

## Subject card

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February 2023		Academic year of			2023/2024					
second-cycle studies		Subject group								
Full-time studies		, , ,			at the university					
1		•			Polish					
2					3.0					
general academic profile		Assessment form			assessment					
Katedra Inżynierii Materiałów Funkcjonalnych WETI -> Faculty of Electronics, Telecommunications and Informatics										
Subject supervisor	prof. dr hab. inż. Piotr Jasiński									
Teachers	dr inż. Iga Szpunar									
		prof. dr hab. inż. Piotr Jasiński								
		dr hab. inż. Sebastian Molin								
Lesson type	Lecture	Tutorial	Laboratory	Projec	:t	Seminar	SUM			
Number of study hours	30.0	0.0	0.0	15.0		0.0	45			
E-learning hours inclu	uded: 0.0				i		i			
Learning activity						udy	SUM			
Number of study hours	45		5.0		30.0		80			
The objective of the course "Energy Storage Methods" is to provide students with a thorough understanding of various energy storage technologies and their applications in practical scenarios. Students learn the basic principles of energy storage, such as electrochemical, thermal, and mechanical storage methods, and how these methods impact the efficiency and stability of energy systems. The course also aims to understand the challenges associated with integrating energy storage into sustainable and decentralized energy systems.										
Course out	come	Subject outcome Method of verification								
mathematical and numerical relat methods to analyze and design elements, systems and power fund			related to the exploitation of energy resources and use fundamental concepts from the			[SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject				
environmental effects technologies used; is the issues of effective management and use renewable energy so broad and well-estable knowledge of the pro	s of energy s familiar with e energy e of ources, has a olished ocesses of	energy conversion technologies, their implementation, on the economic and environmental		[SW3] Assessment of knowledge contained in written work and						
1. Introduction to Energy Storage 2. Energy in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Lead-Acid, Flow Batteries) 4. Modern Electrochemical Batteries (Lithium-Ion, Flow Batteries) 5. Energy Storage in Electric Vehicles 6. Generation and Storage of Hydrogen Energy 7. Hydrogen Storage: Hydrides, Compressed, Liquid 8. Supercapacitors 9. Chemical Energy Storage: Methanol, Ammonia, Biofuels 10. Thermal Energy Storage (PCM, Water Systems, Rocks) 11. Mechanical Energy Storage - Compressed Air (CAES), Flywheels, Gravitational Energy Storage 12. Hydraulic Energy Storage Systems (PHES) 13. Nuclear Energy - Nuclear Fuel 14. Energy Storage in Energy Grids 15. Case Studies - Analysis of Cases										
	February 2023  second-cycle studies  Full-time studies  1  2  general academic pro Katedra Inżynierii Ma Informatics  Subject supervisor  Teachers  Lesson type  Number of study hours  E-learning hours inclu Learning activity  Number of study hours  The objective of the co of various energy sto principles of energy sto p	second-cycle studies  Full-time studies  1  2  general academic profile  Katedra Inżynierii Materiałów Funkci Informatics  Subject supervisor  Teachers  Lesson type Lecture  Number of study hours  E-learning hours included: 0.0  Learning activity Participation in classes includiplan  Number of study hours  The objective of the course "Energy of various energy storage, such as these methods impact the efficiency challenges associated with integratiin  Course outcome  [K7_U02] is able to use known mathematical and numerical methods to analyze and design elements, systems and power transmission networks and internal installations  [K7_W07] knows the environmental effects of energy technologies used; is familiar with the issues of effective energy menagement and use of renewable energy sources, has a broad and well-established knowledge of the processes of energy production and use  1. Introduction to Energy Storage 2. Energy in Traditional Carriers: 63 3. Basic Electrochemical Batteries 4. Modern Electrochemical Batteries 5. Energy Storage in Electric Vehies 6. Generation and Storage of Hyd 7. Hydrogen Storage: Hydrides, C 8. Supercapacitors 9. Chemical Energy Storage: Meth 10. Thermal Energy Storage (PCM, 11. Mechanical Energy Storage (PCM, 11. Energy Storage in Energy Grids  13. Nuclear Energy - Nuclear Fuel 14. Energy Storage in Energy Grids	February 2023  Academic y realisation  second-cycle studies  Full-time studies  Mode of de  Language of the Language of general academic profile  Rasessmer  Katedra Inżynierii Materiałów Funkcjonalnych WET Informatics  Subject supervisor  Teachers  Lesson type  Lecture  Lecture  Tutorial  Number of study hours  E-learning hours included: 0.0  Learning activity  Participation in didactic classes included in study plan  Number of study hours  The objective of the course "Energy Storage Method various energy storage, such as electrochemic these methods impact the efficiency and stability of challenges associated with integrating energy storate mathematical and numerical methods to analyze and design elements, systems and power transmission networks and internal installations  [K7_U02] is able to use known mathematical and numerical methods to analyze and design elements, systems and power transmission networks and internal installations  [K7_W07] knows the environmental effects of energy technologies used; is familiar with the issues of effective energy management and use of renewable energy sources, has a broad and well-established knowledge of the processes of energy production and use  1. Introduction to Energy Storage 2. Energy in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Lead-Acid, Floth Storage) in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Lead-Acid, Floth Storage) in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Cead-Acid, Floth Storage) in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Cead-Acid, Floth Storage) in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Cead-Acid, Floth Storage) in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Cead-Acid, Floth Storage) in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Cead-Acid, Floth Storage) in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Cead-Ac	second-cycle studies  Subject group  Full-time studies  Mode of delivery  Language of instruction  ECTS credits  general academic profile  Katedra Inżynierii Materiałów Funkcjonalnych WETI -> Faculty of Informatics  Subject supervisor  Teachers  Prof. dr hab. inż. Piotr Jasińs dr hab. inż. Piotr Jasińs dr hab. inż. Sebastian Molin  Lesson type  Lecture  Tutorial  Laboratory  Number of study hours  E-learning hours included: 0.0  Learning activity  Participation in didactic classes included in study plan  Number of study hours  The objective of the course "Energy Storage Methods" is to provio of various energy storage technologies and their applications in principles of energy storage, such as electrochemical, thermal, arthese methods impact the efficiency and stability of energy syster challenges associated with integrating energy storage into sustain  Course outcome  [K7_U02] is able to use known mathematical and numerical methods to analyze and design elements, systems and power transmission networks and internal installations  [K7_W07] knows the environmental effects of energy technologies used; is familiar with the issues of effective energy management and use of renewable energy sources, has a broad and well-established knowledge of the processes of energy production and use  1. Introduction to Energy Storage 2. Energy in Traditional Carriers: Coal, Oil, Gas 3. Basic Electrochemical Batteries (Lithium-Ion, Flow Batteries) 4. Modern Electrochemical Batteries (Lithium-Ion, Flow Batteries) 5. Energy Storage in Electric Vehicles 6. Generation and Storage of Hydrogen Energy 7. Hydrogen Storage: Methanol, Ammonia, Biofuels 10. Thermal Energy Storage Systems (PHES) 11. Methanical Energy Storage Systems (PHES) 12. Lectry Storage in Learny Storage Compressed Air (CAES), Flywf 12. Learny Storage in Learny Storage Systems (PHES) 13. Lectry Storage Systems (PHES) 14. Lectry Storage Systems (PHES) 15. Case Studies - Analysis of Cases	February 2023  Academic year of realisation of subject  second-cycle studies  Subject group  Full-time studies  Mode of delivery  Language of instruction  ECTS credits  general academic profile  Katedra Inżynierii Materiałów Funkcjonalnych WETI -> Faculty of Electrolinformatics  Subject supervisor  Function of the driving in the profile of the profi	February 2023  Academic year of realisation of subject  second-cycle studies  Subject group  Full-time studies  Mode of delivery  1 Language of instruction  2 ECTS credits  3.0  general academic profile  Assessment form  assess  Katedra Inżynieni Materiałów Funkcjonalnych WETI -> Faculty of Electronics, Te Informatics  Subject supervisor  Teachers  Full-time study  Assessment form  Full-time study  Assessment form  Assession for dr hab. inż. Piotr Jasiński  dr inż. Iga Szpunar  prof. dr hab. inż. Piotr Jasiński  dr hab. inż. Poitr Jasiński  dr hab. inż. Sebastian Molin  Lesson type  Lecture  Tutorial  Laboratory  Project  Number of study  Number of study  Number of study  plan  Nu	February 2023 Rademic year of realisation of subject second-cycle studies Subject group  Full-time studies Mode of delivery at the university  1 Language of instruction Polish  2 ECTS credits 3.0  general academic profile Assessment form assessment  Katedra Inzynierii Materialow Funkcjonalnych WETI -> Faculty of Electronics, Telecommunicati Informatics  Subject supervisor prof. dr hab. inż. Plotr Jasiński  Teachers dr inż. Iga Szpunar  prof. dr hab. inż. Plotr Jasiński  dr hab. inż. Sebastian Molin  Lesson type Lecture Tutorial Laboratory Project Seminar  Number of study  Num			

Data wydruku: 27.04.2024 23:10 Strona 1 z 2

Prerequisites and co-requisites					
Assessment methods	Subject passing criteria	Passing threshold	Percentage of the final grade		
and criteria	Final test	50.0%	75.0%		
	Laboratory	80.0%	25.0%		
Recommended reading	Basic literature	<ol> <li>Barnes F. S., Levine J. G., Large Energy Storage Systems Handbook, CRC Press, Taylor and Francis Group, 2011</li> <li>Ahmed Faheem Zobaa, Energy Storage - Technologies and Applications, InTech 2013. ISBN 978-953-51-0951-8, DOI: 10.5772/2550;http://www.intechopen.com/books/energy-storage- technologies-and-applications</li> <li>Rafi qul Islam Sheikh, Energy Storage, InTech 2010, ISBN 978-953-307-119-0; http://www.intechopen.com/books/energy- storage</li> </ol>			
	Supplementary literature  eResources addresses	publications from Elsevier, Wiley publishing houses (and others     internet resources  Adresy na platformie eNauczanie:			
Example issues/ example questions/ tasks being completed	Please describe the basic methods of energy storage in Poland?     Please describe a possible energy storage scenario 20 years from now?     What technologies can be used for storing energy on a small and large scale?				
Work placement	Not applicable				

Data wydruku: 27.04.2024 23:10 Strona 2 z 2