system, including those with a significant share of unstable sources. Characteristics of mechanical storages (fly wheel, compressed air systems, pumped-storage power plants). Chemical storages (fuel cells and hydrogen).

The project:

Basics of energy storage modeling. Peukert effect. Energy consumption of vehicles. Coasting test. Selection of the drive system for the vehicle. Functional safety. Cybersecurity

The lab:

1. Tests of the charging and discharging process of lead-acid batteries (charging and discharging characteristics, determination of capacity, internal resistance, power density and energy).
2. Tests of the charging and discharging process of li-ion batteries (charging and discharging characteristics, determination of capacity, internal resistance, power density and energy)
3. Analysis of the operation of the lithium-ion battery pack (voltage balancers, thermal tests, including thermovision)

4. Identification of parameters of the lithium-ion battery model
5. Identification of parameters of the supercapacitors model
6. Kinetic storage - demonstration exercise; Lithium-ion battery with supercapacitor

## Teaching methods

Lectures: Multimedia presentation, illustrated with examples on the board, initiating discussions during the lecture. Additional materials are placed in the Moodle system.

Laboratory exercises: multimedia presentation illustrated with examples given on a blackboard, demonstrations and implementation of tasks given by the teacher - practical exercises

Projects: Didactic classes in the auditorium (calculations in books and on the board supported by the application in the Matlab or Excell environment).

## Bibliography

Podstawowa

1. Andrzej Czerwiński, Akumulatory, baterie, ogniwa. Wydawnictwa Komunikacji i Łączności, Warszawa, 2012.
2. Hariharan Krishnan S., Piyush Tagade, Sanoop Ramachandran. Mathematical Modeling of Lithium Batteries: From Electrochemical Models to State Estimator Algorithms. Springer, 2017
3. Herner A., Riehl H. J.: Elektrotechnika i elektronika w pojazdach samochodowych, WKiŁ, Warszawa 2003.
4. Jastrzębska G.: Odnawialne źródła energii i pojazdy proekologiczne, WNT, Warszawa 2009.

Uzupełniająca

1. Akumulatory elektryczne - Terminologia PN-88/E-01004 Polski Komitet Normalizacji Miar i Jakości.
2. 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
5. Denton T.: Automobile electrical and electronic systems, Arnold, London 2000.
6. Larminie J., Lowry J.: Electric vehicle technology. Explained, Wiley, West Sussex 2003

## Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	55	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	45	2,00